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Eastern Nile Watershed Management Project

Cooperative Regional Assessment (CRA) for Watershed Management

TRANSBOUNDARY ANALYSIS
FINAL COUNTRY REPORT
ETHIOPIA

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CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

ADLI	Agricultural Development Led Industrialization
ACT	African Country Almanac
AHD	Aswan High Dam
AHI	African Highlands Initiative
BioCF	BioCarbon Fund
CBA	Cost Benefit Analysis
CBD	Coffee Berry Disease
CIDA	Canadian International Development Agency
CRA	Cooperative Regional Assessment
DFID	Department for International Development
EARO	Ethiopian Agricultural research Institute
EDRI	Ethiopia Development Research Institute
EHRS	Ethiopian Highlands Reclamation Study
ENSAP	Eastern Nile Subsidiary Action Programme
FAO	Food and Agricultural Organization
GEF	Global Environmental Fund
GAIL	Gross Annual Immediate Loss
GDCL	Gross Discounted Cumulative Loss
GDFL	Gross Discounted Future Loss
GDP	Gross Domestic Product
GIS	Geographic Information System
IBRC	Institute for Biodiversity Research and Conservation
IDEN	Integrated Development of the Eastern Nile
IFPRI	International Food Policy Research Institute
IGADD	Inter Governmental Agency for Drought and Desertification
IIED	International Institute for Environment and Development
ILO	International Labour Office
IRR	Internal Rate of Return
IUCN	International Union for the Conservation of Nature
IWMI	International Water Management Institute
JAM	Joint Appraisal Mission
JMP	Joint Multipurpose Programme
Km	Kilometre
Km2	Square kilometre
MoARD	Ministry of Agriculture and Rural Development
MoWR	Ministry of water Resources
MoPED	Ministry of Planning and Economic Development
MCM	Million Cubic Meters
MW	Mega Watt
MERET	Managing Environmental Resources to Enable Transitions to More Sustainable Livelihoods

N	Nitrogen
NBI	Nile basin initiative
NUTMON	Nutrient Monitoring
NCS	National Conservation Strategy
SCRP	Soil Conservation Research Project
SIDA	Swedish International development Agency
SLM	Sustainable Land Management
SWC	Soil and Water Conservation
t	ton
TauDEM	Terrain Analysis Using Digital Elevation Model
TGE	Transitional Government of Ethiopia
UNDP	United Nations development Programme
USAID	United States Agency for International Development
USLE	Universal Soil Loss Equation
WB	World Bank
WBISPP	Woody Biomass Inventory and Strategic Planning Project
WM	Watershed Management

EXECUTIVE SUMMARY

1. Scope of the report:

The Eastern Nile Basin in Ethiopia comprises the Tekeze, the Abay and the Baro-Akobo river systems. The basins are located in the northwestern, western and southwestern parts of the country. The area of each basin and total area within Ethiopia are as follows:

Tekezi/Atbara	-	88,501km2
Abay	-	202,989km2
Baro-Akobo	-	75,856Km2
Total	**-**	**365,137km2**

The total estimated population (2000) of the three basins is as follows:

Tekezi/Atbara basin	-	5,878,655
Abay basin	-	21,746,130
Baro-Akobo	-	2,625,062
Total	**-**	**30,249,847**

The Transboundary Analysis component comprises an integrated, cross-border analysis of the watershed system in order to identify the main watershed characteristics and watershed challenges in each of the Sub-basins, and to opportunities and benefits of cooperation in watershed management. The analysis is being undertaken in five stages:

- National level analysis for the agreed Sub-basins;

This is the subject of this report. This will be followed by

- A Regional Workshop to assure interaction between the national level activities and foster a regional understanding of common issues;

This was undertaken at Alexandria, Egypt between the 22 – 24th August 2006. This Report has been revised and amended in the light of comments and recommendations received at the Regional Workshop and in subsequent written form.

The next stage of the Transboundary Analysis is as follows:

- Consolidation of the three national level analyses into a system-wide analysis of issues and opportunities to improve livelihoods;

- Identification of additional benefits of cooperation in watershed management by identifying potential additional cross-border positive and negative impacts of watershed related interventions;

- Distillation from the system-wide analysis the greatest system-wide opportunities for high impact cooperative watershed management.

This report contains the results of the National level analysis for the Eastern Nile Basin within Ethiopia. It comprises:

(i) a review of successful experiences of interventions to address watershed interventions (with a specific view of approaches aiming at improved livelihoods);

(ii) stakeholder consultations in selected relevant locations;

(iii) a detailed problem and solution analysis for each watershed for current trends in land degradation;

(iv) policy and institutional issues conducive as well as hindering successful interventions on the national level; and

(v) an outline of long-term capacity building and monitoring needs to evaluate successes/impacts of interventions on the watershed.

2. Understanding of the Biophysical and Socio-economic Aspects of the three Sub-basins:

The Report then provides a detailed description of the biophysical and socio-economic aspects of the three Sub-basins. It first provides an overview of the agricultural and forestry sectors and provides some details of production and marketing systems.

There follows a Sub-basin by Sub-basin description of the biophysical and socio-economic features of each Sub-basin.

3. Summary of the Proximate Problem Analysis:

The high seasonality of rainfall over the Ethiopian Highlands, which is confined to a period of three to five months results in commensurate seasonality in river flows. The peak flows are able to transport very high sediment loads during these periods and lead to the high sedimentation rates in Sudan and Egypt.
The highlands of the Tekezi River Basin and the northeastern eastern highlands of the Abay River Basin contain many areas with structural food deficits which suffer frequent reductions in crop production due to low rainfall. The key issues are soil degradation, livestock feed deficits, fuelwood wood consumption rates in excess of sustainable yield, burning of dung and accelerated soil nutrient breaches and poor non-farm employment opportunities. Nevertheless, in recent years the uptake of soil and water conservation measures has been impressive and in many areas of Tigray the rate of adoption exceeds 40 percent of farmers. This has been mainly due to the visible impacts of the increase in soil-water conservation, risk reduction and significant crop yield increases. Communal grazing land management systems are in place in 80 percent of the villages. On-farm tree planting however lags behind that in the Amhara Region, possibly due to a ban on tree planting in croplands.

The western highland areas of the Abay Basin are also long settled but they enjoy higher and more stable rainfall supply. There are large areas that are relatively flat with Vertisols and higher fertility Nit sols. On areas with steeper slopes sheet erosion is a major problem, although over many areas soil nutrient depletion is a more critical problem. This is because higher crop yields and sales of crops lead to higher outflows of soil nutrients. Gully erosion is a problem of both steep slopes and flat valley bottoms. Livestock feed deficits are acute during the wet season when crops are in the ground and large areas of bottomland grazing are flooded.

Since 1991 these areas has seen a massive increase in on-farm tree planting (almost entirely of *Eucalyptus* spp.), driven mainly by the big increase in the market for construction poles. This has been due to the building boom and facilitated by the change in government policy allowing farmers sole use rights over trees on their farms and the abolition of the government monopoly on the sale of poles. However, there are indications that the market for poles may be becoming saturated. Some 80 percent of trees are planted around the homestead and thus do not adversely affect crops.

In the southwestern Highlands large areas are covered with Montane High Forest although smallholder and large-scale agricultural expansion is rapidly reducing their coverage. Valley swamps are increasingly being cleared for agriculture and grazing.

In the western lowlands population densities are low, soils are relatively infertile and acidic being derived from Basement Complex rocks, malaria is prevalent and typanosomiasis occurs in the Beles, Abay, Didessa and Dabus valleys below 1,500 masl. Few livestock are kept and bush fallowing is widespread cultivating mainly sorghum. Slopes are relatively gentle and as the land is open for only two or three years soil erosion is not a major problem. Locally, increasing population and the shortening of bush fallow periods below the optimum is leading to soil degradation (soil nutrient decline and acidification). Fires during clearing for cropland often spread considerable distances reducing surface litter and soil organic matter. Mortality of young trees is high leading to a progressive degradation of the woodland. Large areas of Lowland Bamboo occur across the area, but these are under considerable pressure from cultivation and unsustainable extraction. These Lowlands are also important for the harvesting of resins.

The western Lowlands with their low population densities are seen as an area of potential for agricultural expansion. The area around Humera was the first to be developed in the 1960’s mirroring developments taking place across the border in Sudan. A large state farm was developed in the late 1970’s in the Didessa Valley and a large resettlement scheme developed in the Beles Valley at the same time. The state farm was abandoned because of declining yields. Currently the western Lowlands are being developed in an ad hoc manner for private large-scale semi-mechanized farming.

4. Summary of the Underlying Causes of Natural resource Degradation:

The proximate causes of infield soil erosion are reasonably well known although the science of the linkages between erosion and deposition in the landscape, sediment delivery to streams and total sediment yields with increasing basin size is less certain. An understanding of the underlying causes is still imperfectly understood, notwithstanding the impressive amount of research work undertaken over the past decade. There results of research to-date may be briefly summarized as:

- The profitability of land management technologies is very important, though not the only factor influencing adoption or non-adoption of sustainable land management (SLM) practices.

- Risk is also a very important consideration. Profitability becomes more important for SLM technologies that are risk increasing (e.g. chemical fertilizer) than those that are risk reducing (SWC investments in moisture stressed areas).

- In the context of imperfect markets and institutions the suitability and feasibility of land management interventions in different locations and farmer circumstances are very context dependant making generalisations difficult. The numerous potential factors include: agro-ecological conditions; nature of the technology; land tenure relations; household endowments of natural, human, social and financial assets. Better market access appears to be associated with less SWC investment but more use of fertilizer.

- Land tenure insecurity and limited transfer rights appear to discourage land management investments, but the results are mixed. It appears to have less impact on the adoption of inputs (e.g. fertilizer) than long-term investments (e.g. SWC structures).

- The impact of the degree and type of household livelihood assets on investment decisions is mixed.

- The Malthusian argument of the negative impacts caused increasing population pressure, and Boserup argument for population induced agricultural intensification may both be correct in the Ethiopian situation. Farmers do respond to population pressure with intensified production, but this may not be sufficient to prevent resource degradation and increasing poverty. In this respect, Ethiopia compares poorly with the situation in Machakos, Kenya described by Tiffen et al (1994).

5. Review of Past and Current watershed Interventions in Ethiopia:

A comprehensive review is provided of past and current watershed interventions in Ethiopia. An assessment of past interventions is summarized as:

- In many areas there were substantial benefits with improved soil conservation, planting of woodlots and improved pastureland.

- Many structures were costly in terms of land taken out of production, labour inputs for physical structures were very high, and there was little attempt to incorporate indigenous soil and water conservation techniques. In some areas structures were technically inappropriate and caused water logging.

- The programme focussed narrowly on arresting soil erosion without considering the underlying causes of low soil productivity, the socio-economic factors and the need for immediate tangible benefits to be attractive to poor farmers.

- The programme adopted a very “top-down” approach in its planning and implementation. There was little or no consultation with farmers or communities on felt needs. Woodlots were implemented with no harvesting plans.

- Although a “watershed” approach was adopted the basin size was too large to acquire an understanding of the socio-economics of land degradation and farmers willingness to invest in improved land management.

6. Review of Lessons learnt:

Priority for interventions: There is a very strong relation between SWC and food aid. The latter is concentrated in food deficit areas and this has led to a relative neglect of this SWC work in food sufficient or surplus areas

Innovative approaches: There are now better linkage between SWC, water harvesting and agricultural diversification (based on micro-irrigation). These have been introduced by the MERET project and are now applied by all.

Technology innovation: Some important technology innovations have taken place in watershed treatment. The most substantial change has been the greater emphasis on water resource development enabling the expansion of micro-irrigation.

Water harvesting: (e.g. ponds, small earth dams, river diversion) has become an essential ingredient of SWC programmes, although it has known limitations including:

- Pond and canal seepage are limiting factors, reflecting problems in design, construction and supervision.
- Inflows from harvesting areas have been less than expected due overly optimistic runoff coefficients.
- Excessive sedimentation is a problem, pointing to need to integrate water harvesting with the overall catchment management.
- Pond water is insufficient for dry season irrigation, and is often actually used for supplementary irrigation in the wet season.
- Water should be used on high value crops, but horticultural crops have high input costs and have limited storage capacity (where markets are thin).
- Water borne diseases (malaria and bilharzias) and safety need to be considered.
- Success was achieved where both technical and social aspects were adequately covered.

Impacts and implementation efficiency: Local level watershed protection has been undertaken for three decades, at enormous cost. However, large areas have been treated now, particularly in Tigray. Improved crop transformation and improved livelihood conditions are also mentioned as main achievements.

However, the cost efficiency of all the work is rarely questioned. After many years of SWC practice, field observations still lead to similar conclusions:

- SWC implementation follows a blanket approach, structures are often over-designed; no flexibility or refinement in measures can be observed based on varying terrain conditions,
- maintenance is generally inadequate or lacking,
- there is a strong predominance of mechanical, loose rock structures which could be replaced in many places by cheaper, biological measures contributing in the same time to productivity,
- quality control is limited to target fulfilment and is not concerned with optimum impact of measures.

Monitoring and Evaluation: The type of data collected with regard to SWC implementation generally focuses on physical achievements (i.e. length of terracing, seedlings produced, etc). After three decades of massive soil conservation campaigns, it is possible to trace exactly how much food was spent, but it is not possible to say what the impact has been on agricultural production, farm incomes, which areas have been covered (and even covered how many times) and whether the work was carried out in an efficient way.

Budget transparency: The pattern of actors in watershed activities, amounts of work achieved, and budgets dispensed, is often complex, especially in weredas where several donors are active. However, no annual synthesis is made at the wereda level of all activities carried out, differentiating between donor, source of funding, and type of activity (paid or unpaid). Also, the conversion of works performed into areas treated, is a mathematical and artificial one. No cartographic record is kept of areas treated. After some years, as a result of high staff turn-over, nobody knows anymore who has done what and where.

The need for greater transparency and better record keeping is obvious. Given the ongoing land degradation and the enormous amounts of work ahead, it will be necessary to know better how and where to select future priority areas, and at what costs these could be treated.

Some positive experiences but limited up-scaling: There have been a number of very innovative and positive experiences in developing approaches and technologies for SLM. However, there has been only limited up-scaling of these.

The Role of Food/Cash for Work: The overriding role of food-for-work is often ignored. A number of government and NGO field workers hold that food/cash-for-work is a major obstacle to scaling up. They feel that the concept has been institutionalized in such a way that farmers are unwilling to undertake any measures without payment, even when these are to their own benefit".

Building on the Past: The MERET/WFP project has been operating some 25 years (under different names), and offers a wealth of experience. The experiences in watershed management (including water harvesting) suggest a few key considerations for future projects:

- Community ownership and institutional structures are basic to project success
- The 'building blocks' for watershed management should be community catchments in the 200-500 ha range
- Larger projects (e.g. the current projects) should be seen as target areas for coverage by 'micro-projects' at the 200-500 ha level i.e. should be assemblages of micro-watersheds grouped and linked at a broader scale
- Larger projects can 'add value' by allowing physical integration of the micro-projects and by allowing a more holistic approach than possible at the micro scale
- Projects benefit from an 'integrated' approach. However, concepts on 'integrated' vary and rarely extend beyond agricultural production
- Due to the diversity of landscape and socio-economic conditions in Ethiopia, interventions need to be adapted to local conditions rather than following standard models.
- Implementation is easiest in areas offering most immediate benefits, i.e. in moisture-stressed areas. By extension, water conservation offers more immediate and visible benefits than soil conservation.
- Extensive support by Development Agents is required for project implementation. Optimum support levels are around 3 diploma level development agents per development centre. This has important implications for project implementation and management. The scale of the proposed projects will make major impositions on the capacity of the Regional Bureaux of Agriculture. Future projects may need to either provide support to these bureaux or to have a separate implementation management (albeit linked to the bureaux)
- Payment (food or cash for work) will most likely be required for a large part of project implementation.
- A key issue yet to be resolved is how to 'scale up' from the micro-watersheds to larger areas – a question to which upcoming watershed management projects should make an important contribution.
- It is difficult to sustain watershed management on increased productivity of food grains alone; diversification for cash crops adapted to local markets or other income generating activities is an essential

part of the mix. This emphasizes the importance of markets and marketable products to offset the cost of investment in conservation.

- Key constraints are institutional capacity limitations at Regional, Wereda and Kebele/community levels; free grazing of livestock; the requirement of external support (generally food-for-work) to support community mobilisation; and lack of maintenance after completion of the project.
- There are no evaluation data available on post project benefits as compared to baseline situations. Most observers agree that, within the moisture deficit and food insecure Weredas, crop and forage production benefits are positive. MERET has undertaken an economic analysis which suggests that activities are economically viable.
- Despite the previous point, the evidence of community driven watershed management and self-replication is limited. Efforts have been, and remain, primarily supply-driven by government and donor agencies, and supported by payment (food or cash for work).

7. Regional Watershed Management Planning Framework:

A regional watershed management planning framework is presented. The eastern Nile Basin is divided into a number of Development Zones based on agricultural potential, access to markets and whether highland or lowland. Bundle of integrated interventions are proposed for each Development Zone.

This followed by a number of supporting interventions required at the strategic level. These include:

Incentives: A distinction is made between incentives for on-farm (i.e. private) soil conservation investments and those for community investments. A different basis needs to be created for motivating and/or compensating farmers to contribute to community work. Some measures for consideration are:

- establish a transparent distinction between on-farm work, voluntary as much as possible, and off-farm development activities that can be compensated by FFW or CFW,
- abandon the application of FFW for on-farm work, and promote the integration of SWC as to become part and parcel of farming practices,
- to harmonise the above measures with ongoing FFW through the WFP-MERET project,
- replace "Community Participation" and mass mobilisation campaigns by voluntary work in farmers own village areas on locations selected by farmers themselves,

- ensure that farmers exempted from Community Participation are not loosing opportunities of working in other schemes of employment generation,

Resettlement of Population: Since 2003 a new official voluntary resettlement programme is in place. The programme is designed to take into account lessons from resettlement programmes in the past. However, the programme contains a number of risks and it will be important that proposed measures to counter these are pursued.

Improving Rural and Urban Domestic (traditional/biomass) Energy Systems: is seen as an important supporting strategy. In the "Access to Energy" Project a number of strategies are currently being pursued.

Improving Rural-urban socio-economic linkages in the context alternative livelihoods: A number of key strategies are identified:

- Develop and improve access to markets through improved road and other forms of communication (e.g. telecommunications);
- Improve access to capital and credit sources;
- Provide basic technical skills (e.g. bricklaying, carpentry, etc) to improve employability;
- Provide support to traders through improved working capital and credit (they provide the link between farmers and non-farm
- activities and between local, national and international markets).

8. Long-term Capacity and Monitoring Needs:

The report concludes with a number of areas where capacity building is required and describes current programmes in this regard.

The need for long-term and consistent monitoring of landuse/landcover and of sediment monitoring at all levels and scales is stressed.

1. BACKGROUND

1.1 Introduction

The Eastern Nile Basin Watershed Management Cooperative Regional Assessment (CRA) is in support of the Eastern Nile Subsidiary Action Programme (ENSAP). ENSAP, which includes Egypt, Ethiopia and the Sudan, seeks to initiate a regional, integrated, multi-purpose programme through a first set of investments. The first project under this initiative, referred to as The Integrated Development of the Eastern Nile (IDEN) comprises seven components:

- Eastern Nile Planning Model,
- Baro-Akobo Multi-purpose Water Resources Development,
- Flood Preparedness and Early Warning,
- Ethiopia-Sudan Transmission Interconnection,
- Eastern Nile Power Trade Investment
- Irrigation and Drainage
- Watershed Management

The results of the analyses of the sectoral CRA's will be brought together in the design and decisions in a joint multi purpose programme (JMP) of interventions. The general elements of a CRA are (i) institutional strengthening, (ii) a participatory process for building trust and confidence, and (iii) to gain a transboundary understanding the watershed system from a basin wide perspective.

The results of the Watershed Management CRA will provide valuable input to the JMP planning. The CRA will highlight some of the major issues relevant to the JMP, identify transboundary benefits and develop long term cooperative arrangements for monitoring land use change, sediment loads and impacts on livelihoods.

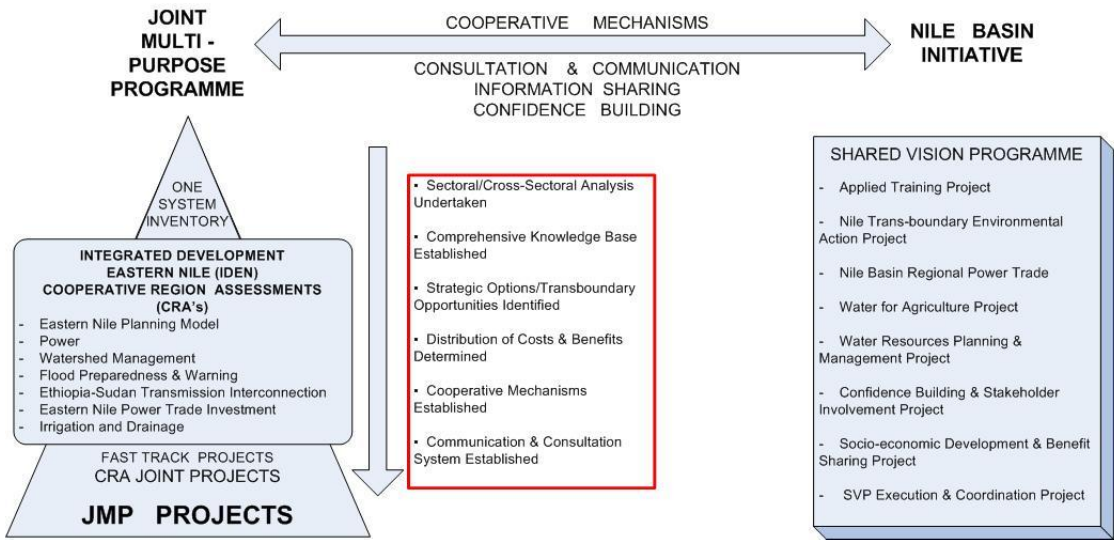
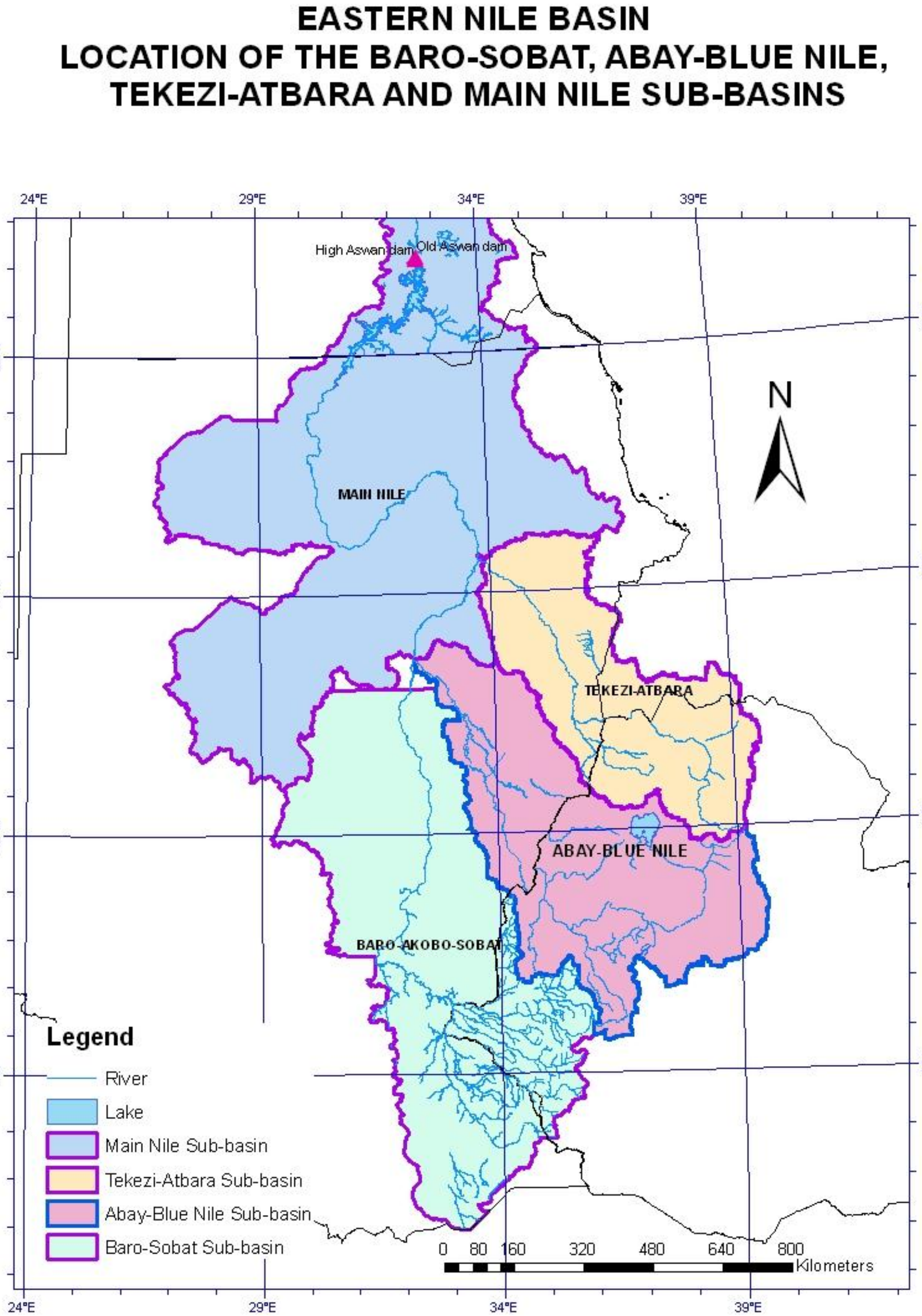


Figure 1. Relationships among and processes of the IDEN CRA's, the Joint Multi-purpose Programme and the Nile Basin Initiative's Shared Vision programme

1.2 Primary Objectives of the Watershed Management CRA

The project focuses on four watersheds: the Abay/Blue Nile, Tekezi/Atbara, the Baro-Sobat-White Nile and the main Nile from Khartoum to the Aswan High Dam (Map 1). The primary objects of the Watershed Management CRA are to develop a sustainable framework for catchment management in order to:

- Improve the living conditions of all peoples in the three sub-basins
- Create alternative livelihoods
- Achieve food security
- Alleviate poverty
- Enhance agricultural productivity
- Protect the environment
- Reduce land degradation, sediment transport and siltation.
- Prepare for sustainable development orientated investments.



Map 1. Eastern Nile Basin: with the Tekeze-Atbara, Abay/Blue Nile, Baro-Akobo-Sobat and the Main Nile Sub-basins.

1.3 The Scope and Elements of Sustainable Watershed Management

1.3.1 Watersheds and River Basins

River basins, watersheds and sub watersheds and their hydrological processes operate in systemic way within a nested hierarchy but often in complex spatial and temporal patterns. For example, the linkages (or coupling) between vegetation cover, soil erosion (or soil conservation) and sediment yield at the micro-watershed level and the sediment load and sedimentation downstream at the macro-watershed level often do not have simple linear relationships. Terminology is generally based on area, although given the potential for extreme variability in hydrological factors this is, of necessity, rather arbitrary. The following classification was used in a recent World Bank assessment of World Bank funded Watershed management projects.

Table 1. Watershed Management Units and Hydrological Characteristics

Management Unit	Typical area (km2)	Example	Degree of coupling
Micro-watershed	0.1 -5km^2	Typical watershed adopted by MERET interventions (Ethiopia)	Very strong
Sub-watershed	5 – 25km^2	An assemblage of micro-watersheds	Strong
Watershed	25 -1,000km^2	Guder	Moderate
Sub-basin	1,000 – 10,000km2	Lake Tana	Weak
Basin	10,000 – 250,000km2	Abay-Blue Nile	Very weak

After World Bank (2005)[1]

In micro and sub-watersheds there is a strong coupling between the catchment area and the channel. Vegetation and land management practices closely control the runoff and the export of water, sediment and dissolved load into the stream channel. There is also a close coupling between groundwater and the river. In medium to large basins coupling between the catchment and the river is weak. The dominant process in basins of this size is transfer of material through the channel network and there is often temporary storage of sediment. Thus, the channel acts as a conveyor belt intermittently moving pulses of sediment during flood events. There is additional sediment from stream bank erosion and drifting sand.

[1] World Bank (2005) "Watershed Management in World Bank Operations (1999-2004): Emerging Lessons, Strategic Issues, Recommendations for Practitioners", unpublished WB report.

1.3.2 Approach Adopted to the Eastern Nile Watershed Management CRA

> *" In view of the multi-sectoral nature of the problem (land degradation, fuelwood demands, population pressures, illiteracy, lack of alternative sustainable livelihoods, etc.) a comprehensive and integrated approach is required, as traditional watershed management actions, in this case, would treat the symptoms, as opposed to address the root causes which lead to the spiral of degradation and poverty.*
>
> *The preparation of an integrated watershed program in the Eastern Nile region will require a holistic approach and interaction between national level and regional studies through a Cooperative Regional Assessment (CRA)."*

(Terms of reference: Cooperative Regional Assessment in Support of the Eastern Nile Watershed Management Project.)

Clearly, the approach to be adopted in developing a framework for watershed management for the Eastern Nile Basin needs to be very broad in order to address a wide-range of objectives based on stakeholder perspectives across multiple levels and countries. The objectives to be addressed go beyond developing and conserving land, water and vegetation in the four sub-basins in the three countries. They include but are not limited to:

- Improving the management of land and water, their interactions and externalities;
- Linking upstream and downstream areas, and integrating environmental concerns with economic and social goals;
- supporting rural livelihoods by linking interventions in other "non-watershed" sectors (e.g. health in pond development, training in non-farm employment activities);
- addressing equity and gender concerns in the distribution of costs and benefits of watershed interventions (e.g. positive and negative externalities at various levels);
- identifying opportunities for incremental benefits accruing to cross-border coordinated interventions, including those being developed for the other IDEN CRA's and the Joint Multi-purpose programme (JMP);
- identifying global benefits (e.g. conservation of tropical forests, biodiversity and carbon sequestration) that accrue from national and regional level interventions.

At the same time it will be important to maintain a "Watershed Perspective". This is necessary to avoid loosing focus on the unique upstream-downstream characteristics of watersheds and river basins. Maintaining such a perspective will avoid the danger of the analysis failing to develop a "system-wide" understanding of the basin-wide issues and thus the identification of transboundary opportunities to improve livelihoods and achieve poverty reduction. Finally, a Watershed perspective will enable the identification of basin-wide synergies from cooperative transboundary interventions.

The approach adopted in the current CRA thus encompasses all the elements of the "broader approaches" outlined above: agro-ecosystems, watershed-based rural development, participatory development, use of a "livelihoods framework and a detailed consideration of externalities and their distribution Regionally, Nationally and across Countries.

Another essential and unique element of the Watershed Management CRA approach that distinguishes it from many Watershed Management approaches is the "Regional Process": i.e. building capacity, trust and confidence among riparian stakeholders. This will be made operational through a continuous process of regional stakeholder consultation.

FAO[2] (2006) has undertaken a review of lessons learnt from decades of Watershed Management Programmes and outlined a new approach to watershed management that is emerging from the "Integrated Watershed Management" approach that has served the past two decades. The review of lessons learnt identified a fundamental dilemma about integrated watershed management programmes and sustainable development processes:

- Should watershed management programmes incorporate sustainable development objectives by providing benefits and services that are not directly related to natural resource management? or
- Should they be embedded in broader sustainable development processes, by ensuring that sustainable development considers land and water issues?

The first option referred to as "programme-led" integrated watershed management has prevailed often because of insufficient coverage by line agencies. Embedded watershed management focuses on those aspects of sustainable livelihoods that are directly linked to natural capital assets. Other elements that are relevant to sustainable development – off-farm livelihood

1. [2] Undertaken in collaboratyion with the European Observatory of Mountain Forests, International Centre for Integrated Mountain Development, Red Latinoamericana de Cooperacion Tecnica en Manejo de Cuenncas Hidrograficas and the World Agroforestry centre.

diversification, education, health, etc – are less relevant to watershed management programmes. Partnerships between watershed management programmes and other institutions working on livelihood, poverty alleviation, land reform, education, and health issues make it easier to address environmental and social issues effectively.

The new approach termed "Embedded Watershed Management" differs in a number of important ways from the previous approach. These are outlined in Box 1.

Box 1. Comparison between (programme led) Integrated and Embedded Watershed Management

Integrated Watershed Management	Embedded Watershed Management
Environment and Social issues are strictly related and cannot be addressed separately.	Most watershed problems are related to socio-economic issues, but there is always scope for measures and actions that specifically address environmental issues.
Watershed management programmes should have a sustainable development mandate and aim at both natural resource and sustainable livelihood goals.	The mandate and goals of watershed management programmes should focus on natural resource management **FOR** sustainable livelihoods and development.
Integrated programmes to address environmental and livelihoods issues comprehensively should be developed.	Sectoral programme focusing on watershed natural capital assets should be developed. Issues that are not related to natural resource capital should be addressed in collaboration with other programmes or institutions.

Along with integration, "participation" has been another essential attribute of watershed management practice for more than 20 years. However, it now clear that beneficiaries (people, communities) are not the only important actors in participatory watershed management. Collaboration between watershed management programmes and stakeholders (including downstream interest groups and countries) at many levels is now seen as essential. This shift is linked to the administrative decentralization process that many countries have adopted in past decade. The differences between the two approaches are set out in box 2.

Box 2. Comparison between Participatory and Collaborative Watershed Management

Participatory Watershed Management	Collaborative Watershed Management
Focuses on communities and people and targets grassroots social actors: households and small communities.	Focuses on civil society and targets a variety of social and institutional actors, including local governments, line agencies, enterprises as well as technical experts and policy makers.
Based on assumption that sound natural resource management is a public concern shared by all social actors.	Based on the recognition that stakeholders have particular – sometimes contrasting – interests in natural resources, which need to be accommodated.
Seeks (claims) to make decisions through bottom-up process, by which grassroots aspirations are progressively refined and turned operational action.	In decision-making, seeks to merge stakeholders aspirations and interests with technical experts recommendations and policy guidelines through a continual two-way (bottom-up and top-down) negotiation process.
Centred on watershed management with local government assisting.	Centred on local governance process, with the watershed management programme acting as facilitator and supporter.
Aimed at creating a consensus, presuming that conflict can be solved through dialogue and participation.	Aimed at managing social conflicts over natural resources, based on awareness that dialogue and participation can mitigate conflicts but not solve them structurally.

Most government and donor funded watershed management programmes follow a clearly defined project logical framework specifying what has to be achieved and how. Objectives, outputs and activities are defined during identification and formulation stage, often based on limited information. This planning approach is not compatible with the new approach to watershed management, which requires greater flexibility in programme design.

Strategic watershed planning needs to take into account different temporal and spatial scales and accept a degree of uncertainty. It can be implemented at scales ranging from small upland watershed to entire trans-boundary river basins. Whilst small-scale projects have the advantage of face-to-face interaction with stakeholders they have limited impact at the watershed or river basin level. The design and operation of local programmes must consider upstream-downstream linkages and a methodology for multi-level watershed, sub-watershed and micro-watershed planning needs to be developed. Scaling-up of successful local experience is critical for the new generation of watershed management programmes.

1.4 Scope and Purpose of the Transboundary Analysis Country Report

The Transboundary Analysis component comprises an integrated, cross-border analysis of the watershed system in order to identify the main watershed characteristics and watershed challenges in each of the Sub-basins, and to opportunities and benefits of cooperation in watershed management. The analysis is to be undertaken in five stages:

- National level analysis for the agreed Sub-basins;

This was completed at the end of July 2006 and draft reports submitted to ENTRO and the three National Steering Committees.

- Regional Workshop to assure interaction between the national level activities and foster a regional understanding of common issues;

This was held in Alexandria, Egypt between 24th – 26th July 2006 and the draft Country reports revised in the light of comments received at the Workshop and in subsequent written form. This report constitutes the revised Draft report.

The next stages are as follows:

- Consolidate the three national level analyses into a system-wide analysis of issues and opportunities to improve livelihoods;

- Identify additional benefits of cooperation in watershed management by identifying potential additional cross-border positive and negative impacts of watershed related interventions;

- Distill from the system-wide analysis the greatest system-wide opportunities for high impact cooperative watershed management.

The analysis at the national level includes:

(vi) a review of successful experiences of interventions to address watershed interventions (with a specific view of approaches aiming at improved livelihoods);

(vii) stakeholder consultations in selected relevant locations;

(viii) a detailed problem and solution analysis for each watershed for current trends in land degradation;

(ix) policy and institutional issues conducive as well as hindering successful interventions on the national level; and

(x) outline long-term capacity building and monitoring needs to evaluate successes/impacts of interventions on the watershed on local livelihoods, agricultural output and sedimentation control.

2. NATIONAL SETTING - ETHIOPIA

2.1 Bio-physical and Socio-economic Setting

With a surface area of 1.1 million square kilometers, Ethiopia is located in the northeastern part of Sub-Saharan Africa between latitudes 3° and 15° north. The estimated population in 2000 was 63.4 million, the second highest in Sub-Saharan Africa. Some 90 percent of the population are rural. The estimated rural population growth rate (1995-2000) was 2.8 percent per annum and the urban rate was 4.5 percent. These growth rates are projected to decline between 2000 and 2030 (figure 2). Nevertheless the total population is projected to rise to 129 million by 2030 (see figure 3).

Figure 2. Changes in Rural, Urban and Total Population Growth Rates 1995- 2030 (Source CSA, 1999)

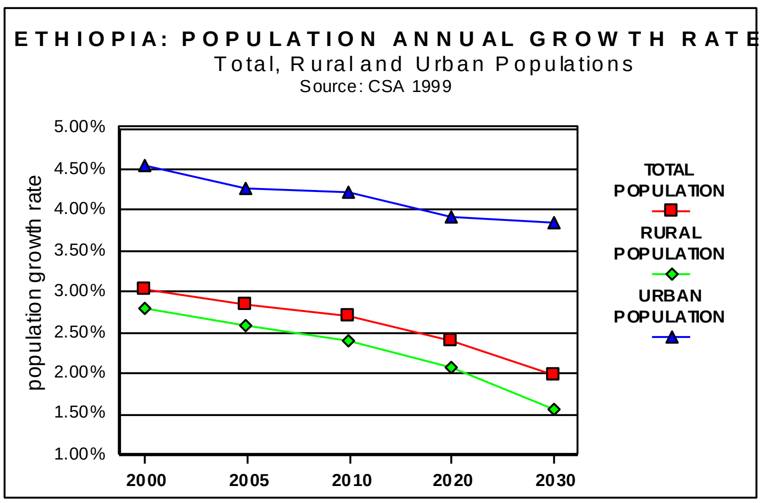
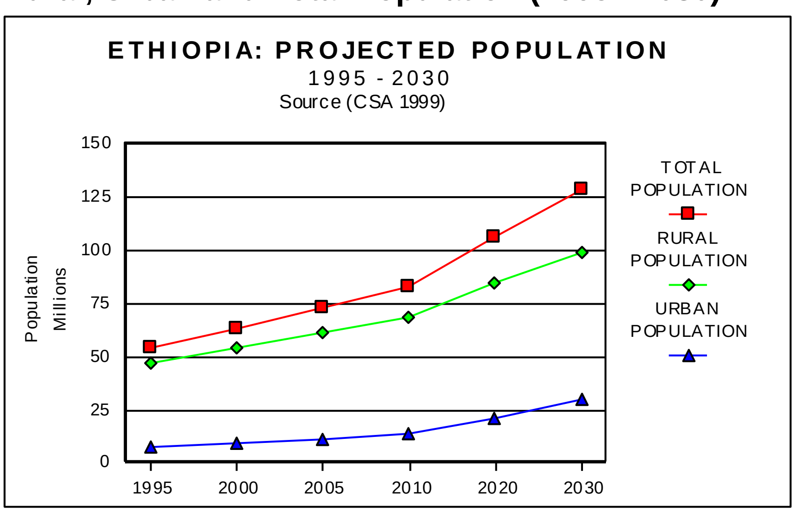
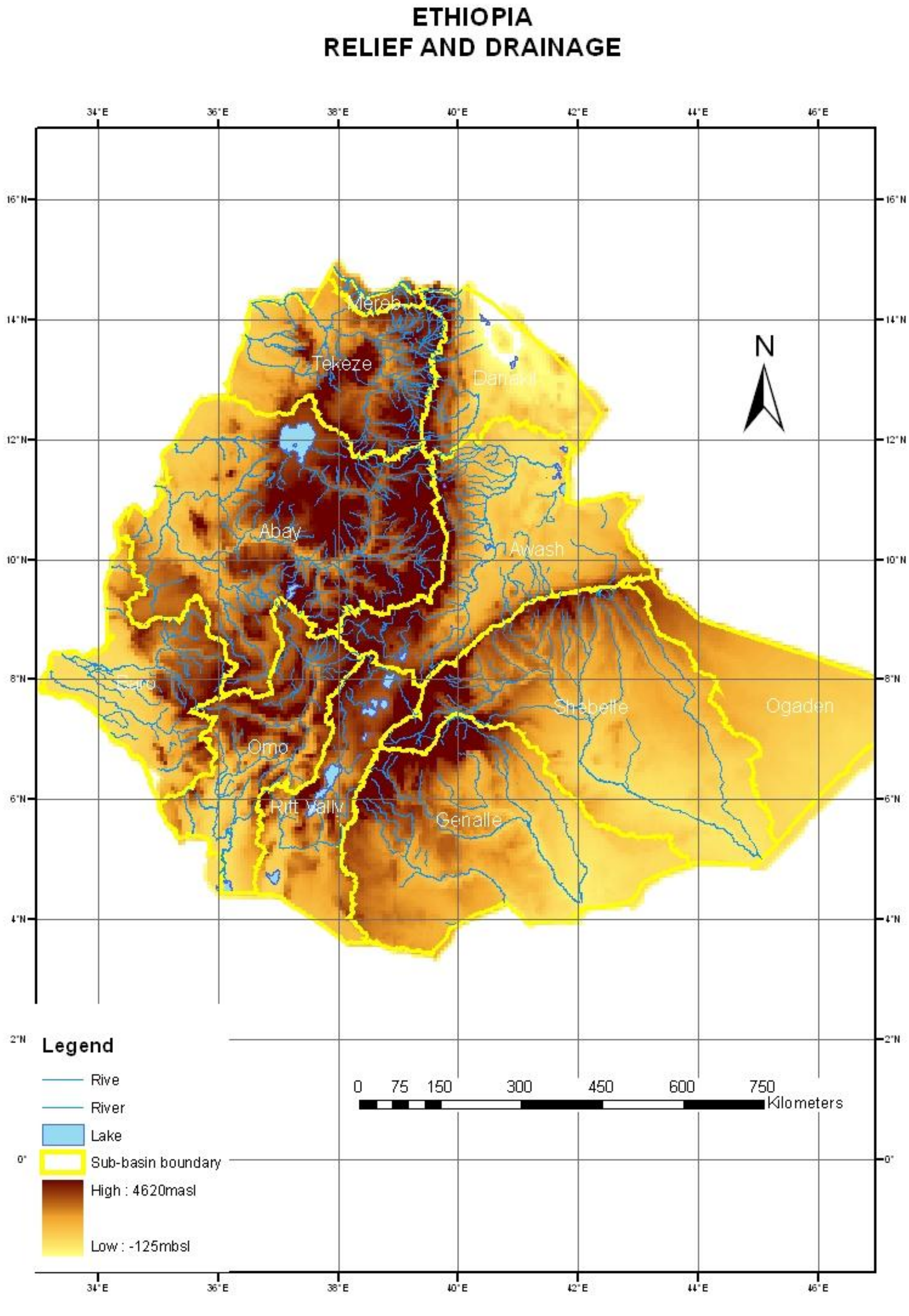


Figure 3. Rural, Urban and Total Population (1995 - 2030)





Map 2. Ethiopia: Relief and Drainage

The Highlands[3] form a broad plateau between 1,500 and 2,500 masl with isolated peaks rising as high as 4,600 masl. They cover 43 percent of the total area. The favorable climatic conditions of the Highlands sustain 88 percent of the population (Map 2). The Highlands account for 95 percent of the cultivated land, and also support 75 percent of the cattle population of 33 million. Most crop cultivation in the Highlands uses the plough and has a history stretching over many millennia. Ethiopia is one of the 12 Vavilov centres of crop genetic diversity, being a main genetic diversity center for crops such as aribica coffee, enset, niger seed, sorghum, finger millet, durum wheat, barley and many others. Given the erosion of genetic material elsewhere in the world, this diversity is assuming an increasing global importance.

Surrounding the highlands on all sides are the lowlands. To the east, southeast and south they are semi-arid to arid with an annual rainfall below 600 mm. These lowlands are inhabited by transhumant pastoralists who herd cattle and sheep (mainly grazers), and goats and camels (mainly browsers). In the Western Lowlands rainfall is much higher but the prevalence of trypanosomiasis precludes livestock production. This factor, together with the prevalence of human tropical diseases not found in the Highlands, has meant that until recently these areas were sparsely populated. However, under increasing population pressure in the Highlands these areas are now increasingly being settled.

In the high rainfall areas of the southwest and southeast highlands the original vegetation of the highlands was broad-leaved montane high forest. Further north with lower rainfall this changed to a mixed coniferous forest (Podocarpus spp. and Juniperus spp.) and woodland. In the driest parts of the north this in turn gave y to low Juniperus woodland. However, millennia of expanding settlement and clearing for agriculture has left only 3.6 percent of the Highlands covered with forest. The semi-arid lowlands of the east, southeast and south support a cover of Acacia-Commiphora woodland and shrubland. Increasingly these Lowlands are the source of fuelwood and charcoal for the highlands. In the wetter western lowlands this is replaced by Combretum-Terminalia woodland, with extensive areas of Lowland Bamboo (*Oxytenanthera abyssinica*).

In the Highlands severe population pressure, poor cultivation practices, steep lands and overgrazing by livestock has led to accelerated soil erosion that now affects more than 50 percent of the cultivated area. Some 95 percent of the cultivated area is farmed by smallholder farmers with average holdings of less than 2 hectares. In many areas an increasing proportion of the rural population have no land. With frequent droughts, each year more than 6 million people require food assistance.

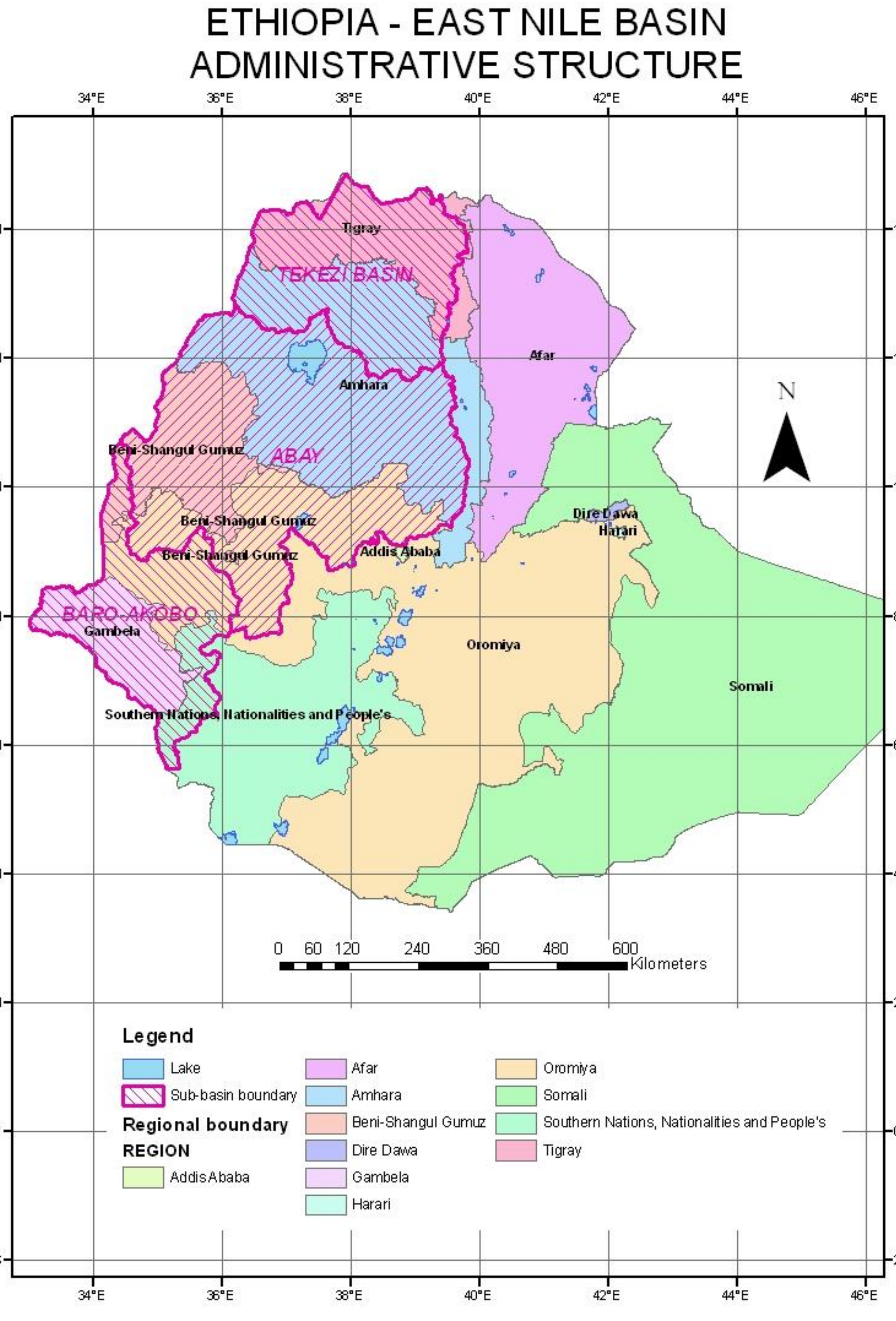
The household energy requirements of this large and fast growing population are supplied almost entirely from traditional energy sources. Biomass energy at the national level provides more than 96.9 percent of the total domestic energy consumption: 78 percent from woody biomass, 8 percent from crop residues, and

[3] "Highlands" in Ethiopia is land over 1,500 meters above sea level.

11 percent from animal dung. Modern energy provides only 3.1 percent of energy consumption. This has serious implications for the natural resource base. Because of the scarcity of fuelwood many households burn dung and crop residues. The use of dung precludes its contribution of the soil nutrient pool, exacerbating declining crop yields due to soil erosion. The burning of crop residues precludes their use as livestock feed for a livestock population barely meeting its energy requirements for maintenance.

2.2 Administrative Structure

In 1991 Ethiopia adopted a federal structure of government with 9 Regional States, the City Administration of Addis Ababa and the Dire Dawa Administrative Council (see map 3).



Map 3. Ethiopia: Administrative Structure and East Nile Sub-basins

Many fiscal and administrative powers of the central government were devolved to the Regions. Within the Baro-Akobo, Abay and Tekezi River Basins there are six Regional States:

- Tigray
- Amhara
- Beneshangul-Gumuz
- Oromiya
- Southern Nations, Nationalities and Peoples (SNNP)
- Gambela

Within each Region there is a three tiered structure of Government:

- Region
- Wereda
- Rural Farmers Association (Kebele)

The area of the Farmers Association may be sub-divided into smaller areas for the administration of natural resources (e.g. Development Team).

The ministries at the federal level are generally mirrored at the Regional level and to a lesser extent at the wereda level. Ministries at Regional are referred to as "Bureaus" and Wereda levels to "Offices". The most relevant ministries/bureaus for watershed management include:

- Agriculture and Rural Development
- Water Resources
- Finance and Economic Planning
- Federal Environmental Protection Authority and Regional Environmental Protection, Land Administration and Use Authorities
- National Disaster Prevention and Preparedness Commission and Regional Food Security Programme Coordination and Disaster Prevention Offices

2.3 National and Regional Policy Framework

2.3.1 Introduction

A substantial body of policies and policy instruments are already in place with a direct or potential bearing on natural resource management and watershed management. In general, these have been adopted at the regional level.

The main policies and proclamations are:

- Conservation Strategy of Ethiopia (CSE) (1997)
- Agricultural Development Led Industrialisation (ADLI) (1992)

- Ethiopian Water Resources Management Policy (1999)
- Subscription to the Millennium Development Goals (2000)
- Sustainable Development and Poverty Reduction Programme (SDPRP) (2002)
- Food Security Strategy (2002)
- New Coalition for Food Security Programme (2004)
- Rural Development Policy and Strategies (2003)
- Productive Safety Net Programme – Programme Implementation Manual (2004)
- Plan for Accelerated and Sustainable Development to End Poverty (2005)
- Water resources policies and legislation
- Environmental Policy and legislation
- Rural Land Administration and Land Use Proclamations

2.3.2 Conservation Strategy of Ethiopia

The Conservation Strategy of Ethiopia (CSE), formulated in 1995, is at the basis of all environmental efforts and considerations in subsequent policies.

The CSE documentation consists of five volumes: Vol. I the Natural Resource Base; Vol. II Policy and Strategy; Vol. III Institutional Framework; Vol. IV the Action Plan and Vol. V Compilation of Investment Programmes.

The Environmental Policy of Ethiopia has emanated from Vol. II of the Conservation Strategy and was approved by the Council of Ministers of the Federal Democratic Republic of Ethiopia on April 2, 1997.

2.3.3 Agricultural Development Led Industrialisation (ADLI)

ADLI, i.e. using agricultural development as an engine for economic diversification and industrialization is still the government's core policy for rural development as well as overall economic development. Implementation of this policy has focussed on provision of agricultural inputs. Although agricultural production has increased in certain areas, increases in overall agricultural production at the national level are very limited. The modest expansion in the volume of real agricultural output over 1992-2002 was driven by policy measures – liberalization of input and output markets leading to increased use of inputs (fertilizer, and to a lesser extent improved seeds) and expansion of cultivated areas. As a result, yields have slightly improved on average although this masks diverging trends in favourable and less favourable areas. The increased utilization of fertilizers and improved seeds has allowed turning some areas previously in food deficit into food exporters. This was achieved by activist policies in the context of the ambitious agricultural extension programme.

After initial success, the effect of ADLI seemed to stagnate, and has increasingly became the subject of debate. Questions raised are not only related to the way ADLI is implemented, but whether the theoretical basis of ADLI is correct. Central in the debate is the current strong focus on the supply side and the relative neglect of the demand side. It is now increasingly recognized in policy debates in the country that an efficient, low-cost, agricultural marketing system is required in order to close the national food security gap and increase per capita income. In addition, it is considered that there is need for structural change in the agricultural sector towards a more export market orientation that can only be achieved with reducing transport costs to world markets.

2.3.4 Millennium Development Goals (2000)

The document on a needs assessment related to the Millennium Development Goals (Millennium Development Goals Need Assessment: The Rural Development and Food Security Sector in Ethiopia – 2004), mentions important interventions for the period 2005-2015 to respond to the MDG, and focuses on:

- integration of environmental management in the implementation of Rural Development and Food Security programmes (environmental laws, EIA)

- watershed-based natural resource management for sustainable development and mitigation of resource degradation (proper land use, soil conservation, water/forest resource management, irrigation, biodiversity conservation).

2.3.5 Sustainable Development and Poverty Reduction Strategy (2002)

The Ethiopian Sustainable Development and Poverty Reduction Strategy (SDPRS) also focuses on agriculture centred rural development in order to achieve:

- rapid overall development
- liberation from dependency
- promotion of a market economy

It explicitly builds on ADLI by mentioning "an overriding and intentional focus on agriculture as a potential source to generate primary surplus to fuel the growth of other sectors of the economy (industry)" as one of its main thrusts.

Other broad thrusts are:

- Strengthening private sector growth and development especially in industry as means of achieving off-farm employment and output growth (including investment in necessary infrastructure),
- Rapid export growth through production of high value agricultural products,
- Undertake major investment in education and capacity building to overcome critical constraints to implementation of development programs,
- Deepen and strengthen the decentralization process to shift decision-making closer to the grass root population, to improve responsiveness and service delivery,
- Agricultural research, water harvesting and small scale irrigation,
- Focus on increased water resource utilization to ensure food security.

Some of the proposed measures in the agricultural sector are:

- Introduce menu based extension packages to enhance farmers choice of technologies,
- Expand borrowers' coverage of micro-financing institutions,
- Establish an institute for diploma-level training of extension agents and expand agricultural Technical Vocational Education Training (TVET),
- Measures for the improved functioning of markets for agricultural inputs (fertilizer, seed) and outputs,
- Organize, strengthen and diversify autonomous cooperatives to provide better marketing services and serve as bridges between small farmers (peasants) and the non-peasant private sector.

The number of farming households to be covered by the Extension Package Program is expected to increase from the current 4 million (2000/01) to 6 million by the end of the program period.

With regard to food security, the SDPRS takes into account a transition period where there will be continued reliance on food aid. The SDPRS is subscribing the concept of linking relief (*read: food aid*) with development as it has been applied since the late 1980s and is stating that "Various activities of environmental protection such as soil and water conservation, terracing and afforestation carried out over the years have shown positive results, and will be improved and continued in the future."

The latter statement has to be treated with care as it may have an important unwanted bearing on implementation modules in watershed management in which SWC and afforestation are key components. New initiatives of watershed management such those as within the framework of the ENSAP should be more critical with regard to the almost automatic connection between SLM, watershed protection activities and food aid. It is particularly in the field of SWC where food aid has had some negative impacts on planning and effectiveness of implementation, and its disconnection need to be sought very seriously. A more detailed discussion on this subject is given in chapter 9.

2.3.6 Food security strategy (2002)

The Food security strategy equally underlines the importance of sustainable use and management of natural resources, mentioning more or less the same fields of attention as the SDPRS.

2.3.7 New Coalition for Food Security Programme (2003)

The New Coalition for Food Security Programme document outlines what it considers as the main causes of land degradation, which are actually symptoms of improper management of natural resources: a) cultivation of steep slopes, without conservation practices, poor, nutrient mining farming practices and b) using crop residues and dung for household energy instead of for ameliorating soil fertility c) biodiversity losses due to land degradation and deforestation.

The document suggests participatory watershed management planning as supportive of food security interventions.

2.3.8 Plan for Accelerated and Sustainable Development to End Poverty (2005)

The Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) represents the second phase of the PRSP process (2005-2010) that began under SDPRP. PASDEP pursues initiatives under SDPRP and ADLI but with important enhancements to capture the private initiative of farmers and support the shift to diversification and commercialization of agriculture. It is realized in PASDEP that, “parallel to this shift to commercialized agriculture, improvement of pro-poor subsistence farming still needs to take place as the main welfare improvement for several million households still depends on achieving higher yields of basic food grains.

This second main orientation will be pursued through a combination of intensified extension support at the kebele level, establishment of a network of demonstration centres, increased low-level veterinary services, support for small-scale irrigation, better use of ground water, complemented by productive safety net and off-farm income generating initiatives supported under the Food Security Program. Both approaches need to be pursued with measures to manage the natural resource base and protect the environment.”

PASDEP distinguishes between the three main economic and agro-climatic zones: the traditionally settled semi-arid/sub-humid highlands, the potentially productive semi-tropical valley areas, and the hot semi-arid lowlands. This particularly applies to agriculture but also to the private sector development agenda. Instruments are infrastructural improvement (roads, telecommunication, electric power supply), strengthening of financial and administrative development capacity, and control of malaria and tsetse and special efforts for pastoral areas in the lowlands.

Watershed management related elements are mentioned under the sectors water management and irrigation (water harvesting) and crop production (water harvesting, soil and water conservation).

2.3.9 Federal Policy on Rural Development

The federal Rural Development Policy promotes, among others:

- intensification in high rainfall areas,
- livestock improvement and water resource development and marketing facilities in pastoral areas,
- irrigation and overall development of basic facilities/infrastructure in the western lowlands,
- water harvesting and land conversion in drought prone areas,
- livestock improvement through improved breeds and technology.

In its rural development policy it proposes voluntary resettlement programmes to alleviate land shortages as well as helping to develop hitherto uncultivated lands. The Strategic Policy Memorandum (SPM) of the Oromiya Bureau of Agricultural also assumes in the near future movement of people from degraded subsistence areas.

The Rural Development Policy promotes replacement, where possible, of food aid by financial support (Cash-for-work instead of food-for-work). In cases where food aid is to be preferred, food should be purchased from local sources.

Livestock improvement is to be sought through improved breeds and technology and technologies are to be disseminated through training centres for DA's.

Apart from the integrated rural development and agricultural development aspects, also covered in the SDPRS, the Rural Development Strategy also pays attention to the land tenure issue and the proper use of land. Important changes such as the moratorium on land re-distribution and the distribution of land certificates are given a legal basis in a number of federal and regional proclamations.

Protecting user rights of the farmer definitely mitigates an important facet of the problem of tenure security, but does not solve the problem of non-availability of land for young farmers. This will be addressed by improving land use and productivity as well as employing technologies that use more labour resources and thus creating on farm job opportunities. Several measures are already successfully applied to this regard. Gully stabilization and plantation followed by allocation to landless youth is one example; rights of landless people to exploit rehabilitated hill slopes (after hillside closure and/or plantation) are another example. In the long-term, accelerated economic development should hold out the promise of increased job opportunities to the landless.

The more recent Main Report of the **National Livestock Development Project** – NLDP (1999-2003) confirms the pressure on land and forage resources by stating that, at a national scale, natural pastures in the mixed highland farming areas are taken over for cropping and crop residues (7-8 % at a national scale) and agro-industrial by-products are becoming major sources of feed although not adequately used. In these circumstances, the cultivation of fodder crops and forages becomes a serious option for increasing feed resources. Tremendous opportunities are reported for introducing forages into the cropping system through undersowing, intercropping and the use of leguminous shrubs as backyard hedges. The NLDP report further confirms that the need to intensify and integrate livestock production into more profitable farming systems is central to environmentally sustainable land use.

The NLDP project area touches parts of the ENB in ANRS, TNRS as well as in ORNS. It focuses on upgrading genetic resources, improved animal health and increased forage production. The latter is, among others, concerned with forage development in smallholder fattening and dairy production systems, development of local capacity for perennial legume seed production by small holder contract system. It is estimated that forage development may give a net benefit of ETB 6,000/ha (US$ 690/ha).

2.3.10 Regional States Development Policies

Tigray has formulated its Regional Development Policy for 2006-2010, which is available only in Tigrinya language.

The SPM document of the Agricultural Bureau of **Oromiya Regional Government** shows that federal policies such as ADLI have been adopted at the regional level. Priority is given both to small-scale peasant farming and to medium-large scale commercial farming. Agriculture is said to be market oriented. The SPM aims at a transformation of 12 % of the subsistence farmer households into modern farming, and a decrease in the ratio DA/farmer from 1/956 to 1/274.

The SPM seems rather ambitious in setting its targets for capacity building and transforming of subsistence farmers into “modern” farmers, without specifying how to tally these objectives with financial as well as human resource capacity/constraints. Objectives and strategies are mainly focussing on human resource development and increased agricultural production based on improved seeds and credit. Both the SPM and the MP assume some near future displacement of people from degraded subsistence areas.

The SPM refers to land resource development aspects such as water harvesting, improved pasture by oversowing, dryland farming techniques. Nothing is said on land management and conservation. Although this would rather be the mandate of the Natural Resource Department, referring to this issue would have shown the intention of an integrated approach to rural development.

Productive Safety Net Programme – Programme Implementation Manual

The change from subsistence farming to a more diversified economy can only be made if the Government guarantees a safety net to farmers. Recently, a country-wide safety net programme has been prepared with the help of the World Bank. Distribution of food aid should be minimised as much as possible, and be replaced with cash aid, in order not to distort food cereal prices, which inhibits investments in agriculture and maintains low agricultural productivity. Many activities of natural resource management and watershed treatment (soil and water conservation, water harvesting, construction of feeder roads) are now financed through the Safety Net Programme. Reportedly, the programme is more or less replacing the previous Employment Generation Schemes (EGS).

2.3.11 Rural Land Administration and Land Use Proclamations

Several federal and regional proclamations have been issued, among which:

- Federal Rural Land Administration Proclamation (No 89/1997)
- Federal Rural Land Administration and Land Use Proclamation (No 456/2005)
- Amharic Proclamation issued to determine the Administration and Use of the Rural Land (No. 46/2000)
- (a similar proclamation has been issued for Tigray but is not available in English).

The federal proclamation focuses on tasks of land management to be taken up by the regions. All proclamations (federal and regional) describe the rights and obligations of users of rural land, including traditional subsistence farmers, and in the more recent proclamations, also of private commercial farmers.

A breakthrough in land use rights has started in ANRS, where the proclamation stipulates that

- “a book of ownership shall be prepared by the relevant organ”,
- “peasants (individual or in communal holding) have the obligation to have a book of ownership”,
- “redistribution of land shall not be effective unless otherwise the land distribution does not affect the productive capacity, requested by the community, supported by the study and decided by law”.

The recent (2005) federal proclamation demonstrates the government’s concern about land degradation and its commitment to combating the problem. Most importantly in the current context, it defines obligations of rural land users, and land use restrictions. Thus, protection of land becomes an obligation and failure to protect can lead to loss of title. Free grazing in areas with SWC is prohibited and appropriate SWC measures are required for all lands of <30% slope. Cultivation on slopes of 31-60% slope requires bench terraces. Closure of degraded lands, and compensation for prior users is provided for. A minimum holding size is referred to, but is to be determined by the Regions.

In principle, the proclamation is a positive move; the possibility to enforce it in practice is yet to be seen. Some rules for proper use of land are defined in a simplified but yet rather rigid way. For example, the rule that “degraded lands of any slope shall be closed from human and animal interference” would preclude future exploitation on a more sustainable basis (cut and carry). Others are very general and need further specification, e.g. “users should protect and develop the productive capacity, biodiversity in rural wetlands shall be conserved”.

2.3.12 Ethiopian Water Resources Management Policy (1999)

The overall goals of the national water resources management policy of Ethiopia is to enhance and promote efforts towards an efficient, equitable, and optimum utilization of the available water resources and contribute to the country's socioeconomic development on sustainable basis.

The Water Resources Management Policy includes a Water Sector Strategy, which covers certain elements of watershed management under its different components:

- under Water Resources Development: water harvesting

- under Water Resource management: soil and water conservation measures to reduce soil erosion and reservoir siltation; local community participation in watershed management and water conservation measures and practices; a recognition of wetlands as a key feature in watershed management.

2.3.13 Water Resources Management Laws

(i) The National Proclamation on Water Resources Management (2002)

The basic thrust of this proclamation is that water resources management and administration in the country should be based on the National Water Policy, the Integrated River Basin Master Plan Studies (IRBMPs) and the Water Resources Laws of the country. MoWR is clearly identified as 'supervising body' in charge of enforcing the provisions of the proclamation. It is entrusted with broad powers of 'planning, management, utilisation administration and protection of water resources'.

Among MoWR’s duties are inventory of water resources, allocation of water resources, establishing standards for design and construction of waterworks, issuing guidelines and directives for the prevention of pollution of water resources as well as for water quality and health standards, establishing water users' associations, and settlement of disputes. Details of most of the provisions of the Proclamation are expected to be provided in Regulations to be issued in the future. Issues that still need to be tackled are e.g. the integrated cross-sectoral approach to water resources management including environment, agriculture, economic activities at large, health, legal and planning considerations, as well as a specific participation of water users. This is a necessary step towards 'integration' in WRM.

(ii) Water Resources Management Regulations (2004)

The regulations contains a further elaboration of the Proclamation providing in detail the main requirements for the issuance of permits for different uses of water and the conditions for the issuance, as well as the level of water charge and procedure for licensing water operators.

(iii) Regional Water Resources Management Policies and Laws

In 2002, the Oromiya Regional State has issued a Regional water resources policy. A draft regulation for the management of water resources has also already been prepared by that Region. By and large, both the water resources policy and draft regulations for water resources management of the Oromiya Regional State are in line and similar in their content to those issued by the Federal Government.

2.3.14 Environmental laws

Environmental issues are given more and more emphasis in Ethiopia, with the recent development of a set of laws, following up on several new policies and strategies (such as the National Conservation Strategy and the SDPRP). The Ethiopian Environmental Protection Authority (EPA) has drafted three major laws regarding Environmental Pollution Control, Environmental Impact Assessment and Establishment of Environmental Protection Organs.

Although quite general, these laws, and particularly the “Environmental Pollution Control Proclamation” specifies clearly the function of law enforcement of the EPA and the Regional environmental agencies, in charge of taking administrative or legal measures against violations.

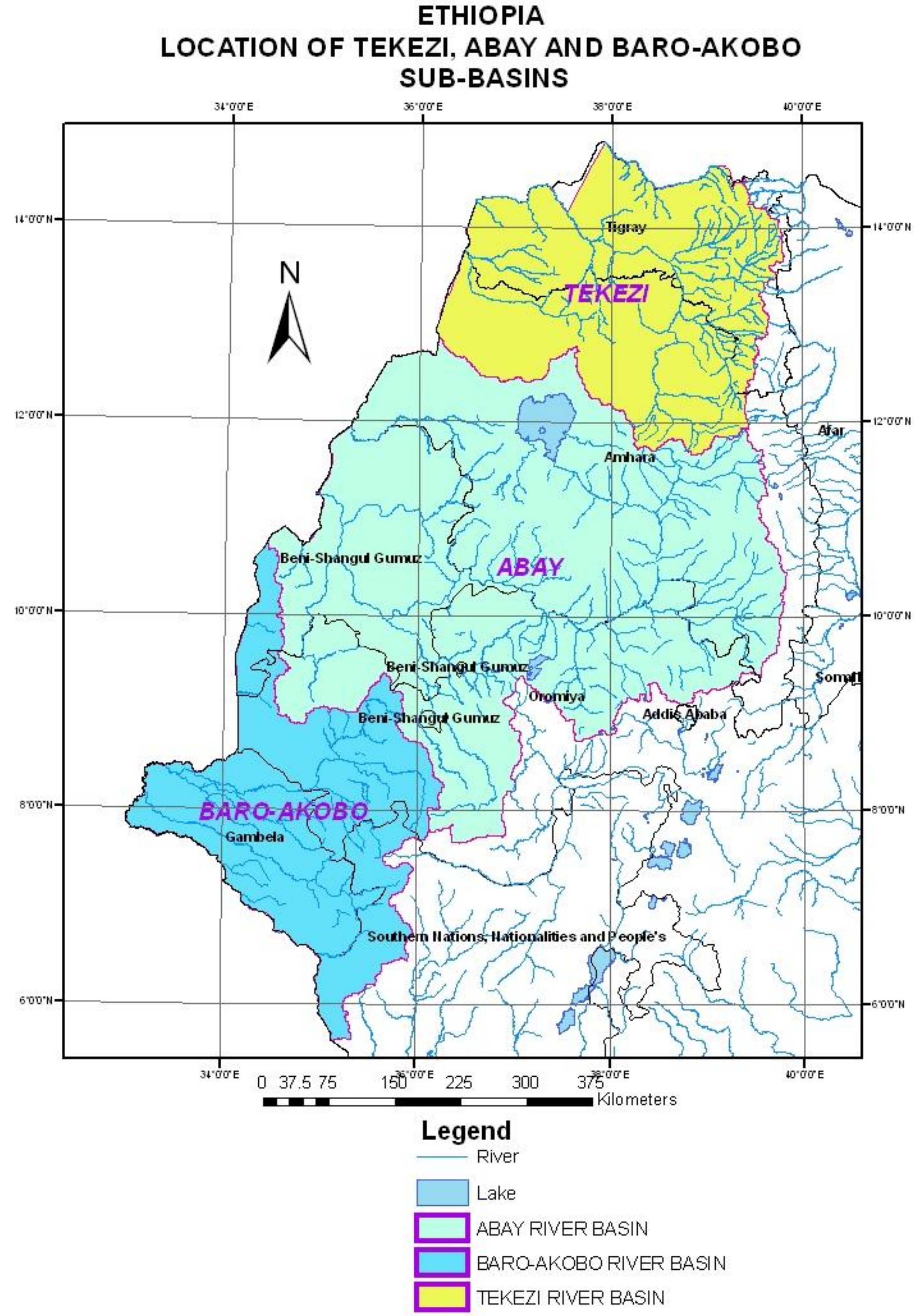
These laws are concerned mainly with pollution, and broader issues such as watershed management are not addressed yet. The need for a more integrated legal framework in line with IWRM or sustainable use of natural resources is noticeable.
According to the 2005 PASDEP document, EPA has now also developed EIA guidelines for agriculture, mining, industry, and road construction. It has assisted all regions to establish a regional EPA. ANRS, ORNS as well as TNRS are said to have developed regional environmental laws.

A key issue is how to get some action on the ground by agencies at the wereda level using a collaborative and not a "legal enforcement" approach.

2.4 Eastern Nile Basin in Ethiopia

The Eastern Nile Basin in Ethiopia comprises the Tekezi, the Abay and the Baro-Akobo river systems. The basins are located in the northwestern, western and southwestern parts of the country (see map 4). The area of each basin and total area within Ethiopia are as follows:

Tekezi/Atbara	-	88,501km2
Abay	-	202,989km2
Baro-Akobo	-	75,856Km2
Total	**-**	**365,137km2**



Map 4. Location Map of Baro-Akobo, Abay and Tekezi Basins

Areas above 1,500 masl (classed as "highland") cover the eastern two thirds with the lowlands extending westwards into Sudan. The highlands are underlain by Trapp basalts in the Abay and southeastern part of the Tekezi basin, with limestones, shale's, sandstones and basement complex rocks on the northern part of the Tekezi Basin and in the western lowlands.

The total estimated population (2000) of the three basins is as follows:

Tekezi/Atbara basin	-	5,878,655
Abay basin	-	21,746,130
Baro-Akobo	-	2,625,062
Total	**-**	**30,249,847**

Administratively the basins lie within four regional States:

Tigray (part)	-	44,902 km2
Amhara (part)	-	136,397km2
Beneshangul-Gumuz (total)	-	50,141 km2
Oromiya (part)	-	97,953km2
Gambela (total)	-	31,872 km2
TOTAL		361,265

2.5 Overview of Situation and Issues

The country's population is currently approximately 64 million. The rate of population growth is expected to decline from 3 to close to 2 percent per annum by 2030, when the country's population will reach between 120 to 130million people. Some 85 percent reside in the rural areas and most are dependant on agriculture or pastoralism for their livelihoods[4].

The high seasonality of rainfall over the Ethiopian Highlands, which is confined to a period of three to five months results in commensurate seasonality in river flows. The peak flows are able to transport very high sediment loads during these periods and lead to the high sedimentation rates in Sudan and Egypt.

The highlands of the Tekezi River Basin and the northeastern eastern highlands of the Abay River Basin contain many areas with structural food deficits which suffer frequent reductions in crop production due to low rainfall. The key issues are soil degradation, livestock feed deficits, fuelwood wood consumption rates in excess of sustainable yield, burning of dung and accelerated soil nutrient breaches and poor non-farm employment opportunities[5]. Nevertheless, in recent

[4] Alemneh Dejene (2003) "Integrated Natural Resources Management to Enhance Food Security: The Case for Community-based Approaches in Ethiopia", FAO, Rome.

[5] Hagos, F.J, J. Pender and N. Gebreselassie (1999) "Land degradation in the highlands of Tigray and strategies for sustainable land management", Socioeconomic and Policy research Paper No. 25, ILRI, Addis Ababa.

years the uptake of soil and water conservation measures has been impressive and in many areas of Tigray the rate of adoption exceeds 40 percent of farmers[6]. This has been mainly due to the visible impacts of the increase in soil-water conservation, risk reduction and significant crop yield increases. Communal grazing land management systems are in place in 80 percent of the villages. On-farm tree planting however lags behind that in the Amhara Region, possibly due to a ban on tree planting in croplands.

The western highland areas of the Abay Basin are also long settled but they enjoy higher and more stable rainfall supply. There are large areas of relatively shallow slopes with Vertisols and higher fertility Nitisols. On areas with steeper slopes soil erosion is a major problem, although over many areas soil nutrient depletion is a more critical problem[7]. This is because higher crop yields and sales of crops lead to higher outflows of soil nutrients. Livestock feed deficits are acute during the wet season when crops are in the ground and large areas of bottomland grazing are flooded.

Since 1991 these areas has seen a massive increase in on-farm tree planting (almost entirely of *Eucalyptus* spp.), driven mainly by the big increase in the market for construction poles. This has been due to the building boom and facilitated by the change in government policy allowing farmers sole use rights over trees on their farms and the abolition of the government monopoly on the sale of poles[8]. However, there are indications that the market for poles may be becoming saturated. Some 80 percent of trees are planted around the homestead and thus do not adversely affect crops.

However, the scale of planting gives rise to concern on the high water use by Eucalyptus and the possible impact it has on groundwater recharge in areas of lower rainfall. For example in Tigray a Eucalyptus woodlot planted in a valley bottom between 1950 and 1960 dried out a swamp and the surrounding soil. This in turn led to deep cracks in the Vertisols which in turn led to tunneling, collapse and the formation of a large gully[9].

In the western lowlands population densities are low, soils are relatively infertile and acidic being derived from Basement Complex rocks, malaria is prevalent and typanosomiasis occurs in the Beles, Abay, Didessa and Dabus valleys below 1,500 masl. Few livestock are kept and bush fallowing is widespread cultivating

[6] See figure 3 "Terracing in the Ethiopian Highlands", in Mahmud Yesuf & J. Pender "Determinants and Impacts of land management Technologies in the Ethiopian Highlands: A Literature Review - Draft", EEPFE and IFPRI.

[7] Desta L et al (2001) "Land degradation in the Highlands of Amhara region and strategies for sustainable land management", ILRI, Livestock Policy Analysis Programme, Working Paper No. 32, Addis Ababa.

[8] WBISPP (2002) "Amhara Region: A Strategic Plan for the Conservation and Sustainable Management of Woody Biomass Resources", MoANR, Addis Ababa.

[9] Nysssen, J et al (2005) "Assessment of gully erosion rates through intervews and measurements: a case study from northern Ethiopia", Earth Surface Processes and Landforms 30.

mainly sorghum. Slopes are relatively gentle and as the land is open for only two or three years soil erosion is not a major problem. Locally, increasing population and the shortening of bush fallow periods below the optimum is leading to soil degradation (soil nutrient decline and acidification). Fires during clearing for cropland often spread considerable distances reducing surface litter and soil organic matter. Mortality of young trees is high leading to a progressive degradation of the woodland. Large areas of Lowland Bamboo occur across the area, but these are under considerable pressure from cultivation and unsustainable extraction. These Lowlands are also important for the harvesting of resins.

The western Lowlands with their low population densities are seen as an area of potential for agricultural expansion. The area around Humera was the first to be developed in the 1960's mirroring developments taking place across the border in Sudan. A large state farm was developed in the late 1970's in the Didessa Valley and a large resettlement scheme developed in the Beles Valley at the same time. The state farm was abandoned because of declining yields. Currently the western Lowlands are being developed in an ad hoc manner for private large-scale semi-mechanized farming.

The proximate causes of infield soil erosion are reasonably well known although the science of the linkages between erosion and deposition in the landscape, sediment delivery to streams and total sediment yields with increasing basin size is less certain. An understanding of the underlying causes is still imperfectly understood, notwithstanding the impressive amount of research work undertaken over the past decade, particularly with the African Highlands Initiative[10]. Underlying many of these is the almost total dependence on the natural resource base by the rural population. The results of research to-date may be briefly summarized as:

- The profitability of land management technologies is very important, though not the only factor influencing adoption or non-adoption.

- Risk is also a very important consideration. Profitability becomes more important for technologies that are risk increasing (e.g. chemical fertilizer) than those that are risk reducing (SWC investments in moisture stressed areas).

- In the context of imperfect markets and institutions the suitability and feasibility of land management interventions in different locations and farmer circumstances are very context dependant making generalisations difficult. The numerous potential factors include: agro-ecological conditions; nature of the technology; land

[10] J.Pender (2005) "Annex 1: Concept Note for Proposed Research Project – Poverty and Land Degradation in Ethiopia: How to Reverse the Spiral? Concept Note", in Report on Stakeholder and Technical Workshops on the proposed Applied Research Project:, May 31st 2005, Addis Ababa.

tenure relations; household endowments of natural, human, social and financial assets. Better market access appears to be associated with less SWC investment but more use of fertilizer.

- Land tenure insecurity and limited transfer rights appear to discourage land management investments, but the results are mixed. It appears to have less impact on the adoption of inputs (e.g. fertilizer) than long-term investments (e.g. SWC structures).

- The impact of the degree and type of household livelihood assets on investment decisions is mixed.

- The Malthusian argument of the negative impacts caused increasing population pressure, and Boserup argument for population induced agricultural intensification may both be correct in the Ethiopian situation. Farmers do respond to population pressure with intensified production, but this may not be sufficient to prevent resource degradation and increasing poverty. In this respect, Ethiopia compares poorly with the situation in Machakos, Kenya described by Tiffen et al (1994)[11].

[11] Tiffen, M et al (1994) "More People, Less Erosion: Environmental Recovery in Kenya", ACT Press, Nairobi.

3. AGRICULTURE AND FORESTRY IN THE EASTERN NILE BASIN

3.1 Irrigation and drainage development:

3.1.1 Evolution of irrigation development:

River basin master plan studies and related surveys indicate a maximum irrigation potential of about 5.7 million ha, but about 3.7 million ha is commonly quoted. The irrigation potential of Sub-basins within the Eastern Nile Basin is at present estimated at about 1.3 million ha, considering the availability of water and land resources, technology and finance (Table 2).

Table 2. Area and annual runoff by for the Eastern Nile Sub-basins in Ethiopia.

River Basin	Area (ha)	As % of Total area	Annual Runoff (km3/yr)	As % of Total runoff
Abay (Blue Nile)	20,298,900	54%	52.60	62%
Baro-Akobo	7,585,600	20%	23.60	28%
Tekeze/Atbara	8,850,100	24%	7.63	9%
Mereb	590 000	2%	0.72	1%
TOTAL	**37,324,600**		**84.55**	

(Source: Water Sector Development programme Reports, 2002)

Table 3. Economical irrigation potential irrigated area by river basin

River Basin	Area (ha)	As % of total area	Economical Irrigation potential (ha)	As % of total potential	Irrigated area (2001) (ha)	As % of total irrigated area	As % of economical irrigation potential
Abay (Blue Nile)	20,298,900	54%	523,000	40%	47,020	56%	9%
Baro-Akobo	7,585,600	20%	600,000	46%	13,350	16%	2%
Tekeze/Atbara	8,850,100	24%	189,000	14%	24,270	29%	13%
Mereb	590,000	2%	500	0%	0	0%	0%
TOTAL	**36,881,200**		**1,312,500**		**84 640**		**6%**

(Source: Preliminary surveys and Master Plans of river basins).

Irrigation in Ethiopia dates back several centuries, if not millennia, while “modern” irrigation was started by the commercial irrigated sugar estate established in the early 1950s by the Imperial Government of Ethiopia and the Dutch company known as HVA-Ethiopia. Recent sources indicate that the area equipped for irrigation was nearly 290 000 ha in 2001, which is 11 percent of the economical irrigation potential of 2.7 million ha. Some irrigation schemes are not operating to their full potential and some are not functional at all due to factors related to shortage of water, damaged structures and poor water management. On the other hand, some farmers are extending canal networks in some modern irrigation projects. Therefore, the area under irrigation can be considered more or less similar to the area equipped for irrigation.

3.1.2 Categories of irrigation schemes

Four categories of irrigation schemes can be distinguished (Table 4):

- Traditional irrigation schemes
- Modern small-scale irrigation schemes
- Modern private irrigation
- Public irrigation schemes

Traditional irrigation schemes: These schemes are constructed under self-help programmes carried out by farmers on their own initiative and vary from less than 1 ha to 100 ha. The total irrigated area is estimated to be about 138,000 ha and about 572,000 farmers are involved. Traditional water committees, locally known as "water fathers", administer the water distribution and coordinate the maintenance activities of the schemes. Traditional irrigation is also very common in peri-urban areas, particularly in Addis Ababa and Bahir Dar, for the production of vegetables for the local market. The major drawback of traditional irrigation schemes is related to unstable headworks and faulty systems of irrigation stemming from lack of technology and knowledge.

Modern small-scale irrigation schemes: These schemes use technologies for irrigating up to 200 ha and are constructed by the government/NGOs with farms participation. They are generally based on direct river diversions but they may also involve micro-dams for storage. The area equipped for irrigation in 2002 was about 48,300 ha and about 74,100 farmers were involved. The operation and maintenance of the schemes are the responsibility of the water users, supported by the regional authorities/bureaus in charge of irrigation development and management. Water Users Associations (WUAs) are formally established in some schemes but traditional water management dominates in most of the modern schemes.

Modern private irrigation: Private investment in irrigation has recently re-emerged with the adoption of a market- based economy policy in the early 1980s. Virtually all irrigated state farms were privately owned farms until nationalization of the private property in the mid 1970s. At the end of 2000, private investors had developed about 5,500 ha of irrigated farms, distributed in Afar (37 percent), Oromiya (48 percent) and the Southern Nations, Nationalities and People's Region (SNNPR) also known as the Southern Region (15 percent).

Public irrigation schemes: These schemes comprise medium- and large-scale irrigation schemes with areas of 200-3,000 ha and above 3,000 ha respectively and a total estimated area of about 97,700 ha. They are constructed, owned and operated by public enterprises. These schemes are concentrated along the Awash River Course and were constructed in the 1960s-70s as either private farms or joint ventures. No such schemes have been developed for the last 7-8 years.

Table 4. Irrigated area by region (Source: MoWR, 2003).

Region	Traditional small-scale irrigation	Number Of farmers	Modern small-scale irrigation	Number Of farmers	Private small-scale irrigation	Medium-& large-scale Public irrigation	Total irrigation	As % of total irrigation
	(ha)	**(No)**	**(ha)**	**(No)**	**(ha)**	**(ha)**	**(ha)**	**(%)**
Addis Ababa	352	8 608	0	0	0	0	352	0.12
Afar	2 440	16 640	0	0	2 000	39 319	43 759	15.11
Amhara	64 035	384 210	5 752	17 166	0	0	69 787	24.11
Beneshangul-	400	2 000	200	170	0	0	600	0.21
Gumuz	640	1 536	860	2 696	0	0	1 500	0.52
Dire Dawa	46	373	70	280	0	0	116	0.04
Gambela	812	558	125	71	0	0	937	0.32
Hareri	56 807	113 614	17 690	61 706	2 614	35 376	112 487	38.85
Oromiya	2 000	2 700	11 577	45 000	800	20 308	34 685	11.98
SNNPR	8 200	16 400	1 800	7 000	0	2 700	12 700	4.39
Somali	2 607	25 692	10 000	40 000	0	0	12 607	4.35
Tigray								
Total	**138 339**	**572 331**	**48 074**	**174 089**	**5 414**	**97 703**	**289 530**	**100.0**

About 62 percent of the area equipped for irrigation is located in the Rift Valley, while 29 percent of the area equipped for irrigation is located in the Nile basin. The remaining 9 percent is located in the Wabe-Shebelli basin. Region-wise, about 39 percent of the irrigated area is in Oromiya in central Ethiopia, followed by 24 percent in Amhara in the north, 15 percent in Afar in the northeast and 12 percent in SNNPR, while the remaining 10 percent is in the other regions.

Nearly 100 percent of the irrigated land is supplied from surface water, while groundwater use has just been started on a pilot scale in East Amhara. Sprinkler irrigation is practiced on about 2 percent of the irrigated area for sugar cane production by government enterprises, while localized irrigation has recently started in the Tigray and Amhara regions. Pump irrigation by a group of farm households and private farms is practiced in some areas, while human-powered (treadle pump) irrigation has also recently started in the Tigray and Amhara regions. Though quantitative information is not available, spate irrigation and flood recession cropping are practiced in the lowland areas of the country, particularly in Dire Dawa, Somali, East Amhara and Tigray in the eastern and northeastern parts of the country.

3.1.3 Role of irrigation in agricultural production, economy and society.

Both irrigated and rainfed agriculture is important in the Ethiopian economy. Virtually all food crops in Ethiopia come from rainfed agriculture with the irrigation sub-sector accounting for only about 3 percent of the food crops. Export crops such as coffee, oilseed and pulses are also mostly rainfed, but industrial crops such as sugar cane, cotton and fruit are irrigated. Other important irrigated crops include vegetables and fruit trees in medium- and large-scale schemes and maize, wheat, vegetables, potatoes, sweet potatoes and bananas in small-scale schemes. There is a marked value added in irrigated agriculture. A case study carried out in 2001 estimated that average yields of cereals under irrigation and rainfed conditions are 1.75 and 1.15 tons/ha respectively. The same study indicated that production costs per ha were US$90 for cereals, US$60 for pulses and US$290 for vegetables, while the corresponding gross incomes per ha were US$ 345, US$215 and US$1 870, respectively.

Supplementary irrigation is widely practiced in all irrigation categories, although separate quantitative information on the area supplied with supplementary irrigation is not available. The areas under traditional and small-scale irrigation systems are supplied with full irrigation during dry periods and with supplementary irrigation when the rain comes late or withdraws early, or when there is inadequate rainfall.

Rainfed farming has always been the main livelihood for most Ethiopian people and it is supported by traditional water harvesting practices particularly in central-north, eastern and southeastern areas of the country.

3.1.4 Status and evolution of drainage systems:

Drainage is as important as irrigation, particularly in the highlands of Ethiopia. However, except in irrigated lands, drainage is not given the required attention in rainfed agriculture where farmers construct traditional drain ditches commonly diagonal to the main slope of the farmlands. Because of irregularity in cross-sections and longitudinal slopes as well as inadequate capacities, the drains are usually converted to gullies if the same drains are adopted year after year. To avoid this happening, drain lines are changed every year. Designs of small-scale irrigation schemes incorporate drainage systems but these are not properly implemented. The typology of the drainage system used in the country is the surface drainage system (gravity drainage).

3.1.5. Water management (WM):

Medium and large-scale irrigation schemes are managed by government enterprises. The water management of small-scale irrigation schemes is the responsibility of the farmers themselves, mainly through informal/traditional community groups. Some formal Water Users Associations (WUAs) have been established. Apart from the provision of extension and training services to the WUAs on the part of the MoA/BoA, no institution is directly involved in water management in smallholder-irrigated agriculture. Once the construction of irrigation schemes is completed, they are handed over to the beneficiaries but maintenance remains within the responsibility of the regional governments. The absence of any appropriate local-level organs to cater for small-scale irrigation has resulted in a lack of guidance in irrigation operation and maintenance at a community level.

With an increase in irrigated areas and more users, irrigation water management and rules for water allocation are becoming more complex and problematic. Disputes are already common, especially between upstream and downstream users. A decentralization process is under way with regional and lower level administrative organs which are becoming more autonomous in aspects related to irrigation development and water management. The strategy is to establish WUAs before projects are implemented and to strengthen them through both training and involvement in the process so that they can take over the responsibility of operation and water management when construction is completed.

3.1.6 Finances of Water Development:

Funding for water development activities is determined by the federal or regional government. The irrigation authorities have financial autonomy only over their approved and allocated budget. So far, neither cost recovery nor irrigation charges have been considered in irrigation development. However, in some cases beneficiaries have been contributing to development of some small-scale irrigation schemes by providing free labour for up to 10 percent of the investment.

The 15-year National Water Sector Development Programme, presented in 2002, envisages cost recovery or cost-sharing mechanisms, in which case financing for small-scale irrigation development projects will come from the regional governments (45 percent), beneficiaries (20 percent), multilateral and bilateral sources (20 percent), NGOs (10 percent) and private investors (5 percent). Similarly, medium- and large-scale irrigation development will be covered by the federal government (40 percent), multilateral and bilateral sources (40 percent), beneficiaries (10 percent) and private investments (10 percent). Obviously, there is a long way to go to establish a cost-sharing system because most beneficiaries have not even contributed to the operation and management of the existing schemes, left alone to construction costs. In some small-scale irrigation schemes, though, beneficiary communities collect irrigation charges for covering minor maintenance costs, each beneficiary paying the same amount irrespective of farm size or quantity of water consumed.

A Water Resources Development Fund (WRDF) has been established recently within the MoWR to serve as a public financial intermediary dedicated to financing the water supply and sanitation services and irrigation development through the provision of a long-term loan to groups meeting established criteria and based on the principles of cost recovery. The WRDF, which finds funds from donors, is a nucleus for the development of a financially autonomous institution for water resources development through a cost recovery system.

3.2 Agriculture Production

3.2.1 Inputs Use

Use of improved inputs, fertilizer and improved seed is very low. Total national fertilizer consumption in the years 1996-1999 are shown in table 5.

Table 5. Ethiopia: Fertilizer Consumption for 1996 – 1999.

1996			**1997**			**1998**			1999		
DAP	**Urea**	**Total**	**DAP**	**Urea**	**Total**	**DAP**	**Urea**	**Total**	**DAP**	**Urea**	Total
209,883	43,169	253,152	163,603	51,808	220,431	193,395	87,976	281,371	193,345	94,919	290,264

The use of improved inputs by Region is shown in table 6.

Table 6. Use of Improved Inputs by farmers by region.

Region	% crop area: Improved seed	% crop area: Pesticide	% crop area: Fertilizer	Amount fertilizer applied/farmer (kgs)
Tigray	0.9%	1.3%	35%	25.4kgs
Amhara	2.2%	1.3%	27%	22.4kgs
Oromiya	3.3%	1.4%	45%	32.0kgs
BSG	1.3%	0.4%	11%	4.2kgs
SNNPR	1.5%	2.5%	6%	12.7kgs
Gambela	0%	1.0%	1%	1.5kgs

Generally, improved inputs are used more frequently in Oromiya and Tigray Regions and least in Gambela and BSG Regions. This is partly a reflection of accessibility, partly to the degree of marketed crops that are cultivated. Interestingly, Tigray despite the potential problems of the variability of soil moisture has a relatively high proportion of crops fertilized. Nevertheless, rates of fertilizer use are well below the recommended rates.

3.2.2 Crop Production

Despite significant variations between agro-climatic locations and crops, Ethiopia's agriculture over the past two decades is characterized by low productivity with little improvement in aggregate yields. Of the total area under major crops in the 1990s, cereals and oilseeds accounted for 88.7 percent, 8.7 percent, and 2.7 percent, respectively. Over the 1980-2000 period, trends in area under cultivation and the volume of grain production were positively related. In the 1980s, there was a flat trend compared to the post-1995 period, when both production and area under cultivation have jointly increased. Thus, average yields for cereals, which comprise 80 percent of total grain production, remain in the vicinity of 1.1 to 1.2 tons per hectare, one-fifth the yield achieved in the Asian Green Revolution (World Bank, 2004).

Agricultural production trends throughout the 1980s up to the mid-1990s were characterized by wide fluctuations in total output and weak growth, with grain production increasing at a rate of 1.37 percent annually compared to population growth of 2.9 percent. Throughout the 1980s, production growth was constrained by: "a repressive policy regime, which included the nationalization of all private commercial farms; suppression of private sector investment, involuntary collectivization, enforced quota deliveries of grains at low prices; and restrictions on grain movement from surplus to food-deficit areas (Kuma, 2002)." Since the mid-1990s, total annual production levels increased substantially from an annual average of 6.7 million metric tons in the 1980/81-1994/95 period to 9.3 million metric tons in the 1995/96-1999/00 period (Table 3.1). In 1995/96 and 1996/00, estimated cereal production reached peak levels of 10.3 and 10.4 million metric tons, respectively (CSA, Annual Abstract 2001).

However, the increase in production was mainly due to the advent of good weather, except for the occurrence of drought in 1993/94 and the El Nino effect in 1997/98; appropriate policies and strategies of the government; and increased use of agricultural inputs such as fertilizer, improved seeds, chemicals, and herbicides. In terms of yields, maize is the only grain with significant changes in yields over the period, reaching up to 2 tons per hectare in 1995/96, while total grain yields per hectare for total grains have remained between 0.9 and 1.4 tons per hectare for the last two decades.

3.2.3 Crop Yields and Productivity:

Trends in crop yields vary considerably among the major farming systems. Data in Table 7 for the growing season 2005 show that all crop yields are low. In addition, the absolute yield levels are generally low by international standards.

Table 7. Ethiopia: Area Production, and Yields of Grain, 1980-2000

Period (5 years)	Area (000 ha)	Production (000 MT)	Cereals Yields (tons/ha)	Maize Yields (tons/ha)	Teff Yields (tons/ha)
1980/81-1994/95	6009	6750	1.2	1.5	0.8
1995/96-1999/00	8439	9315	1.2	1.9	0.9

Source: Central Statistical Authority, 2001.

If one examines yield of rainfed sorghum (the most important food crop in Ethiopia), the trend has remained stagnant or has declined during the last decade. The trends in Table 8 reveal the decline in yields and minimal differences between average sorghum yields in the fertile areas and the less fertile traditional farming areas. The reasons need to be explored but they almost certainly include (i) a reduction in fertility in areas that have been continually cropped for decades in the areas without fallow and no conservation practices; ii) the well-documented expansion of sorghum cultivation into marginal areas where the probability of substantial destruction of soil structure, soil erosion, and hence low yields is close to 100 percent; and (iii) in the traditional rainfed subsector, particularly, the low yields reflect a serious lack of support services such as research, extension, high yielding varieties, certified seeds, pest and weed control, fluctuation of rain fall and lack of credit for smallholders.

Table 8. Average yield (T/ha) and yield % of main crops in Ethiopia as compared to World average, 2005.

Crop	Ethiopia	World*	
	Ton/ha	%	
Wheat	1.37	47	2.91
Rice, Paddy	1.85	46	4.02
Barley	0.99	40	2.44
Maize	1.95	41	4.72
Oats	0.92	45	2.02
Sorghum	1.33	101	1.31
Potatoes	10.53	61	17.20
Sweet Potatoes	10.00	68	14.78
Yams	4.2	47	8.97
Beans, Dry	0.73	102	0.71
Broad Beans, Dry	1.13	63	1.78
Peas, Dry	0.75	49	1.71
Chick peas, dry	1.02	126	0.81
Lentils	0.61	60	1.01
Vetches	1.00	83	1.20
Pulses	0.54	62	0.86
Soybeans	3.6	157	2.29
Ground nuts	1.05	41	2.52
Castor Bean	1.5	151	0.99
Rape seed	1.15	66	1.72
Safflower	0.53	57	0.95
Sesame	0.7	159	0.44
Seed Cotton	1.01	53	1.92
Linseed	0.51	59	0.86
Oil seeds	0.42	33	1.27
Cabbage	10.13	46	21.68
Tomatoes	12.5	45	27.47
Onions	12.9	56	23.14
Garlic	14.8	115	12.88
Carrots	7.14	33	21.91
Vegetables Fresh	2.75	20	13.88
Bananas	16.0	252	6.33
Oranges	7.27	44	16.65
Lemons & limes	6.4	41	15.55
Mangoes	12.27	167	7.32
Avocados	7.76	94	8.21
Papayas	20.91	120	17.35
Tropical Fruits	7.0	97	7.22
Veg. + Roots Fodder	10.0	45	21.99
Coffee, Green	0.93	127	0.73
Tea	0.97	73	1.33
Pepper	0.66	76	0.87
Nutmeg, Mace	0.33	94	0.35
Anise, etc	0.8	121	0.66
Ginger	4.86	164	2.96
Spices	0.51	36	1.40
Jute-like Fiber	0.5	38	1.31
Fiber Crops	0.8	26	3.10
Tobacco Leaves	0.67	41	1.64

* World yield average = 100%
Source: FAO. 2006. FAO-STAT, Records 456 and 641.

3.3 Livestock production

3.3.1 Livestock Production Systems

All Highland mixed crop-livestock systems are characterized by varying degrees of integration. Crop residues can provide a source of livestock feed, oxen can provide draught power, and cattle can provide manure for cropping. Livestock production objectives also include with varying degrees of importance milk production (for sale or for butter), breeding females for surplus of male animals for sale, and breeding females for supply of oxen, and keeping oxen for draught purposes.

With increasing population pressure there is increasing competition for land between cropping and grazing. As grazing land is converted to cropland, crop residues assume increasing importance as livestock feed. This requires additional labour for harvesting, storing and feeding. The remaining grazing areas also assume an increasing importance as a source of livestock feed. Although most communal grazing areas in ARS are open without restriction, in a few areas, valley bottoms in particular are increasingly subject to grazing management. In many cases hay production is extremely important. Dry season access to these lands is increasingly strictly controlled. In some areas, even the relatively poorer grazing on hillsides is becoming subject to grazing rules.

The situation is extremely dynamic and grazing management systems and sources of livestock feed are often changing quite rapidly. In areas close to the larger urban centres and in favourable locations along the main livestock trade routes, there is increasing specialization of livestock production. In and around the major urban centres dairying is becoming very important.

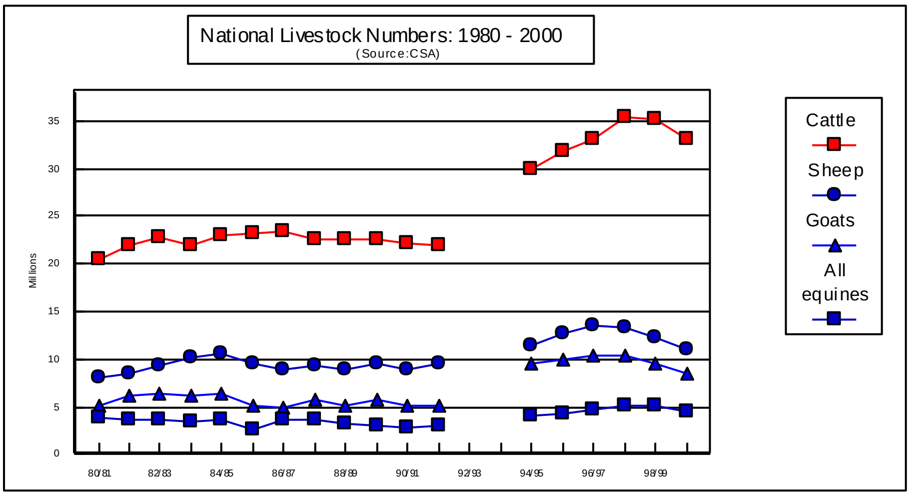
In summary:

- With increasing pressure on land and competition between cropping and grazing, all sources of livestock feed are increasingly in short supply and thus have more value.
- Communal grazing lands are being subject to increasingly stricter management controls, and in some areas use rights are being individualized.
- Crop residues are assuming an increasing vital component of livestock feed, and commanding increasing inputs of labour for harvesting, transport, storage and feeding.
- In areas of the greatest land pressure on-farm production of forage is largely being adopted.
- In areas favourably located to markets there is increasing specialization in fresh milk production.

3.3.2 Livestock Numbers

Comprehensive, up-to-date and accurate data on livestock types and numbers are extremely difficult to obtain at the wereda level. The last comprehensive livestock census at the wereda level was undertaken as part of the General Agricultural Survey in 1983. The CSA has national/regional data from 1980/81 to 1996/97 (although 1992/93 and 1993/94 are missing) (Figure 4).

Figure 4. Ethiopia: National Livestock Figures: 1980 to 2000



Source: CSA

Between 1980 and 1992 national livestock numbers remained relatively constant, with cattle numbers oscillating between 20 and 23 million. However, in 1994/95 after a break of two years data collection, the CSA data recorded an overall increase of 25% in national livestock numbers and which continued to increase the next two years. Part of this increase can be explained by the full inclusion of the Tigray, Afar and Somali Regions in the surveys since 1994 (approximately 2.5 million cattle out of an increase of 8 million). Improved access and easier survey conditions might explain the rest.

3.4 Agricultural Marketing

3.4.1 Crop Input and Output Marketing:

Farmers bring their grain to markets 5 to 20 kms from their villages, with about 80 percent of their cash sales occurring immediately after harvest. There is little or no information available to farmers to enable them to determine what crops to plant and hoe much. Grain prices are generally not negotiated in advance and are seldom influenced by cultural or social relations between seller and buyer. Farmers sell to the small merchants or assemblers in the market towns.

Smaller merchants are constrained by lack of financial credit, storage, transport facilities and are subject to a low capital turnover. Because small traders' capital is tied up in inventory the large merchants can exert considerable influence on grain prices in the absence of any competition.

Wholesale traders are the principal agents in inter-regional grain movements[12] buying in surplus markets and selling in deficit markets and to Addis Ababa and regional capitals. They handle about 45 percent of the estimated 2.6 million tons of grain sold annually. This is approximately 28 percent of total annual grain output. At the national level the 10 percent of the largest traders command about 43 percent of wholesale trade.

Brokers are intermediaries between the wholesale traders and the merchants in the main markets (regional capitals and Addis Ababa). There are two types of brokers. The first is involved in storage, paying transport charges for wholesales, remitting money to the wholesaler and arranging return of empty sacks. The second merely facilitates the grains sales at the main market.

However, there is an increasing involvement in grain marketing of large incorporated private enterprises that may change the marketing structure by their superior access to credit, transport and connections with government. These currently control the marketing of fertilizer. Retailers in the towns buy from the wholesalers and sell in smaller quantities to consumers in convenient locations.

Major constraints identified by all traders are the multiplicity of check points and uncertainty of charges, lack of financial capital, absence of control of unlicensed traders, unavailability of transport services, high transport tariffs, lack of storage facilities at appropriate locations and lack of market information.

There are a number of characteristics of the grain marketing chain. Firstly, there is little transformation along the marketing chain. Bulk grain is sold in unprocessed form. Thus, few market services are provided by the intermediaries in the chain. Secondly, it is common to change the sack at any point in the chain where there is a change of ownership, thereby increasing the costs. Allied to this, there is a complete absence of a system of grading for grain. Consequently, traders generally trade with people they know, thus restricting the size of the market. Finally, one third of grain traded is sold by producers directly to consumers.

[12] Gebremeskal Dessalegn et al (1998) "Market Structure, Conduct and Performance of Ethiopia's Grain Markets", Working Paper 8, Grain Market Research project, MEDAC, Addis Ababa, January 1998.

3.4.2 Livestock Marketing:

Livestock markets function at three levels: primary, secondary and terminal markets. Primary markets are located at the village level with a supply of less than 500 head, where producers (farmers and pastoralists) sell to small traders, other farmers and pastoralists (replacement animals) and local butchers[13].

Secondary markets are trader and to some extent butcher dominated markets, with an average weekly volume of 500 -1,000 head, consisting of finished, breeding and draught stock. These are located mainly at the Regional capitals. Though they serve local consumers, they mainly feed the terminal markets. The secondary markets also supply live animal exporters and meat processors. The primary markets are located in the large urban centres of Addis Ababa, Dire Dawa, Dessie, Nazereth and Sidama. They are dominated by medium to large scale traders. Weekly throughput exceeds 1,000 head a week.

Supply of livestock to the primary, secondary and terminal markets is through trekking. Traders and producers use traditional stock routes. Cattle are walked 35-40 kms and shoats 15-25 kms a day. Staging points are chosen according to customary practices. A 1995 study indicated that costs of a 100 kms trek are EBirr1.15 per cattle and Ebirr0.16 per shoat. Weight losses of about percent (18-40 kgs/head/trip) occur over a 7-8 days trek. Trucking is limited to large scale traders who purchase at distant primary and secondary markets to supply the terminal markets.

Farmers come to markets with no prior knowledge of prices and may take back animals if the price is too low. However, pastoralist who may have trekked some distance take what price is available.

3.5 Agricultural production and market limits

The situation of agricultural production and market limits was already discussed in the Main Report of the Abay River Basin Master Plan (MoWR, 1998)[14], a summary of which is quoted below.

"In terms of markets for food grains, Ethiopia is like an island, isolated from potential export and/or import markets by inherently high transport costs, a function of distance and topography. So long as Ethiopia is deficit in grains then, with free trade and open markets, most output is sold locally. If Ethiopia had a persistent food surplus, then farm gate prices would remain low. If Ethiopia remains on the margin of self-sufficiency, swings between import

[13] Yacob Aklilu (2002) An audit of the Livestock Marketing Status in Kenya, Ethiopia and Sudan, vol. 1., C.A.H.P.E.U. Pan-Africa Program for Control of Epizootics, Nairobi.

[14] MWR (1998) Abay River Basin Master Plan", Addis Ababa.

parity and export parity prices from year-to-year will accentuate seasonal fluctuations, themselves already large given fragmented markets and climatic variability. In surplus years, prices will fall drastically, deterring farmers from adopting high cost inputs in the following year. In deficit years, prices may be high but farmers are still at risk due to climate. Their risks are therefore unbalanced, and their observed reluctance to intensify farming activities is thus not surprising. In self-contained sub-regions that are perennially in deficit, prices will tend to remain high.

The growth of the marketable surplus is thus likely to follow domestic demand since if it exceeds this level, prices will collapse and farmers will respond adversely the following year. Public procurement can offset such swings. However, the impact of climate on rainfed production is such that the costs of ironing out swings completely would be exorbitant and wasteful. Present Government policy is to store food grains to meet the needs of about four million people for a sufficient period (four months?) to allow emergency imports to be arranged. Such a policy provides some price support and implies that Ethiopia must incur higher costs associated with food security than many other countries.

Over time, urbanisation, improved services, the development of infrastructure, rising per capita consumption, and the expansion of local markets, will reduce costs and allow an expansion in the marketable surplus. However, there are no likely conditions under which Ethiopia will have a comparative advantage in the export of basic grains. For a surplus-producing region like the Abay basin, this means that the rise in average productivity is almost certain to remain well below the theoretical potential, unless smallholders diversify into other crops. Another corollary is that commercial production of food grains under mechanised rainfed or irrigated conditions should be discouraged. Such production would aggravate pressures on farm gate prices at the expense of smallholders seeking to market a surplus. In other words, the real constraint on smallholder output is not technical but markets and any developments that depress market conditions will also depress the income-earning efforts of smallholder rainfed farmers.

In food deficit areas, any increase in agricultural output will result in the first place in increased per capita consumption on-farm, and does not alleviate the inability to earn cash. In inaccessible and/or remote areas (e.g. in the lowlands), farmers have no reason to produce more than they can consume even if this is feasible. Thus, only in accessible surplus areas can surpluses be readily marketed. As accessibility improves and markets develop, these areas can expand. Incomes of surplus farmers will, however, be limited by market constraints. And only if alternative sources of growth are developed will it be possible for income increases to be achieved. The only possible source of such growth is economic diversification. Thus, priority must be given to creating the necessary enabling conditions for a rapid process of economic diversification. The Master Plan concludes by saying that Agricultural Development-Led Industrial growth that depends on increasing food output in smallholder agriculture will simply not be enough."

Alleviation of market constraints

Despite positive impact of market reform in the early 1990s, significant constraints to marketing performance remain, among which are mentioned (in several documents of the Ethiopia – Country Economic Memorandum - CEM, 2005): very limited access to finance and modern storage facilities, markets being characterized by inadequate marketing infrastructure and high transaction costs (high cost of transport, storage), high risks, lack of processing linkages, very little legal recourse for contract enforcement, a weak private sector that is under-capitalized and unsupported, weak or missing trade associations as a platform of discussion with policy makers, the inability of the Ethiopian Grain Trade Enterprise to stabilize prices.

Food aid (in kind) is said to play a role in this by its distorting effect in years of marketable surplus at the national level, and the overall unbalanced co-existence of chronic food deficits in some areas and simultaneous localized surpluses in others. Food aid quotas depend on yields in the previous year, which may have negative impact on food producers profit (high food aid import coinciding with high yields results in collapse of prices).

According to the CEM, the road map to improved marketing should lead to markets where buyers and sellers are well coordinated, transaction costs are low, contracts are enforceable, risks are manageable, exchange is impersonal, price volatility is dampened, transaction flexibility is responsive to shifts in demands and supplies and in which, ultimately, the poor benefit.

Market adjustments require a gradual alignment of incentives and behaviours within the context of institutions and social norms. Moreover, efforts require a balance between policy incentives, the broader infrastructural environment, and the development of appropriate market institutions. In short, a road map to improved markets includes an inter-related set of policy changes and investments in three necessary dimensions: **Incentives, Infrastructure** and **Institutions**.

3.6 Forestry and Agro-forestry In the East Nile Basin

3.6.1 Structure of the Forestry Sector

The main components of the sector are industrial timber, poles, construction poles, fuel wood, charcoal and tree products, in particular gums and resins (incense and myrrh). Production estimates for 1992/1993[15] are as follows:

[15] Source: National Policy on the Resource Base, its Utilization and Planning for Sustainability (National Conservation Strategy) Volume I: May 1994.

Table 9. Ethiopia: Wood Products 1992/1993

Type	Unit	Production
Industrial timber	m^3	43,405
Poles	No	30,014
Construction poles	m^3	24,739

Some 2,067 tons of gums and resins were harvested, 65 percent being consumed within the country, the remainder being exported. The official figures do not include timber and poles produced and used outside the official marketing structures, in particular, for domestic use in rural areas.

3.6.2 Types and Extent of Forest Resources with the Eastern Nile Basin

(i) Forests

Friis (1994)[16] and Chaffey (1980)[17] have classified the natural forests of Ethiopia. The basic framework of Friis and Mesfin Tadesse has been used in this report, incorporating some of Chaffey's sub-divisions.

Humid Upland Broadleaved with Aningeria dominant

They are found between 1,500 and 2,600 masl. Mean annual rainfall is between 700 and 2,000 mm and mean annual temperature between 15° and 20° C.
They become more diverse in species from east to west (i.e. with increasing rainfall) and with decreasing altitude (i.e. with increasing temperature). Forests in the Baro catchment are thus floristically richer than in the Omo catchments. Four strata can generally be recognized. The highest stratum is formed by trees 30 to 50 m high, the most important of which are *Aningeria adolfi-friederici, Ficus spp,* and *Syzygium guineense*. Below this is a dense stratum of tree 18 to 25 m high with a wide range of species. The third stratum of small trees and bushes includes *Galinera coffeodes* and *Coffea arabica*. The ground stratum includes *Aframomum korarima*.

In the higher rainfall areas above 2,400 masl on more gentle slopes dense thickets of highland bamboo (*Arundinaria alpina)* occur. It is possible that this is an anthropomorphic sub-climax caused by frequent cultivation. There is

[16] Friis, I (1992) "Forests and Trees of Northeast Tropical Africa", HMSO, London.
[17] Chaffey, D.R. "Southwest Ethiopia Forest Inventory Project: Reconnaissance Inventory of forest in Southwest Ethiopia",. Land Resources Development Centre, Surbiton, UK.

evidence of human disturbance throughout the area and Chaffey considers that all the remaining natural forest is in fact secondary.

The Transitional Semi-Evergreen Forest

This forest is found at the foot of and up the western escarpment overlooking the Gambela Lowlands. Mesfin Tadesse (1990) considers it a separate type of forest from the Lowland Evergreen Forest and the humid Montane Broadleaved Forest.

The Transitional Forest occurs between 500 to 1,000 masl usually in river valleys. At the lowest altitudes it occurs in areas with a high water table. Mean annual temperatures are 20° to 25°C and annual rainfall is about 2,000 mm.

The major tree species are *Aningeria altissima*, *Anthocleista schweinfurthii*, *Ouratea bukobense*, *Celtis philippensis*, *Croton machrostachyus*, *Elaeodendron buchananii*, *Eugenia bukobensis*, *Ficus exasperata*, *Garcinia huillensis*, *Manikara butugi*, *Morus mesozygia*, *Strychnos mitis*, *Trichilia degeana* and *Trilepsium madagascerensis*.

The Lowland Semi-Evergreen Forest

The Lowland Forests are found between 450 and 600 masl. The mean annual temperatures are from 25° to 30ºC and mean annual rainfall 1,300 to 1,800 mm. The Lowland Forest is characterized by the presence of certain species of the Guinea-Congo plant realm. Four strata can be recognized. There is a continuous closed canopy about 15 m above the ground, composed largely of *Baphia abyssinica* in the drier northwest and *Celtis gomphophylla* in the wetter southeast, but with other species occasionally breaking through the canopy. Three species emerge completely from the canopy: *Chlorophora exelsa, Alstonmia boonie* and *Celtis integrifolia.* Below the continuous canopy are smaller trees that form the third stratum the most frequent of which are *Acalypha neptunica, Erythroxylum fisheri, Tapura fisheri* and *Uuaria spp.* The lowest stratum comprises shrubs and herbs.

Riverine Forests

These are varied and have been little studied. Mesfin Tadesse (1990) reports the following common species: *Ficus sycamorus*, *Diospyros mespiliformis*, *Lepisanthes senegalensis*, *Mimusops kummel*, *Phoenix reclinata*, *Tamarindus indica* and *Trichilia emetica*.

Along the major streams and rivers there is generally a narrow band of gallery forest. Both these types of forest are dominated by *F. sycamorus*, together with two other tall trees: *Garcina livingstonea* and *Vepris dainellii*. Other common trees are *Cordia africana, Diospyros spp., Teclea nobilis*, and *T. emitica*.

(ii) Woodland

Combretum-Terminalia (Deciduous) Woodlands

These woodlands are found in the higher rainfall areas, generally with above 750 mm mean annual rainfall in the wetter lowlands of Gambela and BSG Regions. The main type of woodland/shrubland comprises Combretum-Terminalia woodland. Apart from the two dominant species others include: *Oxytenanthera abyssinica, Boswellia payrifera, Lannea schimperi, Anogeissus leiocarpa, Stereospermum kunthianum.*

Boswellia-Comiphora-Acacia (Xerophillous) Woodlands

These are in areas with lower rainfall, generally below 750 mm, mainly in BSG Region. A wide range of species occurs including *Acacia tortilis, A. melifera, Balanites aegyptiaca,* and species of *Acallypha, Barleria, Aerva, and Capparis, etc.* These woodlands contain trees producing valuable gums and resins.

Boswellia-Comiphora-Acacia (Xerophillous) Woodlands

These are in areas with lower rainfall, generally between 750 and 450 mm. A wide range of species occurs including *Acacia tortilis, A. mellifera, Balanites aegyptiaca,* and species of *Acallypha, Barleria, Aerva, Combretum, Terminalia, Capparis, etc.* These woodlands contain trees producing valuable gums and resins. They are found in the lowlands of Wag Hemra, North and South Wello, and North Shewa Zones.

Mountain Woodlands

These woodlands are found at higher altitudes above 2,500 masl. Common species are *A. abyssinica, Protea, Cussonia, Hagenia abyssinica, Erica arborea, and Hypericum.* The major land use in these areas is cereal cultivation, with grazing on the steeper slopes with shallow soils.

(iii) Plantations

Plantations include industrial and fuelwood plantations, as well as community woodlots. Eucalyptrus and Cupressus are the main species. The estimated area of plantation within the Eastern Nile Basin in Ethiopia is shown in table 10.

Table 10. Ethiopia: Estimated area of Industrial and Community Plantations by Region

Region	Industrial	Fuelwood	Community
Tigray	500		**n.k.**
Amhara	44,550	8,048	**66,211**
BSG	1,100		**300**
Oromiya	22,922		**27,818**
SNNPR	14,610		29.290
Gambela	0		0
TOTAL	**83,682**	**8,048**	**94,358.29**

Source: various WBISPP Strategic Plans.

4. ABAY RIVER BASIN - BIOPHYSICAL AND SOCIO-ECONOMIC SITUATION

4.1 Biophysical Characteristics

4.1.1 Location and Physiography

The Abay basin is located in the northwest region of Ethiopia and covers approximately 202,994 km^2 (Map 5). Four major landscapes units can be identified: (i) an undulating high plateau that surrounds Lake Tana and extends to the south limit of the basin, (ii) mountainous relief with several major peaks, (iii) a gorge system incised by the Abay river and (iv), relatively flat lowlands to the Sudan border.

The elevation ranges from 490 masl, where Abay crosses the Sudan border, to approximately 4 250 masl in the eastern highlands of the basin. However, most of the land is located between 600 and 2 600 m, with dominant altitudes ranging from 1 300 to 2 200 m. Table 11 and Figure 5 depict the various altitudinal classes, while Map 5 gives a clear view of the spatial organization of such zones. The hook shape of the Blue Nile that deeply incises the highlands until reaching Lake Tana is very evident in this figure.

Table 11. Elevation classes of the Abay basin

Contours (masl)	Area (km^2)	% of basin
500 – 1000	34,367	17
1000 – 1500	42,454	21
1500 – 2000	54,583	27
2000 – 2500	40,432	20
2500 – 3000	24,259	12
3000 – 3500	6,065	3
3500 – 4000	809	0.4
>4000	25	0.01
Total	**202,994**	**100**

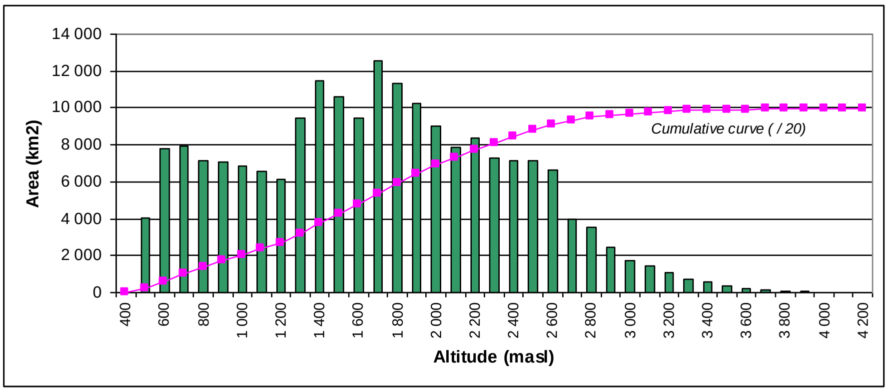
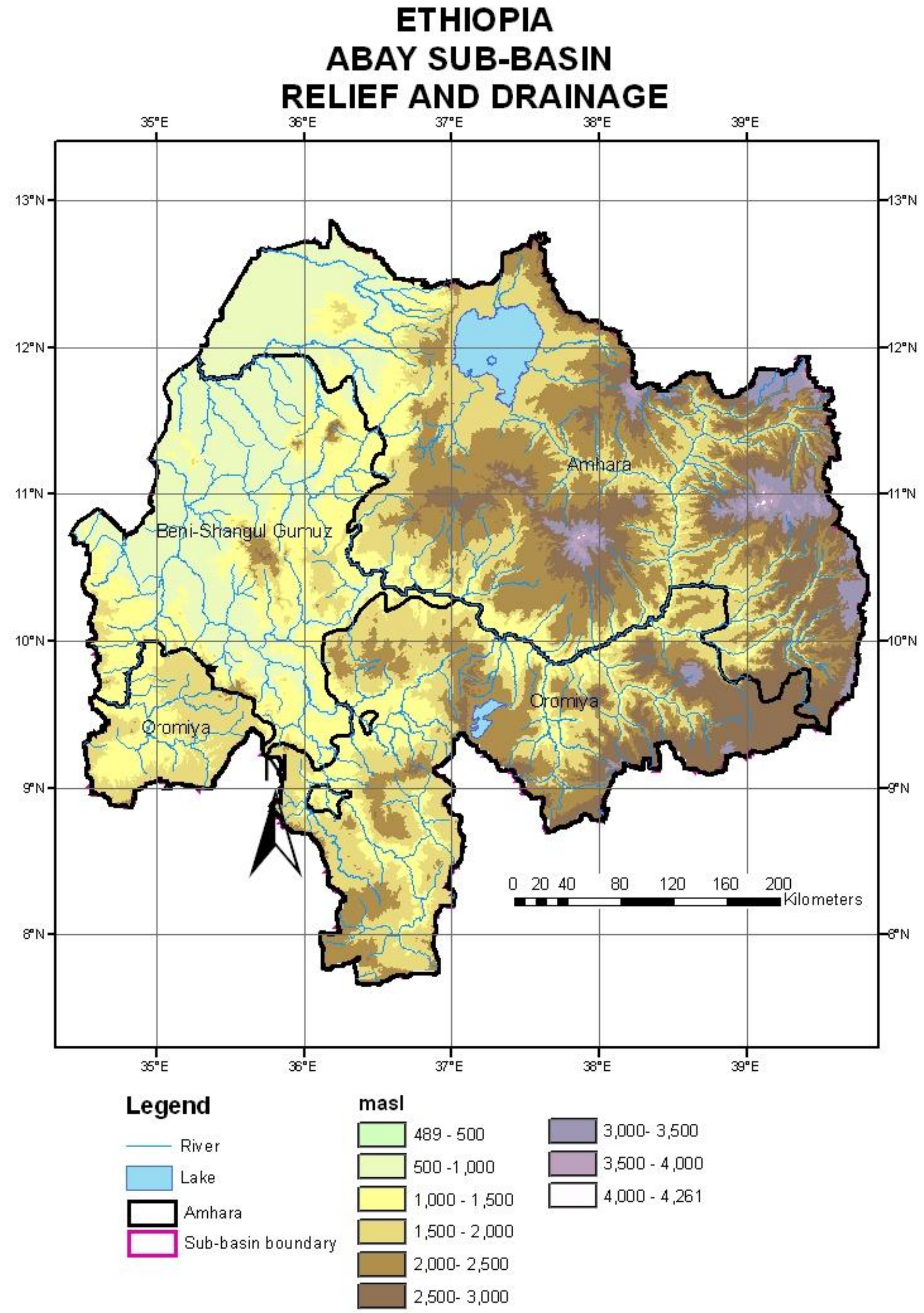


Figure 5. Distribution of lands per altitudinal class



Map 5. Ethiopia – Abay Sub-basin: Relief and Drainage

The altitudinal zone map reflects the main physiographic regions of Abay Basin, in the sense that most of the gentle slopes are located in the lowlands and high plateau, while a high proportion of steep slopes are found in the Blue Nile Gorge and the mountainous ridges. Given the extent of the first two zones and the presence of small plateaus within the mountainous area, most of the basin exhibits slopes less than 15 degrees (Figure 6). Notwithstanding the high proportion of gentle slopes, the steep lands play an important role, not only with sediment production, but also transportation, given that they occur within the whole basin and have direct link with the Abay river (Map 6). It will be noted in a later section that, given the intensive agricultural activities in the region, runoff and gully processes reach high levels even in relatively flat areas.

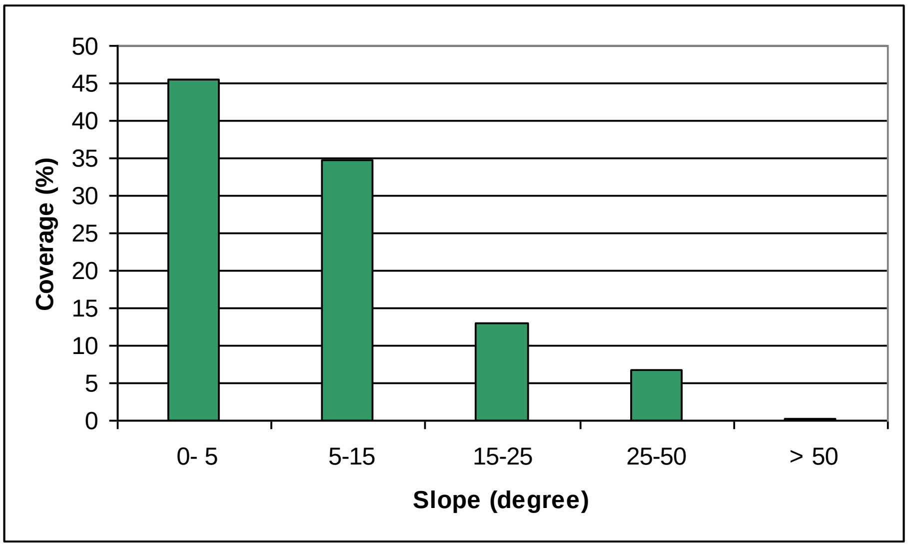
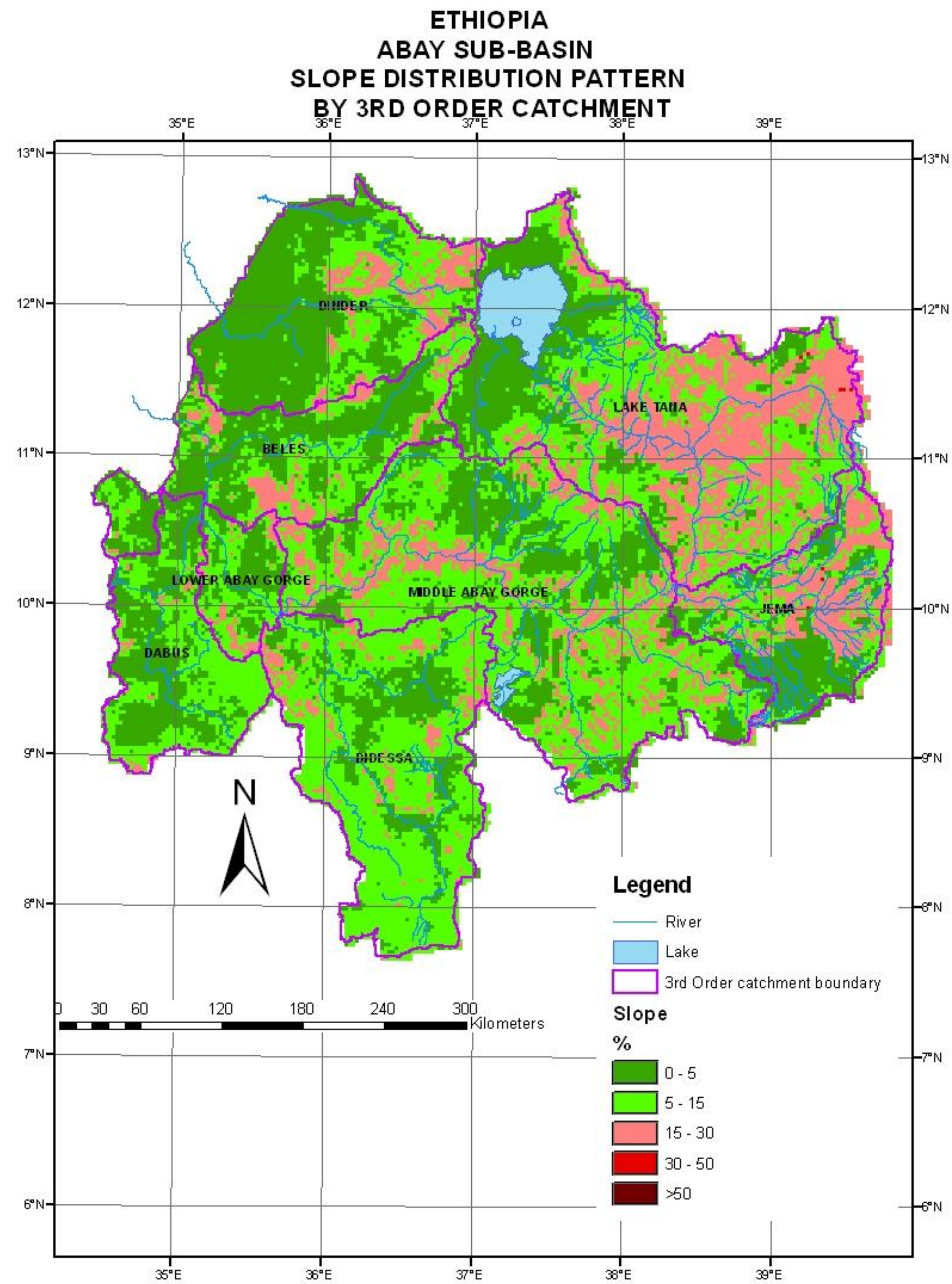


Figure 6. Relative area covered per slope class



Map 6. Slope distribution pattern within Abay Basin

4.1.2 Climate

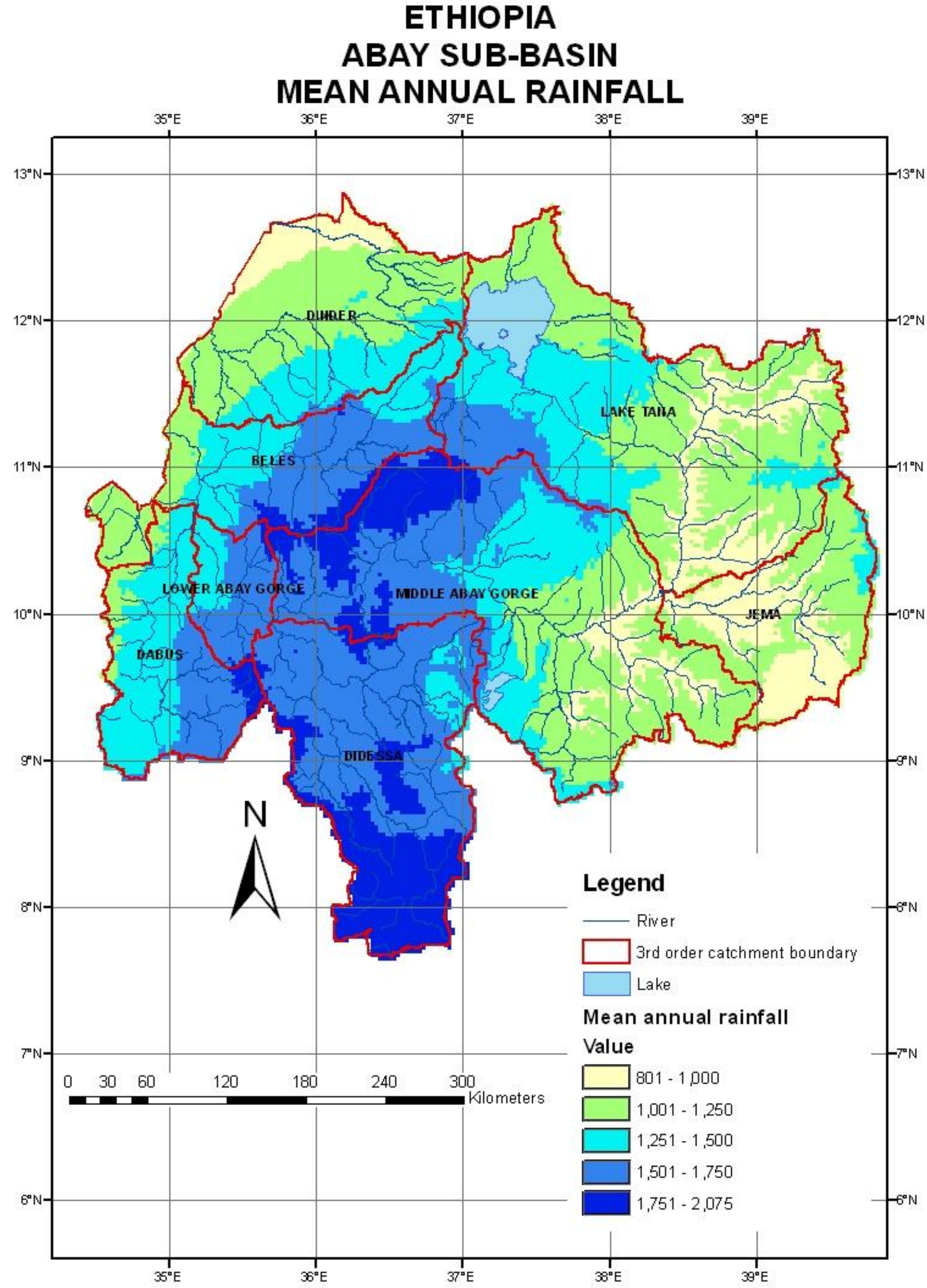
(I) Rainfall

Mean annual rainfall of Abay river basin varies between 693 mm, in Gundebert, and 2 596 mm, in Meko. The main rainy season, (*Kiremt*), lasts from June to September, contributing from 50 % up to nearly 90 % of the annual amount received in the basin. The small rainy season, (*Belg*), occurs from February to May and is only significant in the extreme east of the basin. It is practically absent around Lake Tana and south of the Abay where it represents less than 10% of annual rainfall. The eastern edge of the basin (from Mota to Nifas-Mwucha, Wogel-Tena, Dessie to Debre-Birhan) generally receives low annual rainfall. As a consequence, rainfall amount during *Belg* period represents nearly 50 % of the *Kiremt*, which gives a bimodal pattern with low precipitation in June.

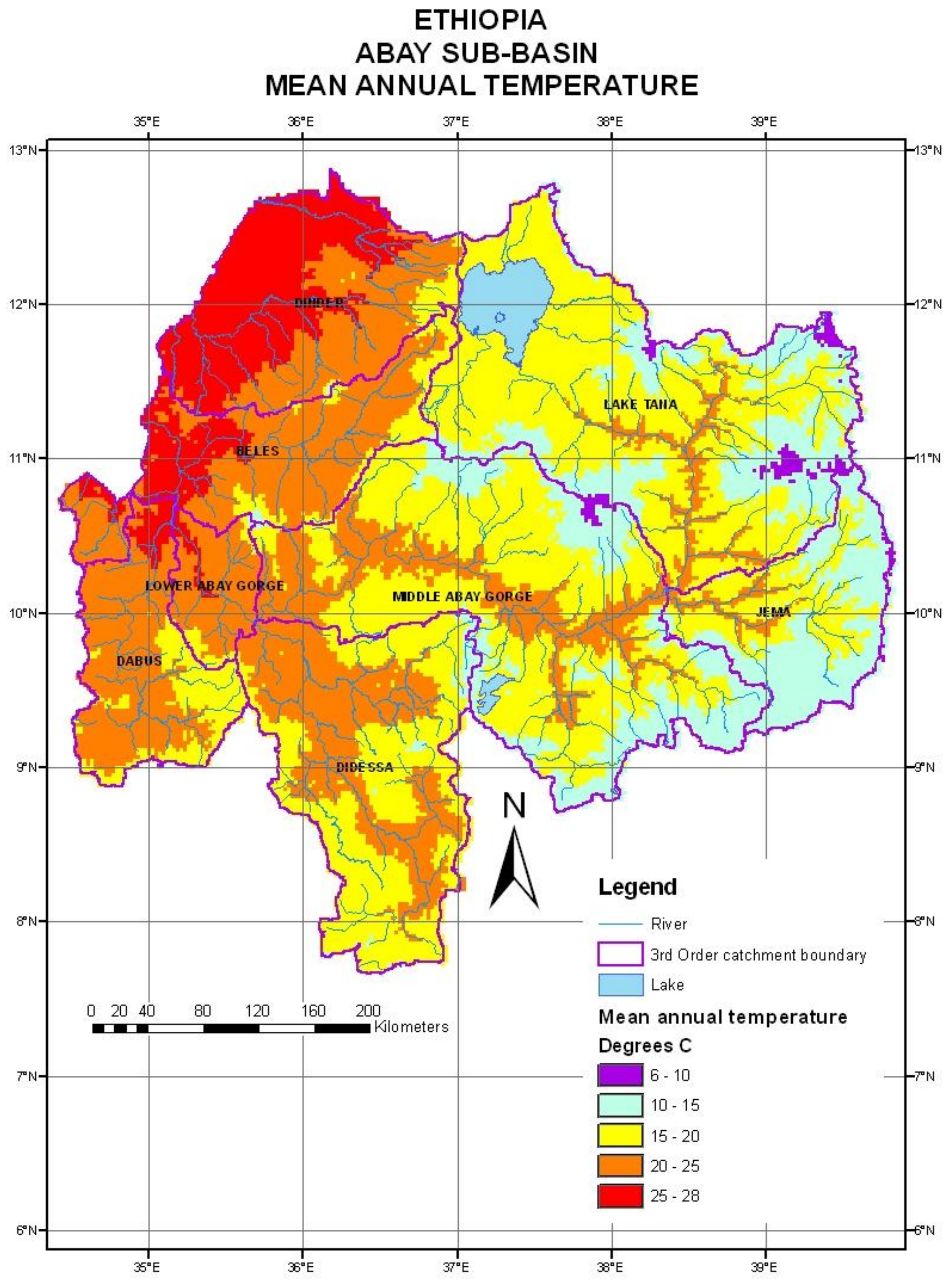
Two regions of high rainfall regime can be identified within the basin (Map 7). The first is located in the central region around Dangla and Injebara (in Amhara Regional State), while the second zone is located in the south from Bedele to Nekemte, Gimbi and Nejo (in Oromiya Regional State).

(II) Temperature

The mean monthly temperature recorded in the basin varies between 12.8 ^{o}C to 28.7 ^{o}C. The coldest period occurs from November to December (Sululta), while the warmest one is recorded in March (Mankush). An altitudinal pattern is observed in the basin, at a reduction rate of about 0.7 ^{o}C per each 100 meter of increase in altitude. Thus there is a strong relationship between the temperature spatial pattern and the extent of the various physiographic zones as depicted in Map 8.



Map 7. **Annual Rainfall map of Abay basin**



Map 8. **Temperature map of Abay Basin**

(iii) Humidity

The mean monthly relative humidity recorded in the basin varies between 31 % in February (Mankush) and 92 % in July and September (Anger Gutin).

(iv) Wind

The mean monthly wind speed recorded in the basin varies between 0.5 m/s in October – November (Nejo) and 3 m/s in January (Sululta). However, these values vary locally according to slope exposition, valley orientation, altitude, etc.

(v) Sunshine

The average daily sunshine duration in the basin varies between 3.1 hr in August (Chagni) and 10.1 hr in December (Pawe). The sunshine duration is almost independent of altitude. In fact, its variation is mainly regional, showing a strong gradient from east to west, and north to south, as observed for the rainfall pattern.

(vi) Evapotranspiration

The potential evapotranspiration (Penman – Monteith) varies between 2.4 mm/day in July – August (Nekemte) and 5.5 mm/day in March (Mankush) and April (Pawe).

(vii) Agroecological zones

The Weina Dega and Kolla zones cover respectively 40 % and 37 % of Abay Basin (see Table 12 which defines the agro-ecological zones by combining annual temperature and rainfall). Wet and moist conditions share approximately an equal proportion in these two zones (Table 13). The moist Dega, which covers most of the high plateau, ranks fifth in area after wet Kolla zone. The remaining agroecological zones are related with the upper portion of the mountain ridge and cover less than 3 % of Abbay basin.

The spatial pattern of the agroecological zones follows the landscape units and the rainfall regions (Map 9). Thus, the Kolla zone covers most of the lowlands near the Sudan and the lower section of the incised Blue Nile. The Weina Dega and Dega zones cover the high plateau and the area around Lake Tana. The Abbay gorge encompasses the dry Kolla and the moist Weina

Dega zones. The Wurch and Alpine Wurch zones are found on the high summits in the east and north-east of the Abbay basin.

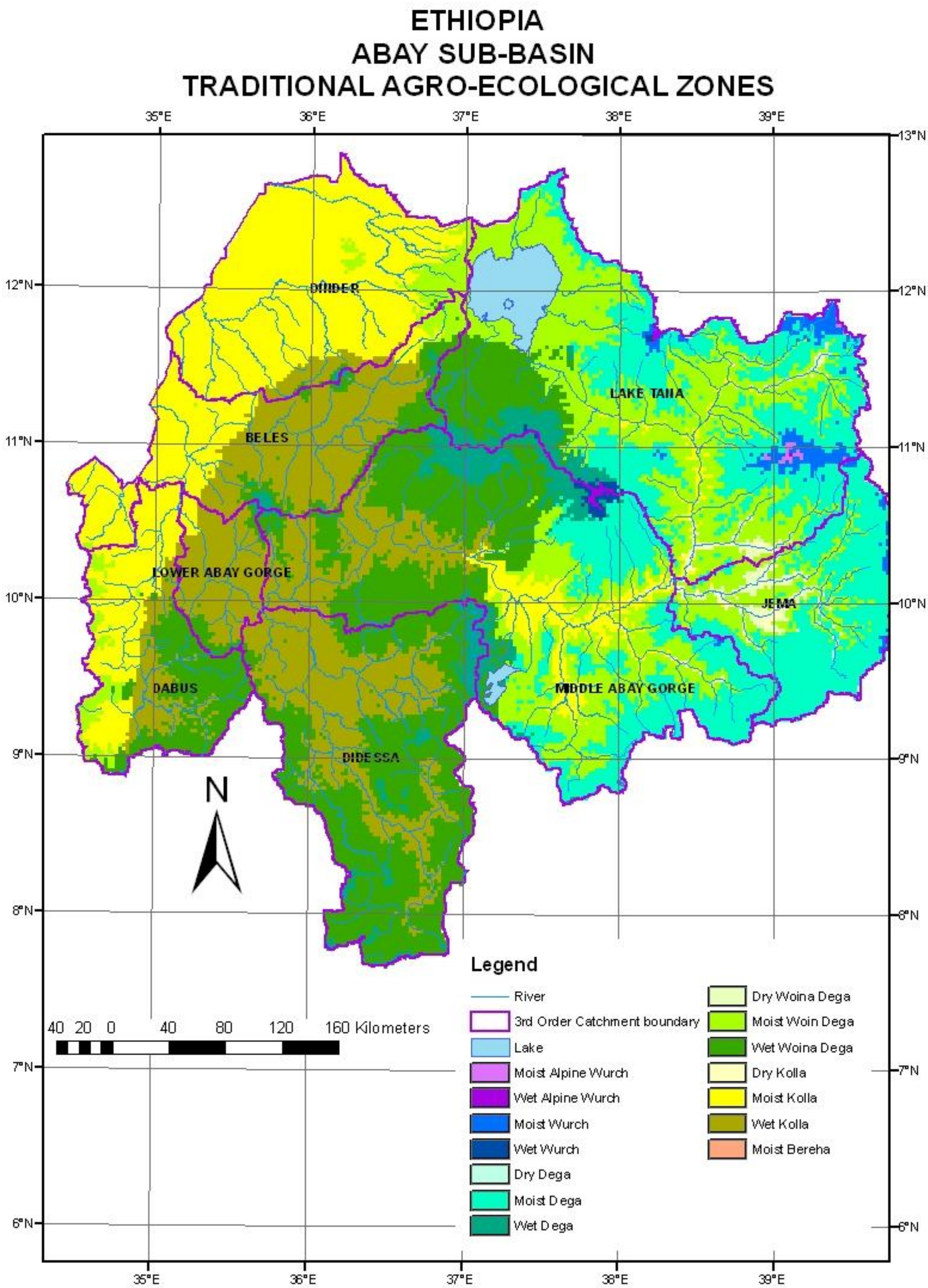
Table 12. Agroecological Zone Classification System

AGROECOLOGICAL ZONES

Temperature during growing season (°C)	Altitude (m a.s.l.) (approximate)	Rainfall (mm/yr)		
		< 900 (dry)	900-1400 (moist)	> 1400 (wet)
< 7,5 °C (High Wurch)	> 3700 m	Dry Alpine Wurch	Moist Alpine Wurch	Wet Alpine Wurch
11,3 - 7,5 °C (Wurch)	3200 - 3700 m	Dry Wurch	Moist Wurch	Wet Wurch
17,0 - 11,3 °C (Dega)	2300 - 3200 m	Dry Dega	Moist Dega	Wet Dega
21,3 - 17,0 °C (Weina Dega)	1500 - 2300 m	Dry Weina Dega	Moist Weina Dega	Wet Weina Dega
25,0 - 21,3 °C (Kolla)	500 - 1500 m	Dry Kolla	Moist Kolla	Wet Kolla
> 25,0 °C (Bereha)	< 500 m	Dry Bereha	Moist Bereha	Wet Bereha

Table 13. Percent area of Agroecological zones within Abbay basin

Agroecological zone	%
Moist Alpine Wurch	0,08%
Wet Alpine Wurch	0,08%
Moist Wurch	1,24%
Wet Wurch	0,23%
Dry Dega	0,01%
Moist Dega	17,26%
Wet Dega	3,71%
Dry Weina dega	0,66%
Moist Weina dega	19,42%
Wet Weina dega	19,97%
Dry Kolla	0,67%
Moist Kolla	19,11%
Wet Kolla	17,58%
Moist Bereha	0,00%



Map 9. Agroecological Zone Map of Abbay basin

4.1.3 Geology

The Abay basin geology is quite complex given the presence of various sedimentary layers that are covered by volcanic rocks. These outcrop whenever the landscape is deeply dissected by erosion or reshaped by tectonic processes. However, most of the basin can be considered as being composed of basic rocks, mainly basalts. The main inclusions of sedimentary and igneous rocks (granite, graniodorite, sandstones, limestones) are found in the south west where they have been exposed by the down-cutting of the Abbay River. Inliers of acid volcanic rocks (rhyolites) are found in the east as mountain peaks.

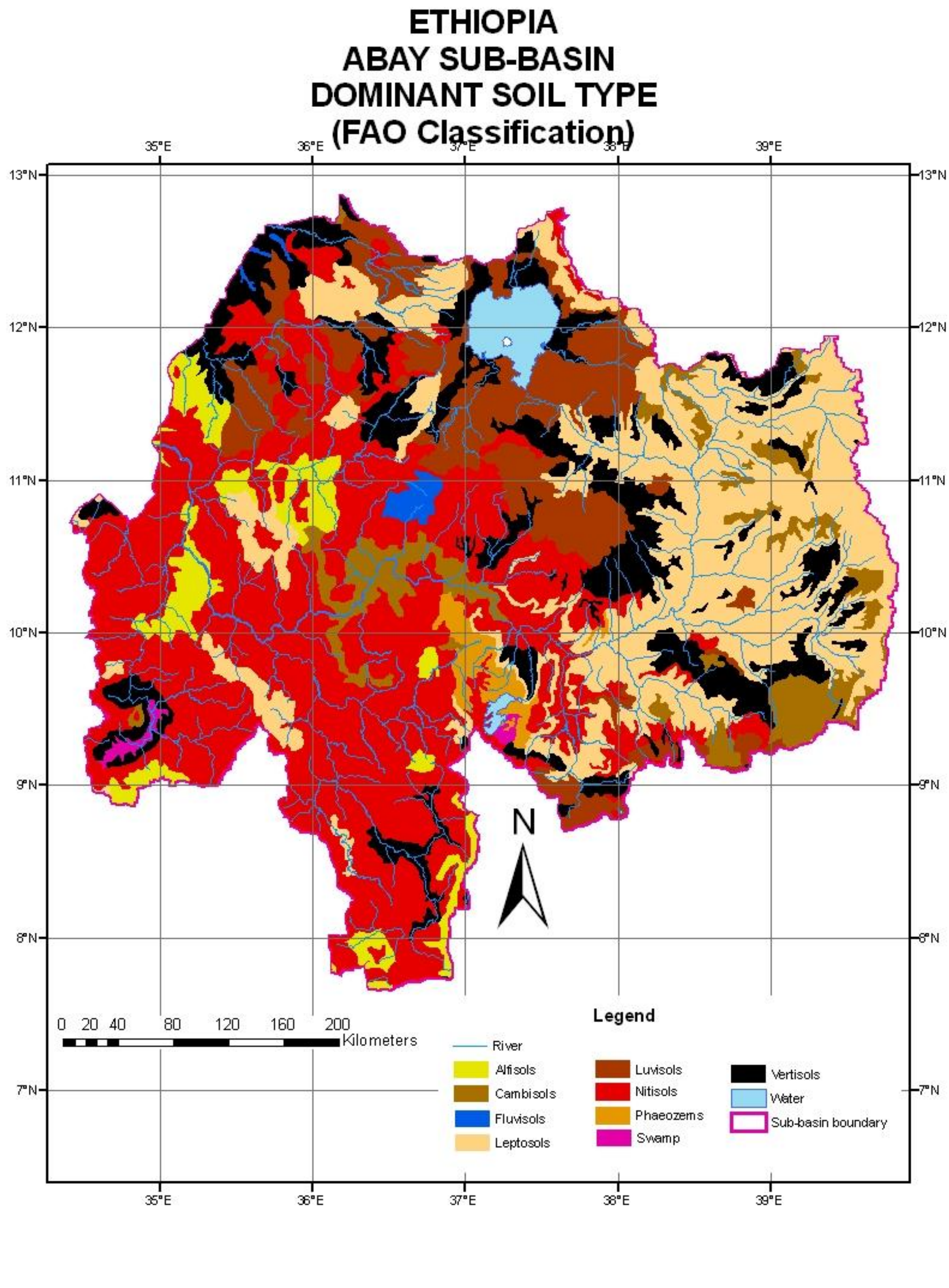
4.1.4 Soils

Eleven major soil groups are cover Abbay basin. The main groups, Nitosols, Alfisols and Luvisols, cover more than 45 % of the basin, mainly on favourable topography (Table 14). These units are therefore moderately to intensively cultivated, although their acidity reduces the availability of nutrients like phosphorus, calcium and magnesium.

Nitosols are mainly located in the south south-west region of the basin, while Luvisols are concentrated in the north, and the Leptosols in the north and east regions (Map11) Vertisols are found on gentle footslopes and valley bottoms. They are mainly located East and West Gojam and on the flat plateaus of South Wello.

Table 14 Major soil groups and soil units identified within in Abbay basin

Major Soil Group	Soil Depth	Soil Unit
Nitosols	Deep to very deep	Haplic Nitisols Rhodic Nitosols
Vertisols	Deep to very deep	Eutric Vertisols Calcic Vertisols
Leptosols	Sallow to very shallow	Eutric Leptosols Rendzic Leptosols Lithic Leptosols Dystric Leptosols
Luvisols	Deep to very deep	Chromic Luvisols Haplic
Cambisols	Moderately deep	Eutric Cambisols Dystric Cambisols Vertic Cambisols
Acrisols	Deep to very deep	Haplic Acrisols
Alfisols	Deep to very deep	Haplic Alfisols
Arenosols	Shallow to moderately deep	Cambic Arenosols
Phaeozems	Deep	Haplic Phaeozems
Regosols	Shallow to moderately deep	Eutric Regosols
Fluvisols	Deep to very deep	Eutric Fluvisols



Map 10. Ethiopia – Abay Sub-basin: Dominant Soil Types (FAO Classification)

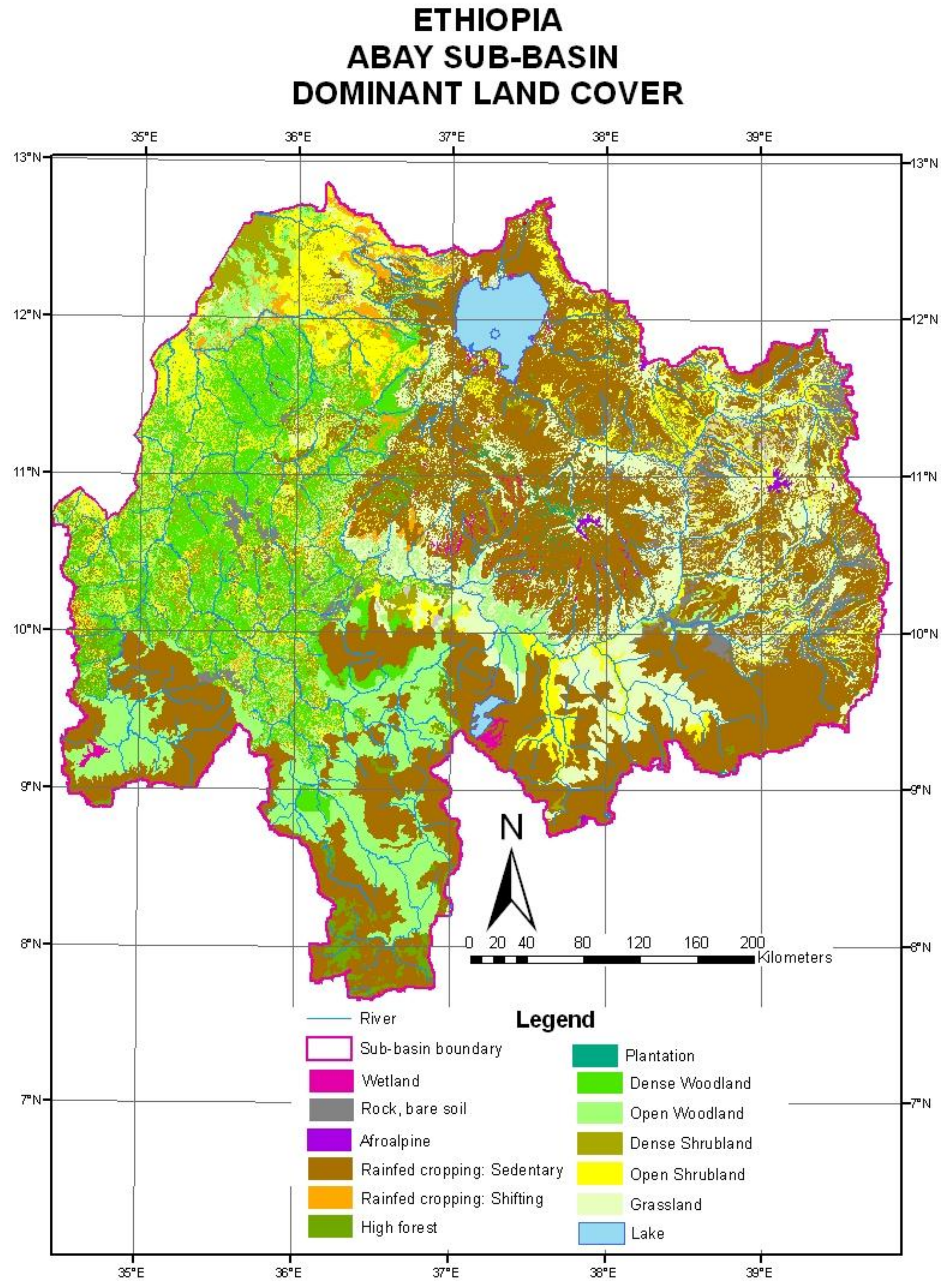
4.1.5 Land Cover / Land Use

Approximately 35 % of the Abbay basin is cultivated (e.g. cereal land cover system) (Table 15). Agriculture land is located around Lake Tana and extends within the highlands and plateaus in the south and south east of the basin (Map 11). The second main land cover types are represented by woodland, shrubland and bushland and cover 30 % of the area. They are located mainly in the lowlands and in the south although shrublands extend to the northern parts of the basin. Grassland ranks third covering 23 % of the basin. Rock and bare earth, which cover approximately 4 % of the basin, are mainly located in the south-east, as well on the steep slopes along the Abbay Gorge. Forest areas represent less than 2 % of the basin, as do water bodies. The forests are located in relatively small patches, which are scattered within the central of Abbay basin to the south of Lake Tana. Finally, agro-alpine and wetland types cover less than 1 % of the basin area.

Agriculture is dominated by system of rainfed mixed crop-livestock farming. Free grazing occurs after crop harvesting and in broad valley bottoms during the dry season. Cereals are the main crop and include teff, sorghum, maize, barley, wheat and millet. Legumes are also cultivated and include horsebean, faba bean, haricot bean, field pea, chickpea and lentils.

Table 15. Dominant Land cover categories identified within the Abay Sub-basin

Dominant Land Cover Category	Area (km^2)	Area (% of Basin)
Cultivated land	69,144	34.06%
Woodland, Bushland, Shrubland	61,319	30.21%
Grassland	46,816	23.06%
Rock	8,048	3.96%
Bamboo	7,433	3.66%
Water body	3,465	1.71%
Wetland	2,419	1.19%
Disturbed forest	2,309	1.14%
Afro-alpine	1,119	0.55%
Plantation	545	0.27%
Tree crops	264	0.13%
Urban area	113	0.05%
TOTAL	**202,994**	



Map 11. Ethiopia – Abay Sub-basin: Dominant land Cover Types

4.1.6. Water Resources

(i) Surface Water

Although the Abbay basin is the second largest drainage area in Ethiopia, it has the highest runoff, estimated to be 51Km^3/yr. The Abbay basin accounts for 50 percent of water runoff in Ethiopia. It also comprises 62 percent of the Nile discharge into Lake Nasser/Nubia and 72 % of the total Ethiopian contribution to the Nile waters.

The Abbay river has a channel length of 922 km and falls 1,295m from Lake Tana (1,785 masl) to the Sudan border (490 masl). Shortly after leaving Lake Tana, the river plunges over the spectacular Tis-Isat falls and, thereafter enters the deep Abbay river gorge. Comparing the mean monthly discharges of Abbay river at Lake Tana and at the Sudan border indicate that there is a 10 times increase in discharge between that at Lake Tana and at the Sudan border (Tables 16 a and b).

Table 16a: Mean monthly discharge of the Abbay River at the outlet to Lake Tana (m^3/s)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Av/ Max/ Min
Mean	83	55	34	19	11	9	31	174	345	312	205	130	**117**
Max	151	108	66	29	19	19	71	341	645	556	351	229	**645**
Min	29	19	12	5	2	1	10	35	71	82	58	41	**1**

Note: altitude, 1785 masl; Catchments area, 15,321 Km2; Length of record 1960 – 1992.

Table 16b: Mean monthly discharge of the Abbay river at the Ethiopian/Sudan border (m^3/s)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Av/ Max/ Min
Mean	345	229	162	141	240	722	2841	5634	4340	2468	1019	526	1556
Max	527	434	306	194	470	1453	6018	6988	5919	3708	1551	755	6988
Min	212	137	93	81	99	472	1930	3693	2813	1305	681	324	81

Note: altitude, 490 masl; Catchments area, 172,254 Km^2; Length of record, 1961 – 1979.

Table 17 presents the area and gross runoff depth of the various sub-catchment of Abbay basin. The runoff from the individual drainage unit is gross runoff, which means, no allowances are made for evaporation and other channel losses. The magnitudes of losses are apparent when the runoff from the individual drainage unit is compared to the runoff yield of 255 mm as measured at the Ethiopian/Sudan border. The table also demonstrates spatial rainfall effects on runoff. The greatest amount of runoff is produced by the Didessa drainage unit which is in the area of highest rainfall in the Abbay basin. Runoff depth then diminishes in the Rahad and Dinder drainage units, which are non-perennial water course basins located in the dry north - west the Abbay basin. These drainage units are the only non-perennial basins within the Abbay system and comprise 12 % of the total basin area.

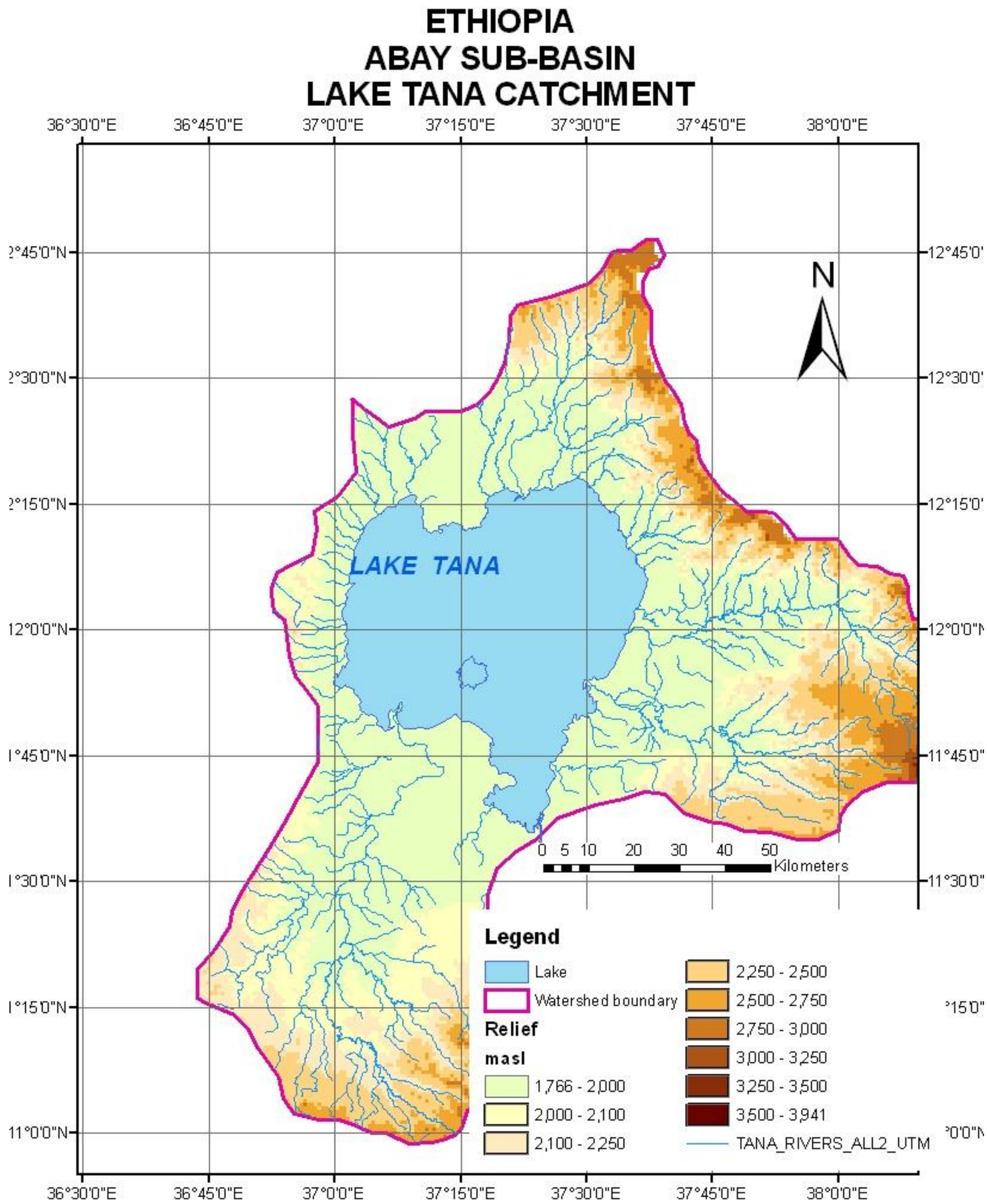
Table 17. Area and gross runoff depth of the sixteen main drainage basin units of the Abbay river basin (rank order by gross runoff depth)

Unit Name	Area (Km^2)	Gross runoff depth (mm)
Didessa	19,943	651
South Gojam	17,029	543
Guder	7,123	537
Anger	8,027	527
Lake Tana	15,294	514
North Gojam	14,618	486
Dabus	21,367	466
Beshilo	13,453	455
Fincha	4,154	450
Muger	8,318	423
Jemma	16,033	422
Welaka	6,517	410
Wombera	13,163	410
Beles	14,426	378
Rahad	8,401	339
Dinder	15,128	276
	202,994	

Lake Tana, some 73 km long and 68 km wide, is the largest freshwater lake in Ethiopia. It is located at 1,786 masl and has a surface area of 3,042 km^2, accounting for 50 % of the total inland water of Ethiopia. The lake stores 29,175 km^3 of water which seasonally fluctuates between 1,785 and 1,787 masl. The lake is shallow and has a mean depth of 9.53 m, while the deepest part is 14 m. The catchment area, totaling 15,054 km^2, contributes a mean annual inflow of 10.3 km^3 from 61 water courses, including four main catchments, namely; Gilgel Abbay (5,004 km^2; west), Ribb (2,464 km^2; east), Gumara (1,893 km^2; south-east) and Megech (2,620 km^2; north) (Map 13). The outflow from the lake is 3.7 km^3/yr. The remainder or 64% of the inflow is mainly lost by evaporation.

Within the lake are 37 islands, the best known island is Dek Estifanos, which has several historic monasteries and churches. Prior to the construction of Chara-Chara weir in 1996, the mean outflow of Abbay river from the lake was 114 m^3/s (max outflow of 204 m^3/s). The monthly mean outflow ranged from 10 m^3/s (May and June) to more than 350 m^3/s (Sept. and Oct.). The outflow is now regulated by Chara-Chara weir and the discharge is now standardized at 110 m^3/s.[18]

[18] Amhara REPLUA (2004) "



Map 12. Main rivers flowing into Lake Tana

(ii) Groundwater Resources

Ground water is almost exclusively confined to consolidated rocks, which include basalts, limestone and sandstone and metamorphic basement rocks. The retention capacity of these rocks is low and any groundwater is linked to the occurrence of fractures within these rocks. The presence of a thick basalt cap overlaying the normally better yielding sedimentary rocks restricts possible recharge of these areas and limits exploitation of shallow aquifers, such as springs and wells. The presence of deep gorges along the Abbay escarpment also provides relatively free drainage for the aquifers which may emerge as springs in the lower slopes. This effectively draws the groundwater table down deeper in the locality of the escarpment which significantly reduces the potential storage ability of the aquifers.

4.2 Socio-economic Characteristics

4.2.1 Population Distribution

(i) Administrative units and population

The Abay basin includes three administrative regions, Amhara, BeneShangul-Gumuz and Oromiya (Map13). Amhara region is located in the northern portion of the basin, covering 47 % compared to 31 % for Oromiya and 22 % for BeneShangul-Gumuz. Oromiya region extends over the southern portion of the basin while BeneShangul- Gumuz is located in the south-west lowlands.

Table 18. Ethiopia – Abay Sub-basin: Rural and Urban Population (2000)

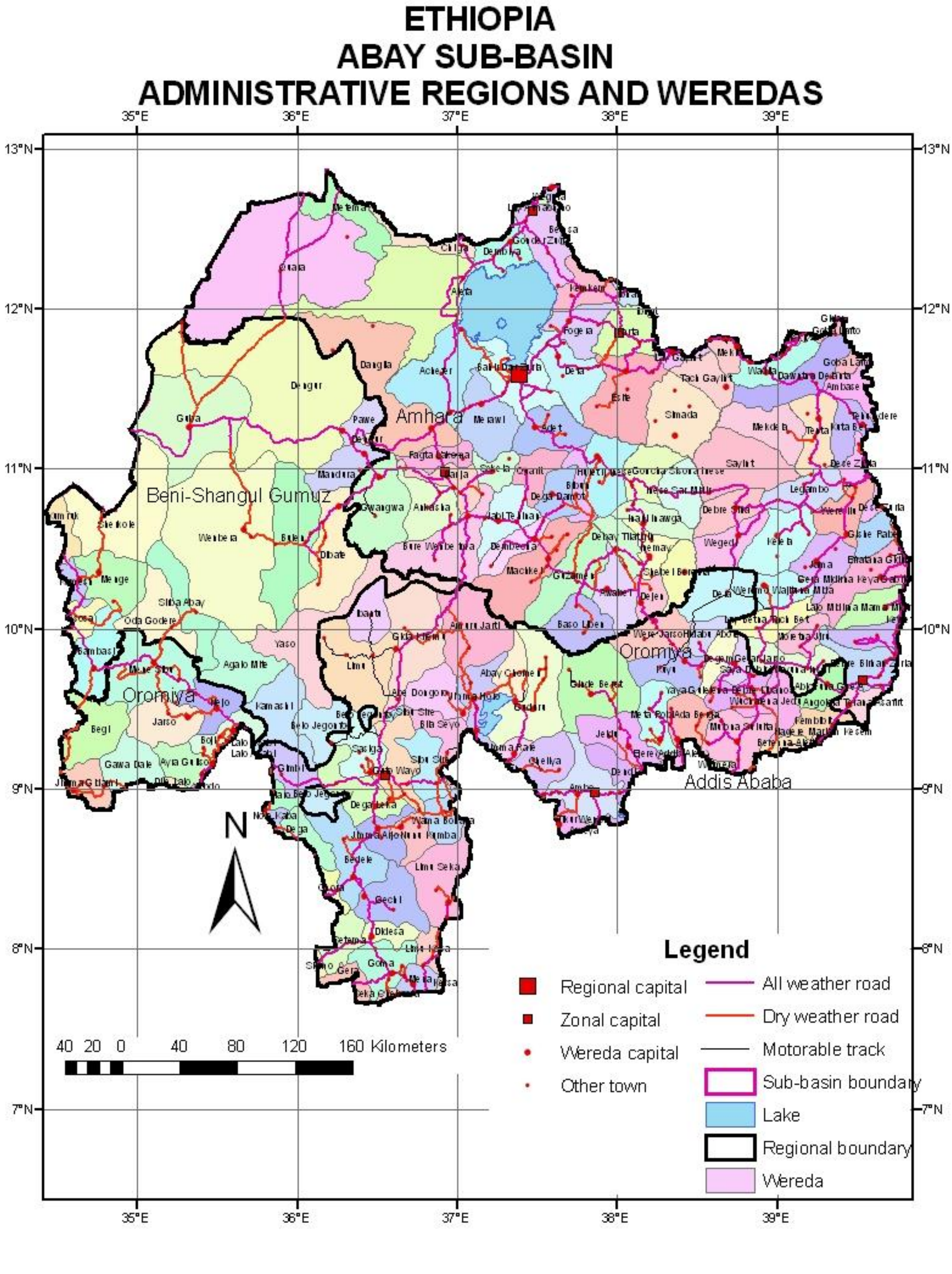
Region	**Rural population**	**Urban population**	Total
Amhara	9,201,609	1,054,820	10,256,429
Beneshangul-Gumuz	419,227	33,200	452,427
Oromiya	5,009,737	591,440	5,601,177
Total: Abay Basin	**14,630,573**	**1,679,460**	16,310,033

Table 19. Ethiopia – Abay Sub-basin: Percent Rural and Urban Population (2000)

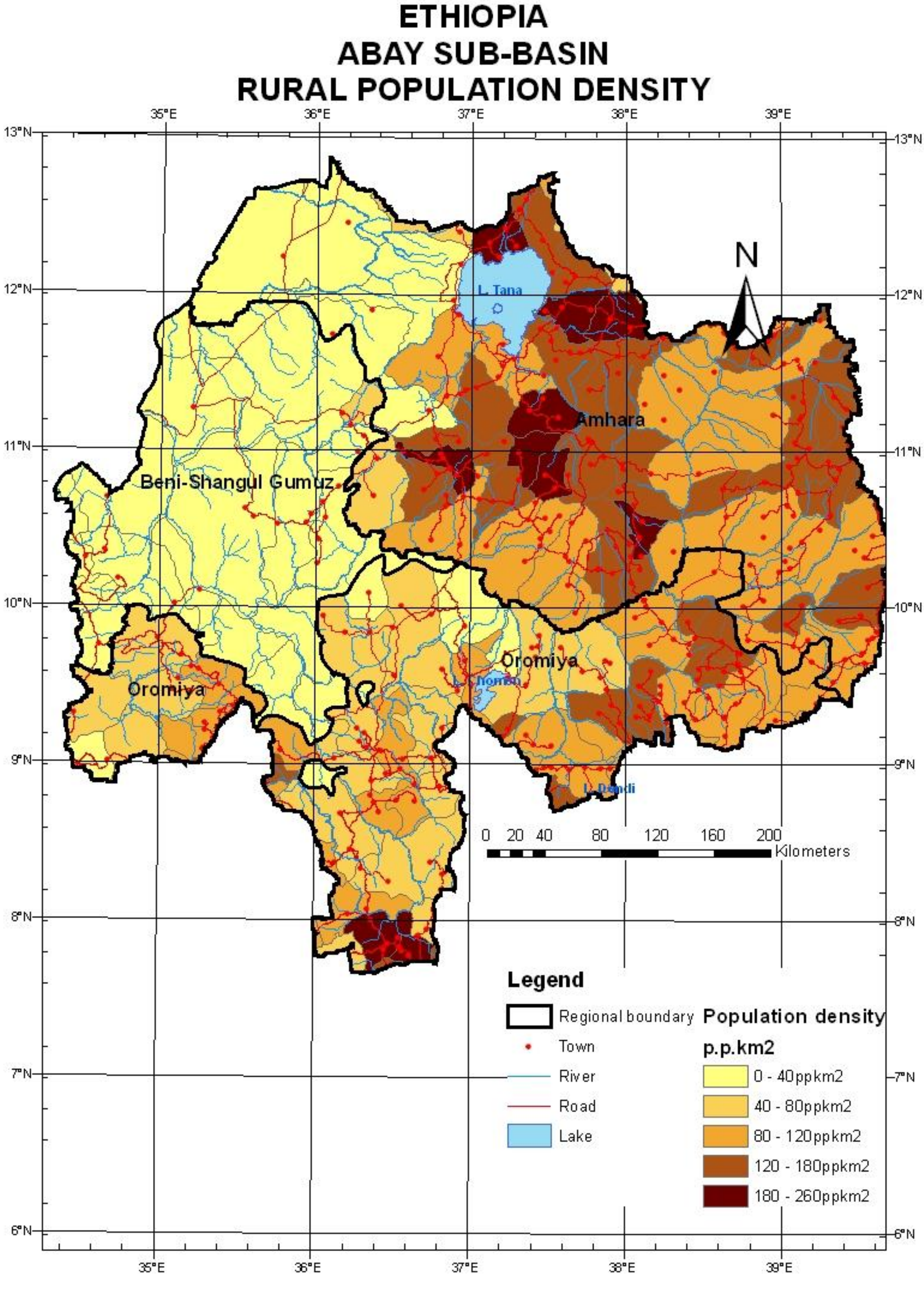
Region	Rural %	Urban %
Amhara	90%	10%
Beneshangul-Gumuz	93%	7%
Oromiya	89%	11%
Total: Abay Basin	**90%**	**10%**

The portion of Amhara region that falls inside the Abbay basin includes 79 Weredas. Oromiya and BeneShangul-Gumuz regions include 69 weredas and 20 weredas respectively.

The density of the rural population varies from 2 inhabitants/km^2 (in Guba Wereda, BeneShangul-Gumuz) to 251 inhabitants/km^2 (in Mena Wereda, Oromiya). The most populated weredas are located on the eastern side of Lake Tana (Map 14). The less populated weredas are located in the lowlands, close to the Sudan border (the majority in BeneShangul-Gumuz and the western portion of Amhara region).



Map 13. Administrative Regions and Weredas in the Abbay River Basin



Map 14. Rural population density per Wereda in Abbay basin (persons per km^2)

Table 20. Main population statistics per Wereda for Abbay basin

Region	Zone	Wereda	Pop rural 2000	Pop urban 2000	Pop total 2000	Density (hb/km2)	Area (km2)
Amhara	Agew Awi	Ankasha	189774	9500	199274	149,23	1267,93
Amhara	Agew Awi	Banja	165213	12067	177280	194,12	848,39
Amhara	Agew Awi	Dangila	152080	22384	174464	39,52	3840,59
Amhara	Agew Awi	Fagta Lakoma	108075	5505	113580	162,06	664,89
Amhara	Agew Awi	Gwangwa	142821	30329	173150	65,18	2186,9
Amhara	Debub Gonder	Dera	158936	14624	173560	146,19	1580,08
Amhara	Debub Gonder	Esite	240480	13104	253584	138,42	2387,25
Amhara	Debub Gonder	Farta	127776	4348	132124	204,95	1188,84
Amhara	Debub Gonder	Fogera	104972	22474	127446	184,88	1042,91
Amhara	Debub Gonder	Ibnat	229456	11869	241325	77,89	204,62
Amhara	Debub Gonder	Kemkem	163712	22660	186372	143,39	926,99
Amhara	Debub Gonder	Lay Gayint	146752	16613	163365	121,66	287,41
Amhara	Debub Gonder	Simada	208508	5629	214137	102,16	2067,31
Amhara	Debub Gonder	Tach Gayint	86520	3272	89792	109,51	857,58
Amhara	Debub Wello	Ambasel	124695	4812	129506	133,67	690,95
Amhara	Debub Wello	Debre Sina	139089	6738	145827	137,7	1000,03
Amhara	Debub Wello	Dese Zuria	231637	121745	353382	162,95	596,13
Amhara	Debub Wello	Jama	120528	4538	125066	101,36	1174,83
Amhara	Debub Wello	Kelela	131361	4941	136302	80,73	1610,04
Amhara	Debub Wello	Kuta Ber	144134	51756	195890	159,45	821,15
Amhara	Debub Wello	Legambo	179649	5242	184891	155,04	1145,3
Amhara	Debub Wello	Mekdela	121392	2491	123884	83,38	1441,17
Amhara	Debub Wello	Sayint	222729	2529	225258	96,9	2276,67
Amhara	Debub Wello	Tehuledere	124943	14418	139361	240,83	11,63
Amhara	Debub Wello	Tenta	152199	7975	160174	120,67	1247,36
Amhara	Debub Wello	Wegedi	116096	2052	118148	105,7	1087,8
Amhara	Debub Wello	Were Ilu	129400	10895	140296	120,31	1052,28
Amhara	Mirab Gojam	Achefer	250180	17364	267544	92,59	2693,6
Amhara	Mirab Gojam	Adet	259746	14895	274641	198,87	1298,9
Amhara	Mirab Gojam	Bahir Dar Zuria	212420	127426	339847	91,56	2308,95
Amhara	Mirab Gojam	Bure Wenberima	218739	23011	241750	99,03	2201,8
Amhara	Mirab Gojam	Dega Damot	144311	2074	146385	193,51	741,53
Amhara	Mirab Gojam	Dembecha	87052	14057	101109	106,76	811,45
Amhara	Mirab Gojam	Jabi Tehinan	190233	30054	220287	171,88	1101,37
Amhara	Mirab Gojam	Merawi	259790	15017	274807	159,36	1623,44
Amhara	Mirab Gojam	Quarit	151218	2456	153674	186,39	807,48
Amhara	Mirab Gojam	Sekela	93783	2396	96179	161,1	579,59
Amhara	Misrak Gojam	Awabel	155935	10672	166607	135,66	1142,08
Amhara	Misrak Gojam	Baso Liben	126697	4583	131280	97,42	1291,92
Amhara	Misrak Gojam	Bibun	94730	2156	96886	172,85	544,74
Amhara	Misrak Gojam	Debay Tilatigin	113578	2644	116223	160,29	703,55
Amhara	Misrak Gojam	Dejen	91324	10922	102246	164,69	549,87
Amhara	Misrak Gojam	Goncha Sisona Inese	129604	4834	134438	122,19	1052,43
Amhara	Misrak Gojam	Guzamen	217577	4298	221875	118,58	1823,71
Amhara	Misrak Gojam	Hulet Ij Inese	207903	25140	233043	144,73	1426,31
Amhara	Misrak Gojam	Inarji Inawga	133384	12242	145626	156,69	844,34
Amhara	Misrak Gojam	Inemay	124132	17319	141451	186,6	659,95
Amhara	Misrak Gojam	Inese Sar Midir	117760	9020	126780	115,39	1012,15
Amhara	Misrak Gojam	Machkel	208177	77986	286163	94,22	2198,32
Amhara	Misrak Gojam	Shebel Berenta	87370	2040	89411	102,63	843,54
Amhara	Oromiya	Chefe Godana Dewerehimedo	177415	14731	192146	143,47	0,22
Amhara	Semen Gonder	Alefa	234823	14692	249515	35,25	6640,99
Amhara	Semen Gonder	Belesa	156228	7164	163392	59,65	43,38
Amhara	Semen Gonder	Chilga	181938	11764	193702	56,63	611,17
Amhara	Semen Gonder	Dembiya	232960	21609	254569	185,37	893,78
Amhara	Semen Gonder	Gonder Zuria	205387	156498	361885	153,38	1302,09
Amhara	Semen Gonder	Lay Armachiho	131031	5851	136882	123,98	73,01
Amhara	Semen Gonder	Metema	51002	13516	64518	13,43	1260,56
Amhara	Semen Gonder	Quara	41059	353	41413	5,22	7731,1
Amhara	Semen Gonder	Wegera	203695	10286	213982	106,34	127,88
Amhara	Semen Shewa	Angolela Terana Asafirt	97554	5161	102716	94,9	499,62
Amhara	Semen Shewa	Antsokia Gumuz	73764	12187	85950	180,81	47,08
Amhara	Semen Shewa	Debre Birhan Zuria	130433	47355	177788	102,85	1140,52
Amhara	Semen Shewa	Efratana Gidim	97665	20200	117864	208,67	0,24
Amhara	Semen Shewa	Gera Midirna Keya Gabriel	145915	9851	155766	89,73	1541,71
Amhara	Semen Shewa	Gishe Rabel	58337	1361	59698	91,47	623,26
Amhara	Semen Shewa	Hagere Mariam Kesem	51866	1405	53271	62,56	12,69
Amhara	Semen Shewa	Kewet	108554	17474	126028	130,59	29,81
Amhara	Semen Shewa	Lalo Midirna Mama Midir	116730	4556	121286	120,7	900,37
Amhara	Semen Shewa	Lay Betna Tach Bet	104596	10980	115576	107,47	963,07
Amhara	Semen Shewa	Mafud Mezezona Migena	146241	12488	158729	123,44	741,78
Amhara	Semen Shewa	Moretna Jiru	81379	8855	90234	128,46	626,47
Amhara	Semen Shewa	Saya Debir Wayuna Insar	136056	6683	142739	113,98	1180,3

Table 21. Ethiopia – Abay Basin: Gross population density (ppkm2) and Density on arable land (ppkm2 arable land) and hectares of arable land per capita.

Basin/Region	Density total land (ppkm2)	Density arable land (ppkm2 arable)	Hectares arable per capita (rural)
Amhara	99	99	1.01
Beneshangul-Gumuz	9	14	7.22
Oromiya	80	104	0.96
Total: Abay Basin	73	85	1.17

4.2.2 Population Projections

The estimated median rural population growth rate (1995-2000) was 2.8 percent per annum and the urban rate was 4.5 percent. These growth rates are projected by the Central Statistical Authority (CSA) to decline between 2000 and 2030 as follows:

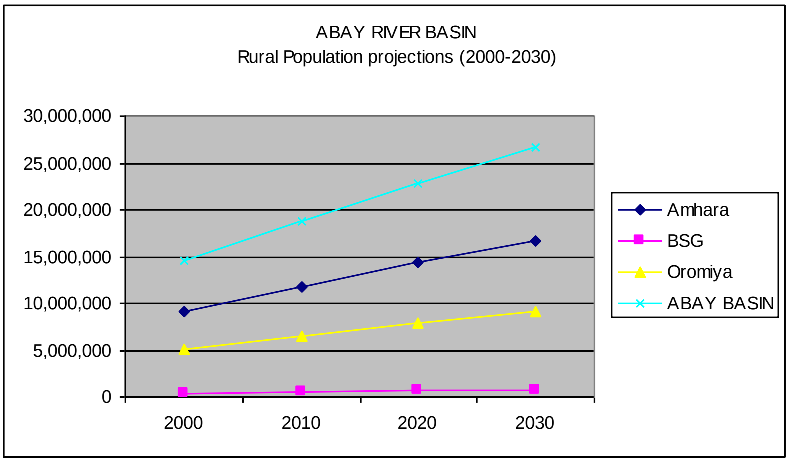
Table 22. Ethiopia: Estimated Median Population Growth rates 1995 - 2035.

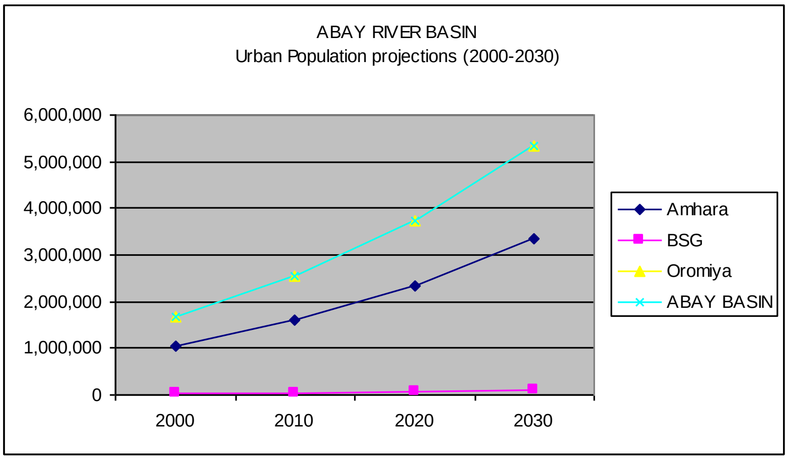
Period	Rural	Urban
1995 – 2000	2.80	4.50
2000 – 2010	2.49	4.25
2010 – 2020	2.00	3.85
2020 - 2030	1.55	3.70

Source CSA (1999)

The impact on the population of the Abay basin is shown in figure 7. Although rural populations shown a distinct reduction in the rate of growth the rural population of the Abay basin is expected to rise from 14.6million to 28.7 million by 2030, a near doubling of the 2000 population. Urban populations increase from 1.7 million to 6.4 million by 2030, a threefold increase. Despite the rapid increases in the urban population the proportion of the rural population in the basin only decreases from 90 to 82 percent.

Figure 7. Abay River Basin: Projected Rural and Urban 2000 - 2030





There is an attendant impact on rural population densities that has important implications for natural resource management and use. Table 23 indicates the increases on gross rural population densities in the basin that will occur.

Table 23. Changes in Rural Population Densities (persons/km2): 2000 – 2030

BASIN/region	2000	2010	2020	2030
ABAY BASIN				
Amhara	99	127	155	180
BSG	9	12	15	17
Oromiya	80	103	125	146
Total	**73**	**94**	**114**	**133**

The highest densities occur in the Amhara and Oromiya Regions within the basin. In terms of population support capacity[19] the picture is similar.

[19] WBISPP (2004) "National Strategic Plan for the Biomass Energy Sector.". Defined as the capacity of land suitable for rainfed cropping to produce sufficient food to support the rural population. The population is increased at the estimates rates for 10 and 25 years to determine those weredas that will reach their capacity within those time periods.

Table 24. Population Support Capacity Assessment for the Abay River Basin: Percent of weredas that will reach capacity only after 2020, between 2010 and 2020, between 2000 and 2010, at capacity in 2000, "Critical" in 2000 and becoming critical by 2020.

BASIN/Region	At capacity after 2020	At capacity 2010-2020	At capacity by 2010	At capacity 2000	Critical 2000	Critical 2020
ABAY BASIN						
Amhara	15%	8%	22%	29%	**27%**	**76%**
BSG	95%	5%	0%	0%	**0%**	**5%**
Oromiya	36%	19%	19%	7%	**20%**	**65%**
Total	**34%**	**12%**	**18%**	**16%**	**21%**	**67%**

This indicates that at the present time 37 percent of weredas in the Abay Basin are at or have exceeded their population support capacities. By 2020 some 67 percent of the weredas will be unable to fully support their populations at the current levels of crop productivity. Most of those weredas that will only reach capacity by 2020 are located in the western Lowlands.

4.2.3 Socio-cultural Aspects of population

In two of the three Regions located within the basin one ethnic group tends to be predominant. Only in the Beneshangul-Gumuz region are the various groups more evenly distributed. There are over 55 ethnic groups represented in the Amhara Region. However, the main groups are Amhara with 91 percent and Agew with 4% of the rural population

There are 6 major ethnic groups represented in the Beneshangul-Gumuz Region. The relative proportions are:

Jebelaw/Koma/Mao	-	29%
Gumuz	-	25%
Amhara	-	20%
Oromo	-	12%
Sinashi	-	7%
Agew	-	3%

In the Oromiya Region as a whole there are over 71 ethnic groups. The main groups are Oromo and Amhara with 88.7 and 7 percent of the rural population respectively.

4.3 Farming Systems

4.3.1 Classification[20]

The Abay Sub-basin exhibits a wide range of farming systems given the range of agro-ecological and socio-cultural conditions. They can be conveniently divided at the highest level into Highland and Lowland systems (an approximate dividing line being the 1500 masl contour[21]). Further subdivisions are made on the major food crops cultivated. These are indicated in table 25.

Table 25. Outline of farming Systems in the Eastern Nile Basin within Ethiopia.

AGRO-ECOLOGICAL ZONE	MAJOR CROPS	LIVESTOCK
NORTHERN HIGHLANDS		
Moist Dega-Wurch	Wheat+barley+peas/beans (only Barley >2900 masl)	Draught oxen, cows, sheep
Wet-Moist Wine Dega	Tef+maize+sorghum+finger millet+pulses	Draught oxen, cows, sheep, goats
WESTERN HIGHLANDS		
Moist/Wet Dega	Wheat+maize+pulses	Draught oxen, cows, sheep
Wet Woina Dega	Maize+tef+coffee	Draught oxen, cows, sheep, goats
Wet Woina Dega	Enset+maize	Cows, sheep, goats
Wet Dega	Enset+Wheat	Cows, sheep
LOWLAND		
Moist Woina Dega	Tef+maize+sorghum	Cattle, sheep, goats
Moist Kolla	Millet, sorghum+maize+beans	Goats
Dry/Moist Kolla	Shifting Sorghum+maize+beans	Goats
Dry/Moist Kolla	Sorghum, maize (rice)	Cattle, sheep

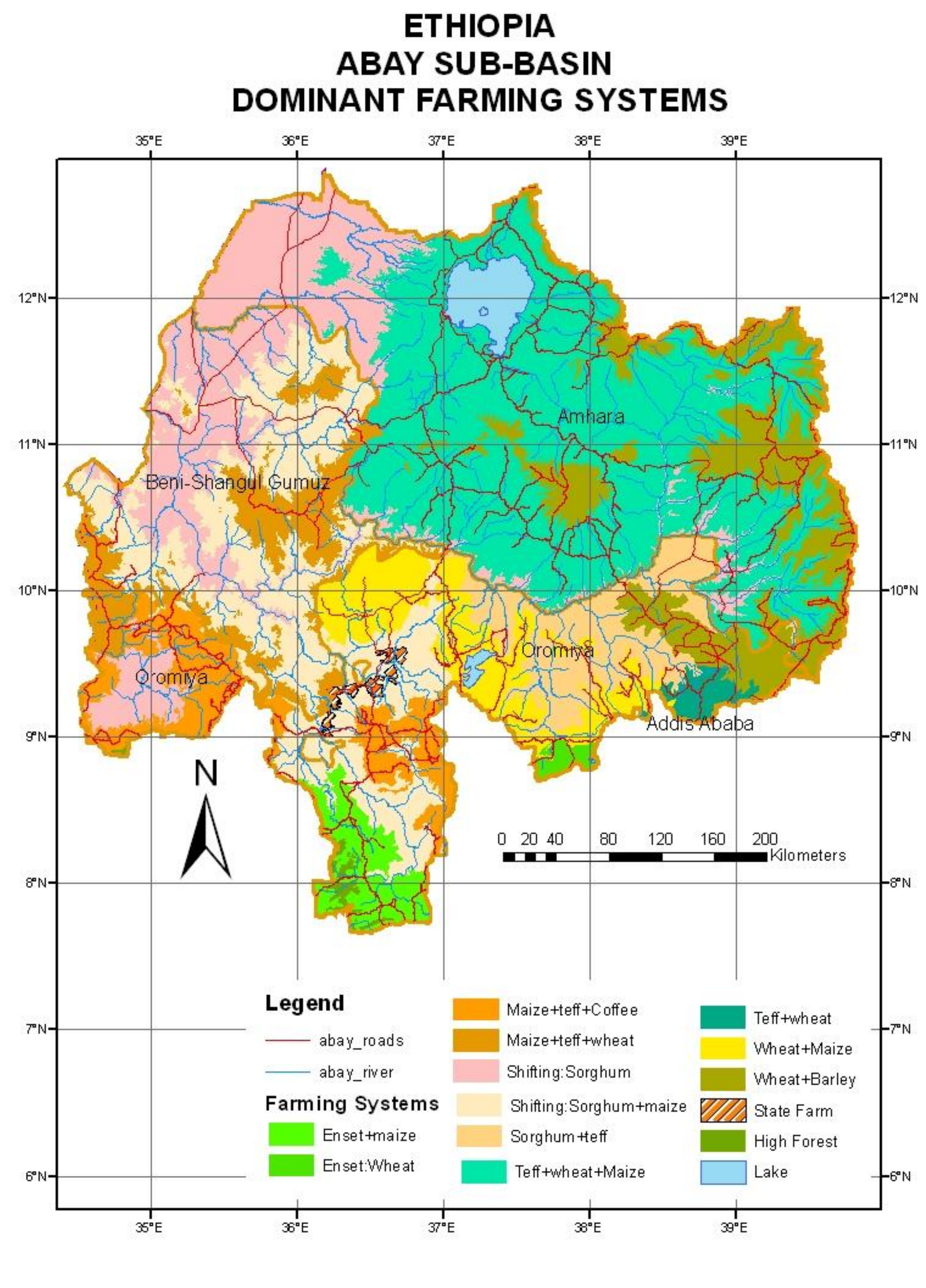
Their distribution is shown in map 15.

4.3.2 Northern Highlands

(i) Wheat-Barley Systems:

Wheat-barley systems are found above 2,500 masl with only barley above 2,900 masl. Pulses comprise horsebean and pea. At lower altitudes some maize and sorghum is cultivated. Average farm size is 1.3 ha although the distribution is skewed to the smaller farm size. More than 80 percent of households have 2 or more plots, although where there is considerable variation in land quality this helps to spread risk. Rainfall is extremely variable and soils are generally of low fertility and as a consequence crop yields are lower and more variable than the national average. There is a major structural (i.e. permanent) grain deficit in this farming system ranging between 240 and 580 kgs of grain per family. Some grain is purchased from sales of livestock. Increasingly, deficits are being made up from food aid and food for work.

[20] Data from the Socio-economic Surveys of WBISPP strategic plans for Amhara, Oromiya and Beneshangul-Gumuz regions.
[21] H. Hurni & Kebede Tatu (1990) "Agro-ecological Zones of Ethiopia", 1:1 million Map, University of Berne, Switzerland.



Map 15. Ethiopia: Eastern Nile Basin: Distribution of Farming Systems

Ox:cow ratios of 1.4 and above indicate the emphasis on draught power rather than milk production. Cattle holdings average about 2.6. Sheep to goat ratios are above 5 indicating a clear preference for sheep. Some 85 percent of livestock feed comes from open and tethered grazing with the balance from aftermath grazing and crop residues. Tethered grazing is particularly important during the wet season when crops are in the ground. The main livestock feed deficits occur between March and June when crop residues are becoming exhausted and pastures are dry and overgrazed.

Some 95 percent of farmers have trees on their farms of which 90 percent are Eucalyptus spp. These are planted mainly around their homesteads. The average number of trees is 260. On-farm tree planting accelerated after 1990 following the change in government policy with respect to tree planting.

(ii) Teff Systems

In the Woina Dega agro-ecological zone between 1,500 masl to 2,300 masl the teff-based farming system predominates in Amhara Region. Within this broad category are two variants: a teff-maize-sorghum system in the high rainfall areas of west Amhara Region and a teff-wheat-sorghum system in the drier areas of eastern Amhara Region.

Average farm sizes vary from 2.07 ha in western Amhara and 1.26 ha in eastern Amhara. Crop yields in eastern Amhara are lower than western Amhara. In the latter farms produce an average surplus over subsistence requirements of 750 kgs of grain compared with a deficit of 96kgs per household in eastern Amhara. As in the previous farming system some grain is purchased from sales of livestock. Increasingly, deficits are being made up from food aid and food for work.

Ox:cow ratios vary between 1.35 to 1.47 indicating an emphasis on draught power. Cattle herd sizes are between 3.6 and 4.2 animals. Sheep to goat ratios in the west are very high at 4.4 but lower in the drier areas of the east indicating a larger proportion of goats. In many areas hay on private plots is an important source of livestock feed.

There are distinct differences among the two systems with respect to on-farm tree planting. In eastern and western Amhara region Eucalyptus species constitute 90 percent of on-farm trees. The number of Eucalyptus trees per farmer varies considerably: 225 and 180 trees in western Amhara and eastern Amhara respectively. Over the past 15 years the rate of on-farm Eucalyptus planting has varied among the systems. In western Amhara the rate has steadily increased to 33 trees per year, and in eastern Amhara it peaked at 19 trees/annum between 1994-97 and since declined.

4.3.3 Western Highlands

The Western Highlands are located south of the Abay in Oromiya and highland Beneshangul-Gumuz Regions. There are three main farming systems found in the western Highlands: enset based; maize-teff-coffee and wheat-maize.

(i) Enset-based:

The enset systems are based on enset with maize at lower altitudes (below 2,300 masl) in the upper Didessa Valley around Bedele, and wheat at higher altitudes. Although relatively small in planted area enset (or its derivative "*kocho*") provides from 40 to 60 percent of food supply. Root crops (sweet and Oromo potato) and vegetables are important homestead garden crops. In the enset-maize system coffee is an important cash crop below 2,000 masl.

Livestock production is based on draught power and milk production. Livestock feeding systems are intensive in the densely populated areas with crop residues and enset leaves comprising upto 40 percent of total feed supply.

Tree planting is becoming important. Eucalyptus is being planted around homesteads and on field boundaries for building poles and for sale. Many scattered trees remain in the fields and remnant forest or woodland on hillsides. Coffee may be planted under large trees (e.g. Ficus) for shade.

(ii) Maize-teff-coffee

The dominant crops are maize and teff and some sorghum. Below 2,000 masl coffee is an important cash crop. Some root crops (sweet potato and Oromo potato) are grown in homestead gardens, occasionally with a small enset plot.

Livestock include cattle, sheep and goats. Cattle are important for draught power, milk and as a store of wealth. Livestock feed supply comprises open grazing, crop residues and grass hay. Because open grazing is still available (although decreasing rapidly), cropping, livestock production and tree growing are not closely integrated.

Tree planting, mainly of Eucalyptus, is relatively common around homesteads, and more rarely on field boundaries. Fuel wood stocks are relatively plentiful but are being harvested well above their sustainable yield. Annual per capita consumption rates are 900 to 1,100 kgs. In the sorghum growing areas stalk residues are used as fuel, however, elsewhere little or no residues or dung are being used as fuel.

(iii) Wheat-maize

Above 2, 300 masl wheat and barley replace maize and teff with horsebean and field pea. Barley becomes increasingly important above 2,600 masl.

Livestock include cattle, sheep and goats. Cattle are important for draught power, milk and as a store of wealth. Livestock feed supply comprises open grazing, crop residues and grass hay.

Tree planting, mainly of Eucalyptus, is relatively common around homesteads, and more rarely on field boundaries. Indigenous trees are not managed. Fuel wood stocks are relatively plentiful but are being harvested well above their sustainable yield

3.1.4 Western Lowlands

Within the Western Lowlands four major farming systems have been recognized.

(i) Moist Woina Dega: Teff-Maize-Sorghum

This farming system is practiced mainly by the Oromo, Amhara, Shinasha and Agew people found in the Woina Dega agro-ecological zone north and south of the Abay River. Farmers use oxen and grow teff, maize, sorghum. finger millet and noug (niger seed). Average cropped area is 2.57ha.

Livestock comprise cattle, sheep and goats, with goats dominating the small stock. Cattle are kept for draught purposes, milk and as a store of wealth. Oxen to cow ratios are 0.96 indicating that cows are relatively important. Sheep to goat ratios are 0.15 indicating the relative importance of goats. Small stock are a very important as a ready source of cash.

Large open fields characterize the agricultural landscape. Some 58 percent of all trees in the landscape are found around the homestead. Indigenous trees dominate in terms of numbers on farmland. Field boundaries are generally unmarked although a small proportion of all trees (18 percent) is found on field boundaries. There are no infields (enclosed or not). Homestead gardens are very small or absent.

(ii) Finger millet, sorghum, maize, sesame and groundnut practiced by the Gumuz, Senashe, Oromo and Agew people

These land use systems are found in the Kolla agro-ecological zone in the western parts Metekel and the eastern parts of Kamashi administrative zones. The system is practiced by the Gumuz people and by Amhara, Agew, Oromo and Shinasha people with no oxen. Finger millet dominates the crop mix, followed by maize and sorghum. Sesame and groundnuts dominate the pulses.

Only 11 percent of farmers use manure, none use compost and only 4 percent weed compost in the cropping system. Some 20 percent of the farmland is under bush fallow, although only 28 percent of all trees are left in fields or placed on field boundaries. No farmers have multi-purpose trees (i.e. for fuelwood/fodder). Only 11 percent of farmers feed livestock with leaves from indigenous trees. Most households obtain most of the two major types of fuel for energy from Communal Lands and Communal woodlands, with only 15 percent coming from their own farms. Crop residues are relatively small contributor to household energy consumption, and dung not at all.

Communal lands are found on the extensive margins to the main village area. The main croplands are often found on or close to streams and rivers on flat slopes and deep soils. Beyond the intensively cropped areas are more extensive lands on steeper slopes and shallower soils. These lands may be cropped using a bush fallowing system. They also provide the main grazing and browsing areas for livestock, and the main sources of fuel wood.

Overall, this farming system is extensive with changes mainly taking occurring as population expands the cultivated area into shrubland and woodland. The expansion of the market for sesame seed for sale has probably led to an expansion of cropland in this important cash crop.

(iii) Sorghum-maize-noug land use system of the Berta/Komo/Mao

This system is practiced by the Berta, Komo and Mao people south of the Abay River. Farmers grow sorghum, maize, noug, and haricot beans A few goats are kept.

Livestock holdings in this land use system are very low. Less than 7 percent of households have cattle, but 47 percent have goats. Most of the system lies within areas of high tsetse challenge, and are thus exposed to trypanosomiasis.

Some 17 percent of farmers are using manure as fertilizer. No farmers have planted multipurpose trees. Some 20 percent of farmers feed their livestock with leaves of indigenous trees. The majority of households obtain most of their wood fuel from the communal lands. Crop residues (12 percent) is a minor contributor to the household energy supply only in the wet season. No dung is burnt.

Communal lands are found on the extensive margins to the main village area. The main croplands are often found on or close to streams and rivers on flat slopes and deep soils. Beyond the intensively cropped areas are more extensive lands on steeper slopes and shallower soils. These lands may be cropped using a bush fallowing system. They also provide the main grazing and browsing areas for livestock, and the main sources of fuel wood. Overall, this farming system is extensive with changes occurring as population expands the cultivated area into shrubland and woodland.

(iv) Finger millet, sorghum and rice land use system of Settlers of Pawi

This farming system is found on the settlement area of Pawi, which comprised the Tana-Beles Resettlement Project of the 1980's. The settlers are a mix of ethnic groups, mainly comprising Amhara and Kambata-Hadya peoples. The area is located on both sides of the Beles River. A high proportion of farmers grow rice, otherwise their crop mix was similar to that of the Gumuz. In area terms, millet, sorghum and rice are the most important crops. Rice (mainly rainfed) is grown as a cash crop on contract.

In this land use system also, a larger proportion of households own oxen than own cows. The ox:cow ratio is 1.49 indicating an emphasis on draught power in the livestock production objectives of this land use system. The sheep:goat ratio of 5.21 indicates a clear preference for sheep.

In the land use system integration among crops, livestock and trees is moderately well developed. Cattle production objectives focus on draught power for crop production. Crop residues and stubble grazing are important sources of livestock feed. Some 47 percent of farmers use manure compared with only 20 percent who use chemical fertilizer. However, no farmers put animals in their fields to fertilize them, although tethered grazing is used by nearly a fifth of livestock owners during the wet season.

This land use system was established as a resettlement area during the 1980's. Land was cleared by the Government and considerable physical infrastructure (roads, water supplies, etc) also provided. Fields tend to be very large with the main woodland and shrubland located along stream-lines and beyond the cleared areas.

The Resettlement area was largely cleared and infrastructure in place by 1990. There has been some movement out as well as in since 1990. There has been little or no on-farm planting of trees in contrast to land use systems 1 and 2. This may be the result of perceived tenure insecurity on the part of the Settlers or that they do not see themselves as permanent residents.

4.4 Social Infrastructure: Health and Education

4.4.1 Health Infrastructure and Health

The data of health infrastructure and health status were taken from the data base of the World Bank's Country Economic memorandum and adjusted to take account of the area and population of the river basin.

Details of health infrastructure and health workers are shown in table 25.

Table 25. Details of health Infrastructure and Workers in the Abay River Basin.

BASIN/REGION	Health Professional/'000 pop.	No. Health Professionals	Health Infrastructure (hospitals, clinics, dispensaries/'000 pop.	No. of health infrastructures
ABAY BASIN				
Amhara	0.27	2,797	0.09	**913**
BSG	0.87	587	0.29	**192**
Oromiya	0.26	1,430	0.11	**619**
Total	**0.29**	**4,813**	**0.10**	**1,723**

The number of health professionals/'000 population is much higher in the Beneshangul-Gumuz Region. This figure is a reflection of the low population numbers. However, health infrastructure is much lower in that Region for the same reason.

Accessibility and the ratio of health workers to the population are key determinants in the number of people who are immunized. This is shown clearly in table 15 where the very low rate of immunization in BSG Region stand out clearly. Malaria is prevalent below 1,500 masl and possibly in areas just above this altitude. The percent area exposed to and the percent of the population vulnerable to malaria are also indicated in table 26.

Table 26. Percent Population Immunized, Percent Population vulnerable to and Area Exposed to Malaria in the Abay River Basin.

BASIN/Region	% Pop. immunized	% Pop. vulnerable to malaria	% Area exposed to malaria
ABAY BASIN			
Amhara	62%	47%	**55%**
BSG	28%	73%	**74%**
Oromiya	40%	49%	**52%**
Total	53%	49%	**55%**

The BSG Region in the Abay Basin has the highest proportion of the population vulnerable to malaria. Just fewer than half the populations in Amhara and Oromiya Regions are so vulnerable.

4.4.2 Educational Infrastructure and Educational Enrolment

The data of education infrastructure and health status was also taken from the data base of the World Bank's Country Economic memorandum and adjusted to take account of the area and populations of the Abay river basin.

The number of Primary and Secondary Schools and the population in the generally accepted age groups for Primary (>5 and <12 years) and Secondary school (>11 and <20 years) per School are shown in table 27.

Table 27. Number of Primary and Secondary Schools and Percent Enrolment in the Abay River Basin

BASIN/Region	No. Primary schools	Pop >3 & <12 yrs/Primary school	No. Secondary Schools	Pop. >11 & <20yrs/Secondary School
ABAY BASIN				
Amhara	2,160	1,572	78	**39,570**
BSG	252	1,067	12	**16,930**
Oromiya	2,155	1,040	72	**23,251**
Total	**5,017**	**1,318**	**162**	**30,623**

Generally, the BSG and Oromiya Regions located within the Abay Basin appear to be better endowed with Primary schools in relation to the target population. With respect to Secondary Schools BSG again appears to be better endowed. Amhara region with its much larger population is clearly at a disadvantage. Enrolment rates for Primary and Secondary Schools are shown in Table 30.

Table 30. Gross Primary and Secondary School Enrolment Rates in the Abay River Basin

BASIN/Region	% Enrolment Primary School	% Enrolment Secondary School
ABAY BASIN		
Amhara	61%	**12%**
BSG	109%[22]	**16%**
Oromiya	64%	**5%**
Total	**64%**	**10%**

The BSG Region has the highest Primary and Secondary School enrolment rates. It is possible that the relatively sparse but clustered settlement pattern in BSG facilitates better physical accessibility to schools and thus to higher enrolment rates

4.5 Transport Infrastructure and Markets

4.5.1 Transport Infrastructure

Given the extreme dissection of the highlands by the Abay River and its tributaries road infrastructure is not well developed. As can be seen on map 16 the all-weather roads tend to be confined to the ridges and plateaus

[22] It is not clear how a gross enrolment rate >100% can be achieved. It is noticeable that Gambela Region also has rates >100%.

between the deeply incised rivers. For example, the Abay has only three road crossings. Thus both road construction and vehicle running costs are high.

Within the Abay basin the length and density of all weather and dry weather roads is as follows:

Table 28. Length and density of All-weather and Dry-weather Roads.

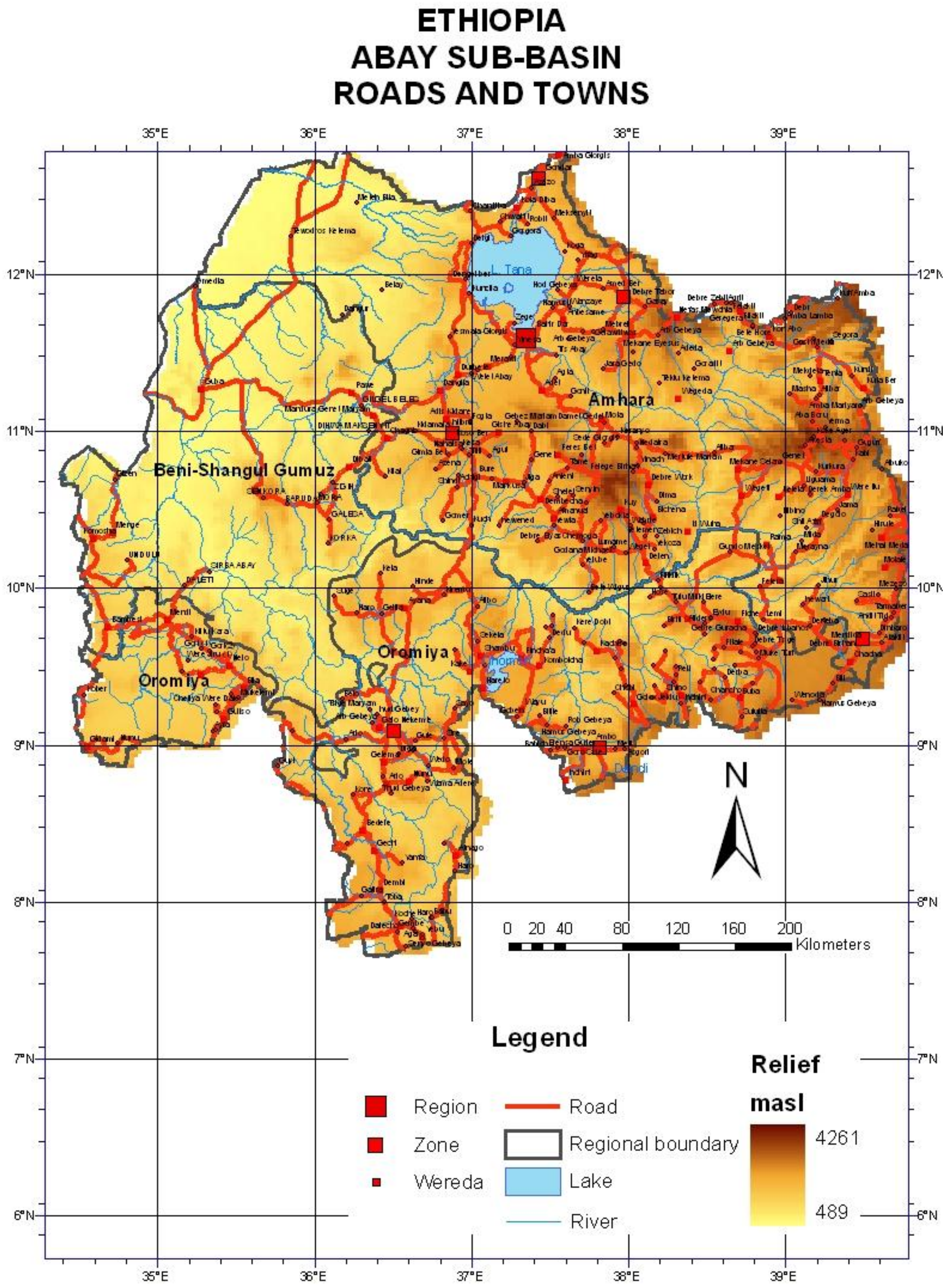
BASIN	TYPE	LENGTH (KM)	DENSITY (KM/1000KM2)
ABAY	All weather	6,324	**32**
	Dry weather	2,922	**68**
	Total	**9,246**	**47**

The length of all-weather roads in the two basins is significantly greater than dry-weather roads. This may be a reflection of the degree to which dry weather roads have been mapped. The road density for Amhara, Beneshangul-Gumuz and the western part of Oromiya Regions are as follows:

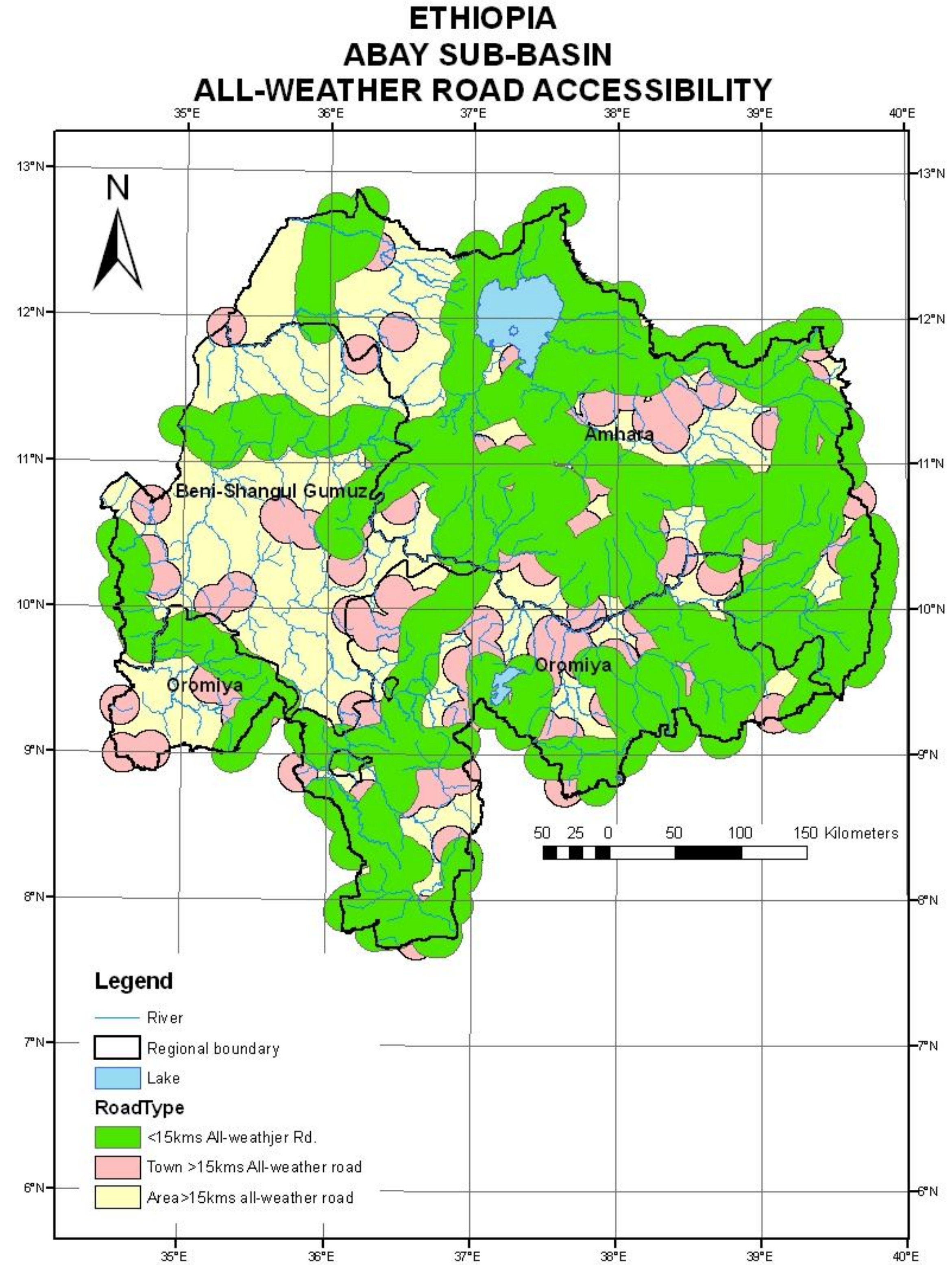
Tigray	-	44km/1000km2	
Amhara	-	46	"
BSG	-	29	"
Oromiya – West Wellega	-	17	"
Oromiya – East Wellega	-	38	"
National	**-**	**31**	**"**

The road density is much lower in the sparsely populated Beneshangul-Gumuz Region and West Wellega Zone of Oromiya.

In terms of accessibility to all-weather roads some 45 percent of the area of the Sub-basin is more than 15 kms distance. (Map 17) This compares with 39 percent in the Tekeze Sub-basin and 63 percent in the Baro-Akobo Basin. The main areas of inaccessibility are located in the western parts of North and South Wello in the Abay Gorge; the middle and the Lower Abay Gorges; and the western Lowlands of the Dinder and Beles Valley



Map 16. Ethiopia – Abay Sub-basin: Road network, Administrative Capitals and other Towns



Map 17. Ethiopia – Abay Sub-basin: Accessibility to All-weather Roads.

5. THE TEKEZE RIVER BASIN - BIOPHYSICAL AND SOCIO-ECONOMIC SITUATION

5.1 Biophysical Characteristics

5.1.1 Location and Physiography

The Tekeze basin is located in northwestern Ethiopia and covers approximately 82,476km^2 (Map 18). Two landscape units identified in Abbay basin extend into the Tekeze basin. These are the flat and undulated lowlands close to the Sudan border and the mountainous relief that border the eastern limit of the basin. The incised nature of the Tekeze River mirrors that of the Abbay River. However, the altitude ranges are smaller within the Tekeze basin and the drainage pattern is more dendritic. The Tekeze basin is also characterized by the presence of isolated volcano necks, highly contrasting with the surrounding undulated relief.

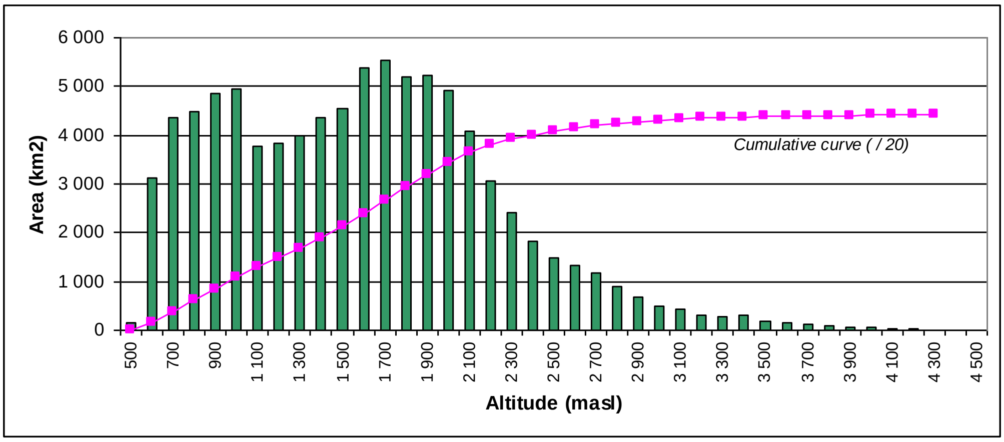
Approximately 70% of the Tekeze river basin lies in the northern highlands of Ethiopia with altitude of more than 1,500 masl, with almost 40% of the basin being above 2,000 masl (Table 29 and Figure 8). The highlands have a mountainous to hilly topography, interspersed with flat to rolling plateaus and plains. Volcanic domes and cones form high relief in many areas. The upper reaches of the basin are surrounded by mountain ranges with a maximum altitude of 4,600 masl at the mountain of Ancua, part of the Ras Dashan system. Plateaus and benches terminate in steeply dissected escarpments, where resistant strata have been broken down by geological erosion. Extremely rugged topography exists where the highlands are cut into a number of blocks by deeply incised gorges of the Tekeze River and its tributaries. To the west, the highlands give way to flat to rolling lowlands along the Sudanese border. The elevation of the lowlands varies between 500 and 1500 masl. The topography is almost flat or slightly undulating, becoming more and more undulating to the east.

The relief (Map 17) reflects these main physiographic regions. For instance, the lowlands are well contrasted with the highlands. The transition zone is highly rugged, mainly around the Tekeze valley. The high plateaus are concentrated in the middle of the basin and extend to the Lake Tana physiographic unit.

Table 29. Elevation classes of the Tekeze basin

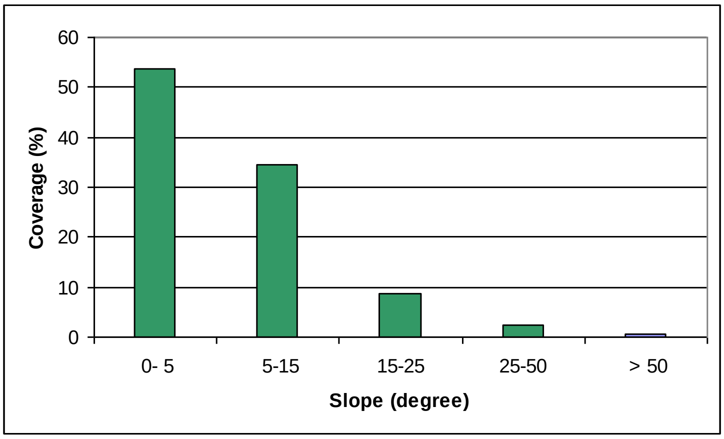
Contours (masl)	Area (km^2)	% of basin
500 – 1000	14,299	17%
1000 – 1500	17,621	21%
1500 – 2000	25,512	31%
2000 – 2500	18,167	22%
2500 – 3000	4,701	6%
3000 – 3500	1,542	2%
3500 – 4000	527	1%
>4000	108	0.1%
	82,476	

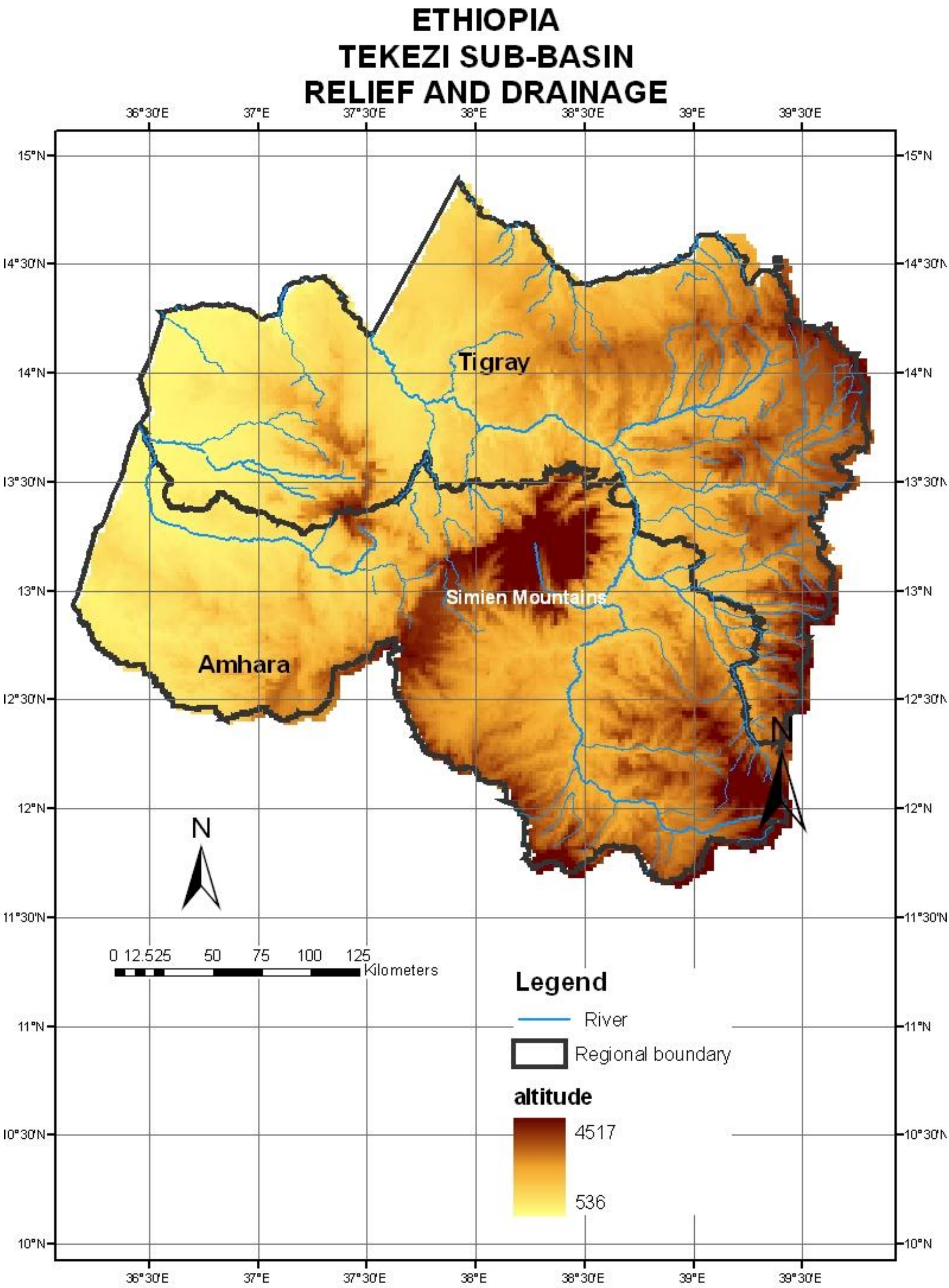
Figure 8. Distribution of lands per altitudinal class



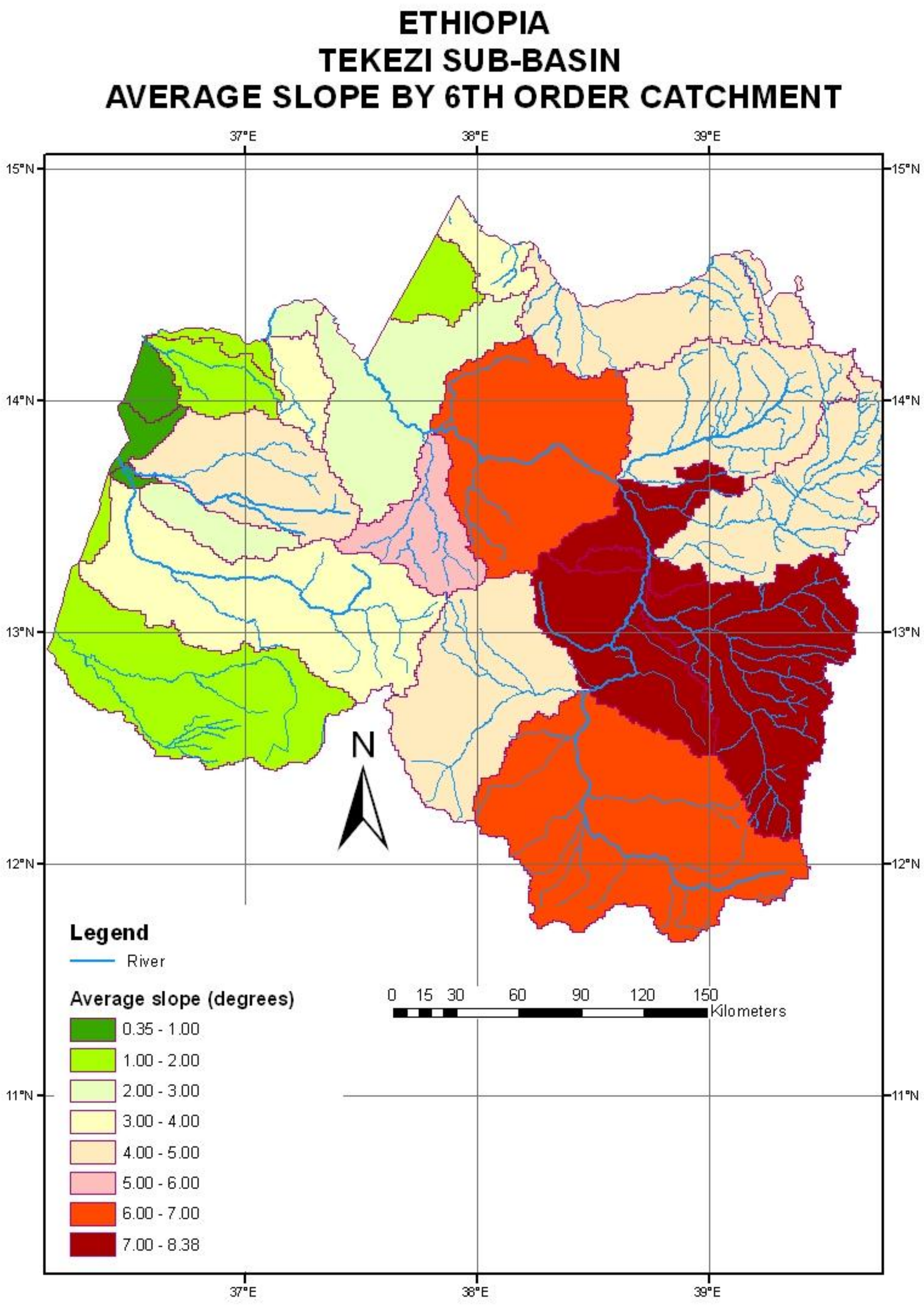
The slope distribution pattern reflects the flat to undulating lowlands in the west, as well as the mountainous ridge in the centre of the basin. As with the Abbay basin, most of the land has slope lower than 15 degrees (Figures 9 and Map 19).

Figure 9. Relative area covered per slope class





Map 18. Ethiopia - Tekezi Sub-basin: Relief and Drainage



Map 19. Ethiopia – Tekezi Sub-basin: Average Slope by 6th Order Catchment (degrees)

5.1.2 Climate

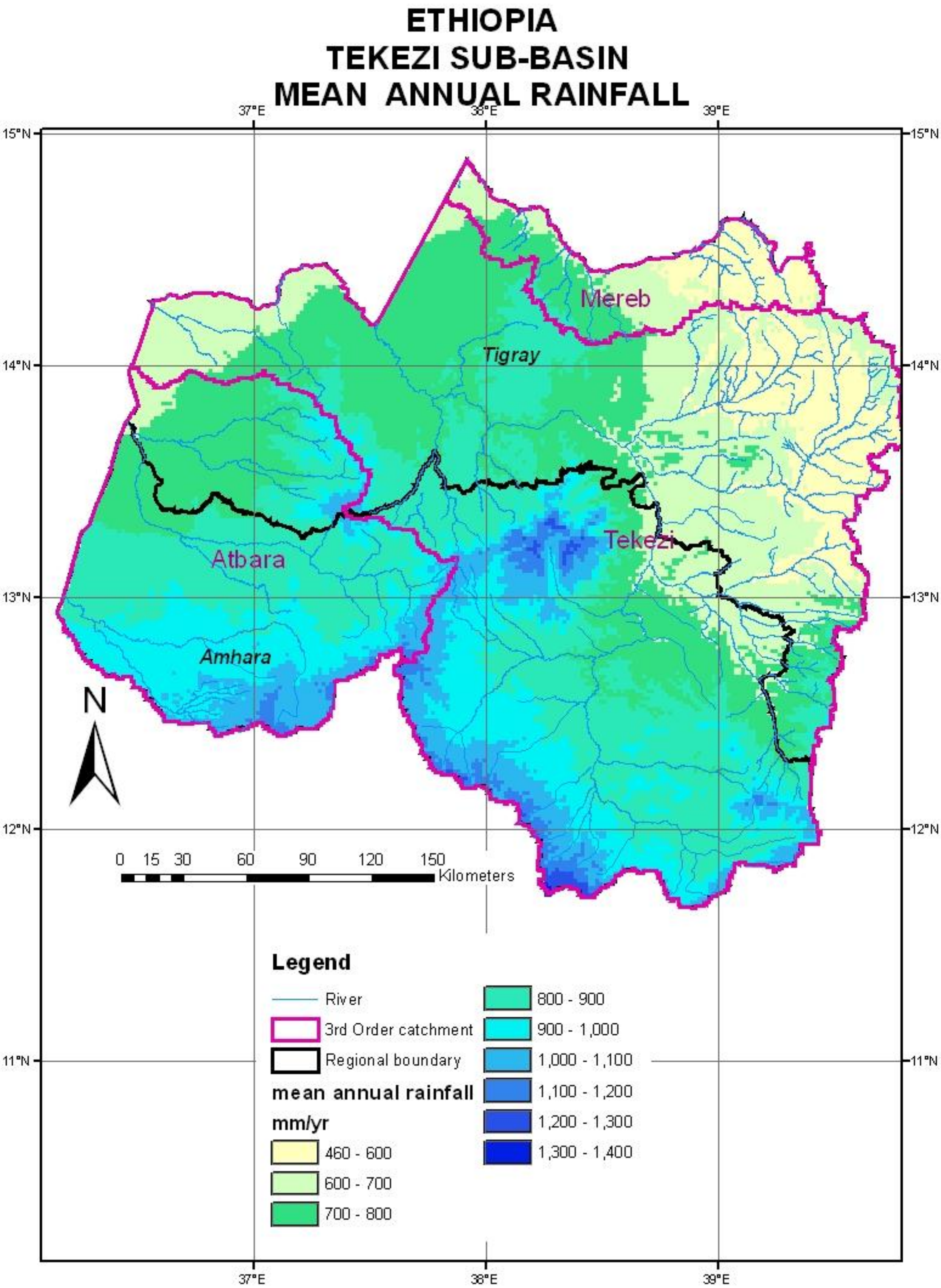
(i) Rainfall

Mean annual rainfall in the basin varies between 466 mm (Hawzen) and 1,312.8 mm (Zarima). The highest rainfall values are recorded in the mountainous ridge in the centre of the basin, and in the south and south-east, close to Lake Tana (Map 20). The lowest amounts are located in the north-east region of the basin.

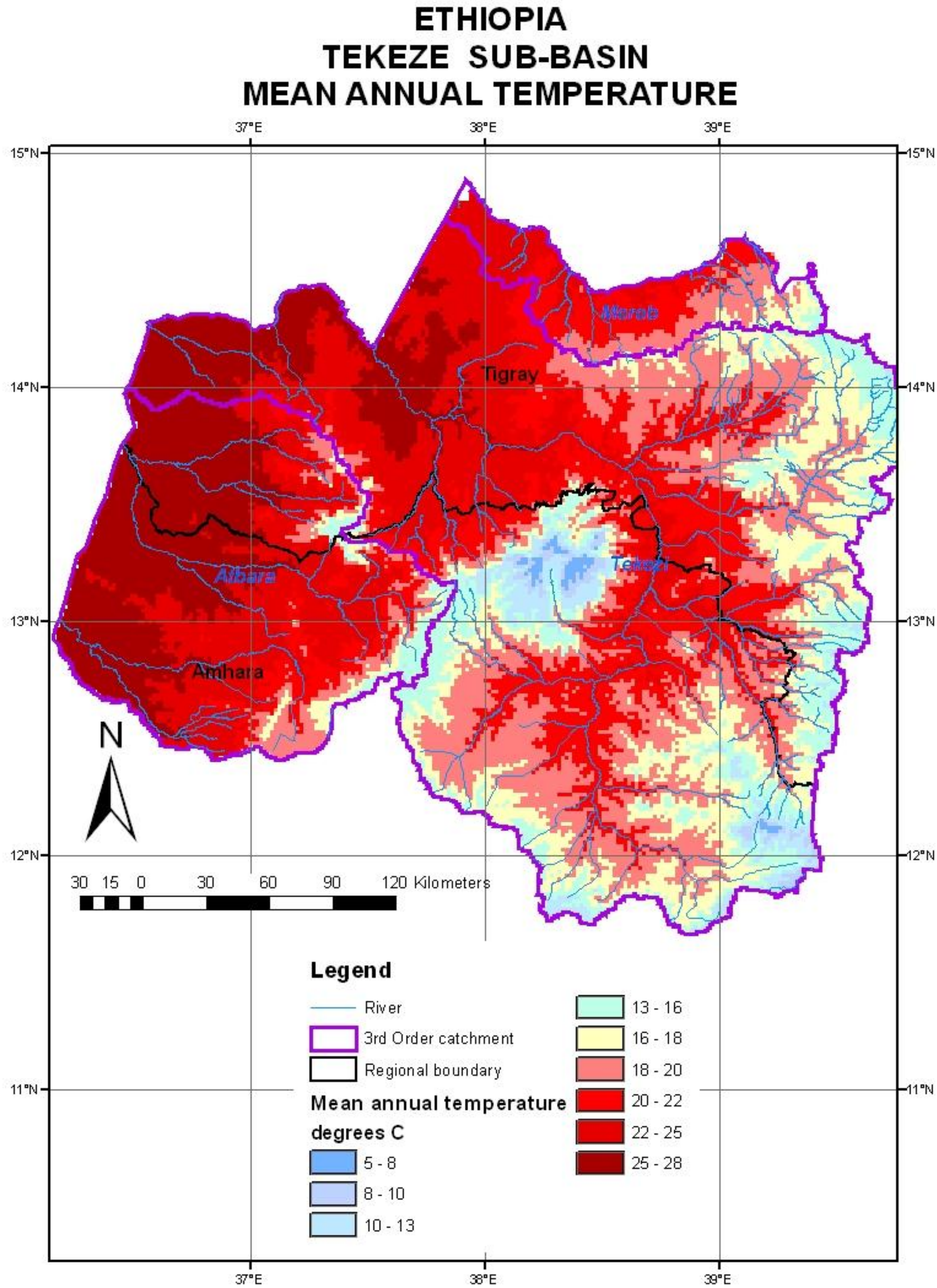
A uni-modal wet season is found to the west of the Simien massif. The wet season lasts about four months, from June to September. East of the Simien massif the rainfall pattern in bi-modal, characterized by two wet seasons. The "*Belg*", or short rainy season, occurs from mid-February to mid-May. However, the rainfall is characterized by inter-annual and inter-seasonal variations. This short rain period is of some agricultural importance, particularly in the north-east where annual rainfall is low. The "*Kiremt*" or main rainy season lasts from June to September.

(ii) Temperature

Lowest minimum mean monthly temperatures occur between December and February, ranging between 3 and 21^{o}C. Highest maximum mean monthly values occur in March – April and range between 19 and 43^{o}C. The spatial distribution of temperature values is strongly related to altitude, resulting in highest values in the lowlands, and lowest ones in the mountain ridges located in the centre and close to the south-east limit of the basin (Map 21).



Map 20. Ethiopia – Tekezi Sub-basin: Mean Annual Rainfall



Map 21. Ethiopia – Tekeze Sub-basin: Mean Annual Temperature (degrees C)

(iii) Humidity

The minimum mean monthly relative humidity values occur during the dry season from October to March. Maximum values are recorded during the main rainy season (July – August). Humidity values drop to 40 % during the dry season, and increase to about 70 % during the wet season.

(iv) Wind

Strongest winds are recorded during the rainy season (July – August).

(v) Sunshine

Mean monthly sunshine hours range between 6.5 and 8.5 hrs/day within the basin (i.e. mean values higher than those recorded in Abbay basin). Highest monthly values, up to 10 hrs/day, occur during the dry period and the lowest ones (below 4 hrs/day) occur during the rainy season, especially in the months of July and August.

(vi) Evapotranspiration

The annual potential evapotranspiration varies between 1276 mm/yr (Afkura) and 2,331 mm/yr (Humera), as calculated by Penman method.

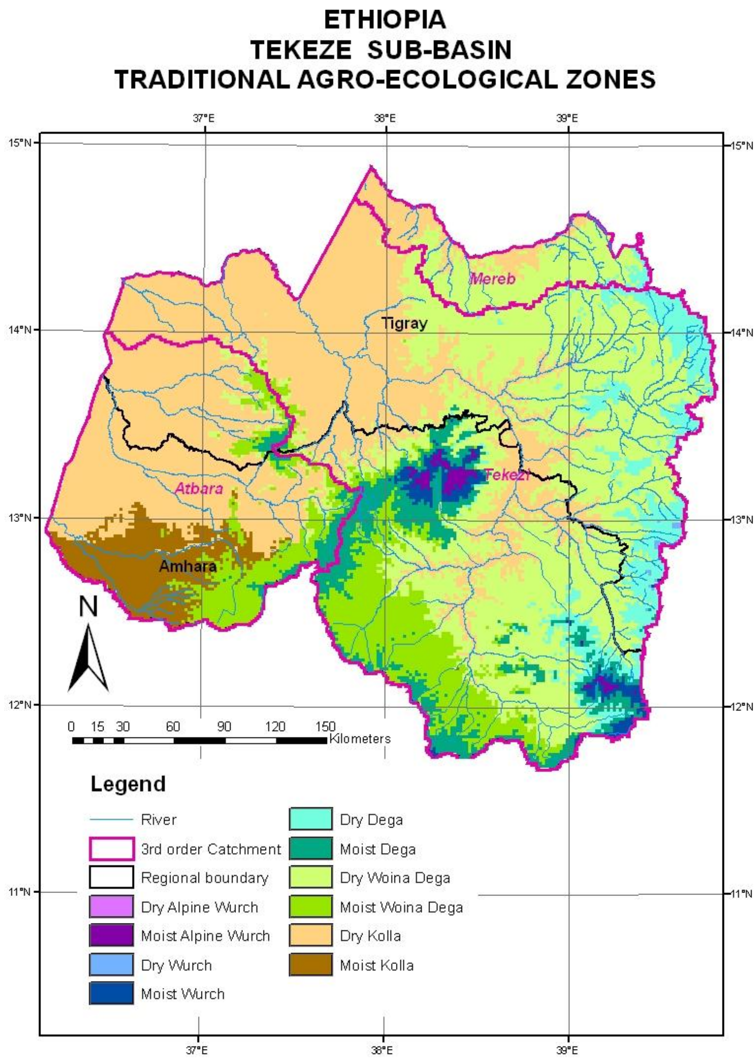
(vii) Agroecological zones

Dry Kolla and dry Weina Dega cover respectively 38 % and 32 % of Tekeze basin (Table 30). The first agreocological zone is located in the lowlands and extends within the Tekeze valley, while the dry Weina Dega dominates in the plateau on the east side of the basin. The moist Weina Dega represents 10 % of the basin and it is mainly concentrated in the south, close to Lake Tana. It also extends along the piedmont of the central mountainous ridges and along a ridge that extends into the lowlands (Map 22).

The moist Kolla zone is found in the south portion of the lowlands. This zone represents approximately 5 % of the basin, similar to the moist Dega (6 %) and the dry Dega zones (6 %). These two zones are concentrated along the central mountainous ridge and within the highlands that divide Tekeze and Abbay basins. In the highest parts of the basin are found the moist and dry Alpine Wurch zones.

Table 30. Area of the Agroecological zones within Tekeze basin (in percentage)

Agroecological zone	%
Dry Alpine Wurch	0,00%
Moist Alpine Wurch	0,46%
Dry Wurch	0,07%
Moist Wurch	1,34%
Dry Dega	6,15%
Moist Dega	6,28%
Dry Weina dega	32,42%
Moist Weina dega	10,46%
Dry Kolla	38,09%
Moist Kolla	4,73%



Map 22. Agroecological Zone Map of Tekeze basin

5.1.3 Geology

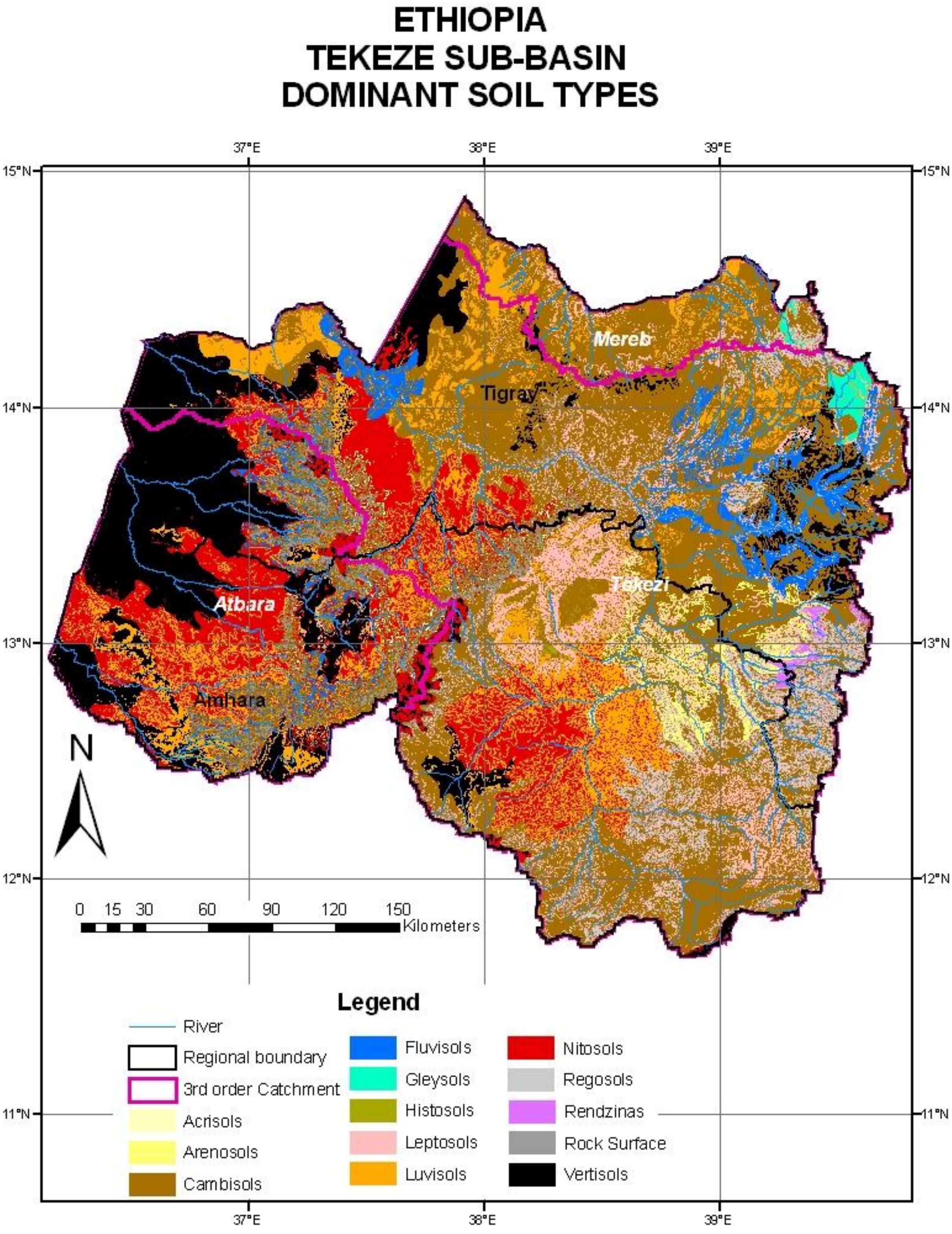
The geology of Tekeze basin can be summarized as follows: the southern half portion is composed of basic to ultrabasic rocks, mainly basalts, while the northern portion is composed of various layers of sedimentary rocks (including sandstones, shales and limestones), as well as metamorphic rocks, such as gneisses and marble. However, given the incised nature of the Tekeze drainage network, the sedimentary and metamorphic rocks are often exposed below the basalts.

5.1.4 Soils

Leptosols are developed over almost 50 % of Tekeze basin (Table 31 and Map 24). Luvisols and vertisols are ranked second and third, covering respectively 19 % and 10 % of the basin. These units are concentrated in the lowlands, as well as at the upper head of Tekeze River and north-east of Lake Tana. Cambisols, which cover the same area as Vertisols (10 %), are mainly scattered in the north and north-east regions of the basin. Finally, two main zones containing Nitisols are observed within the basin: as a strip in the central region and secondly in a south-east north-west direction, close to Tekeze valley. They cover some 3 % of the whole basin.

Table 31. Coverage of the Soil Groups within Tekeze basin (in percentage)

Major Soil Group	Area (km2)	Coverage %
Leptosols	44,984	**54.54%**
Luvisols	15,783	**19.13%**
Cambisols	8,917	**10.81%**
Vertisols	8,480	**10.28%**
Nitisols	2,526	**3.06%**
Lixisols	1,590	**1.93%**
Calcisols	107	**0.13%**
Regosols	89	**0.11%**
	82,476	



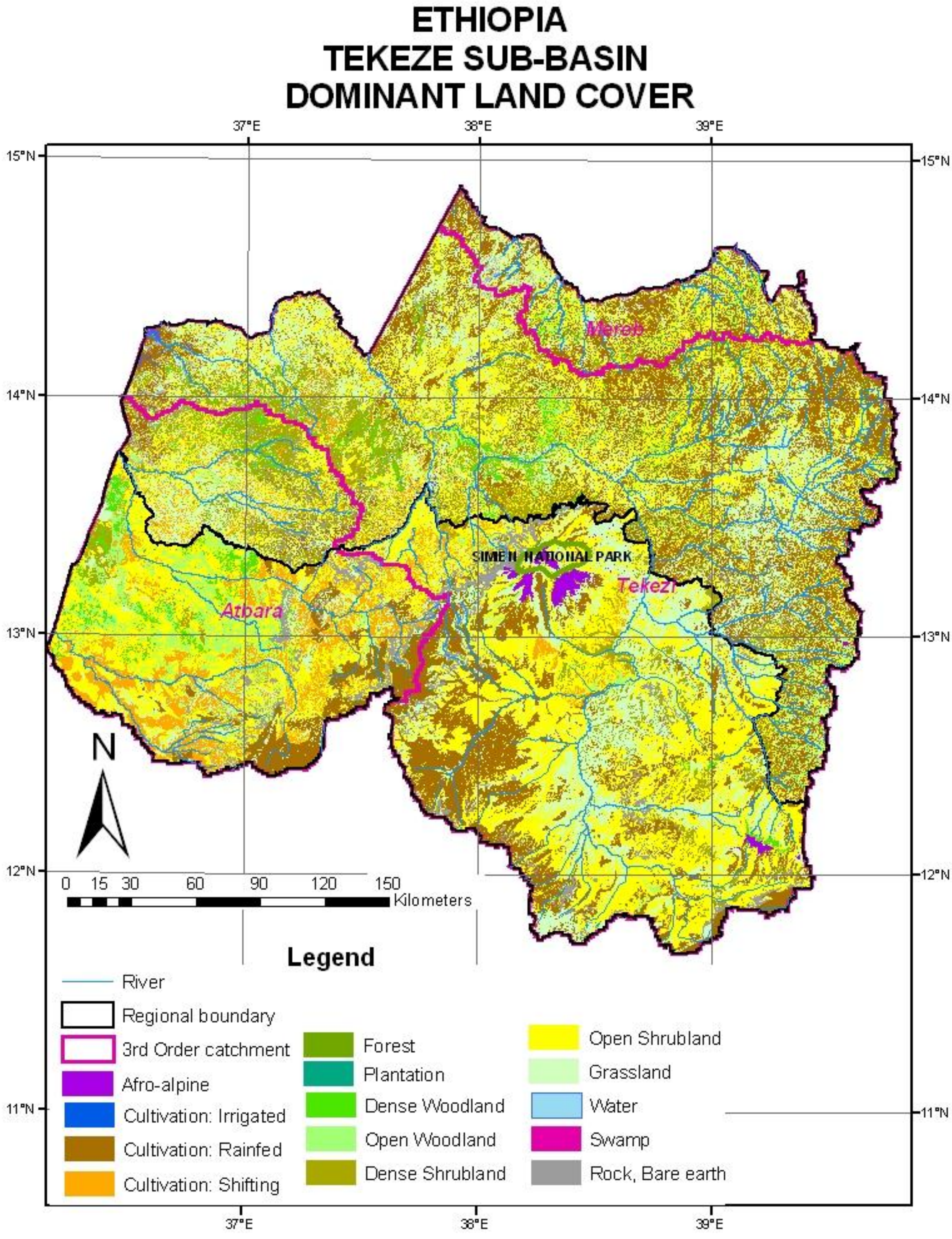
Map 23. Ethiopia – Tekeze Sub-basin: Dominant Soil Types (FAO Classification)

5.1.5 Land Cover / Land Use

Shrublands cover approximately 40 % of Tekeze basin (Table 32). However, agricultural activities occupy an important proportion, with cultivated lands and grasslands covering 27 % and 21 % of the basin respectively. Shrublands are mainly found in the lowlands, as well as in the dissected highlands around the upper head of Tekeze River in the south-east (Map 24). Cultivated lands are well distributed over the basin, with a higher percentage in the north and the high plateau that reaches to Lake Tana. Woodlands cover 6 % of the basin and are mainly located in the south-west part of the lowlands. Barelands (rock and bare soil) are relatively important and total approximately 5 % of the basin. They are scattered all over the basin, with a higher concentration within the gorge of Tekeze River, as well as within the central mountainous ridge. Forests and afro-alpine vegetation represent less than 1 % of Tekeze basin.

Table 32. Coverage of the major land cover types within Tekeze basin (in percentage)

Land cover type	Coverage (%)
Shrubland	40,02%
Agriculture land	27,49%
Grassland	20,91%
Woodland	6,01%
Bareland	4,74%
Afro-alpine vegetation	0,45%
Forest	0,26%
Water body	0,11%
Wetland	0,00%



Map 24. Ethiopia – Tekeze Sub-basin: Dominant Land Cover

5.1.6 Water Resources

The three main rivers originating from Ethiopian highlands and which are the main water sources for Atbara River in Sudan are Tekeze, Angereb and Goang. The Goang becomes the Atbara in Sudan with its main tributaries being the Angereb and the Tekeze. In Sudan the Tekeze becomes the Setit.

The Tekeze River travels more than 750 km, from its source near Lalibela and down to the Sudanese border. The specific watershed of the Tekeze River is approximately 61,293 km^2, and that of the Angereb-Goang 21,194 km^2. There are also small streams flowing between the two main rivers and draining directly into the Sudan.

The two main rivers have a mountainous/highland upper catchment and a lowland lower catchment. The gradients of all the three rivers are relatively steep, which indicates that the flow velocities of the rivers will be fast. With the main rains falling in a concentrated period of about three months and covering mainly the upper reaches of the basins, a short period of very high flows, followed by a longer period of very low flows characterize these rivers. The minimum flows for Angereb and Goang (on the basis of field trip observations) are as low as 1 m^3/s at the Sudan border, while the minimum flows of the Tekeze river (based on monitoring) are in the order of 2 m^3/s.

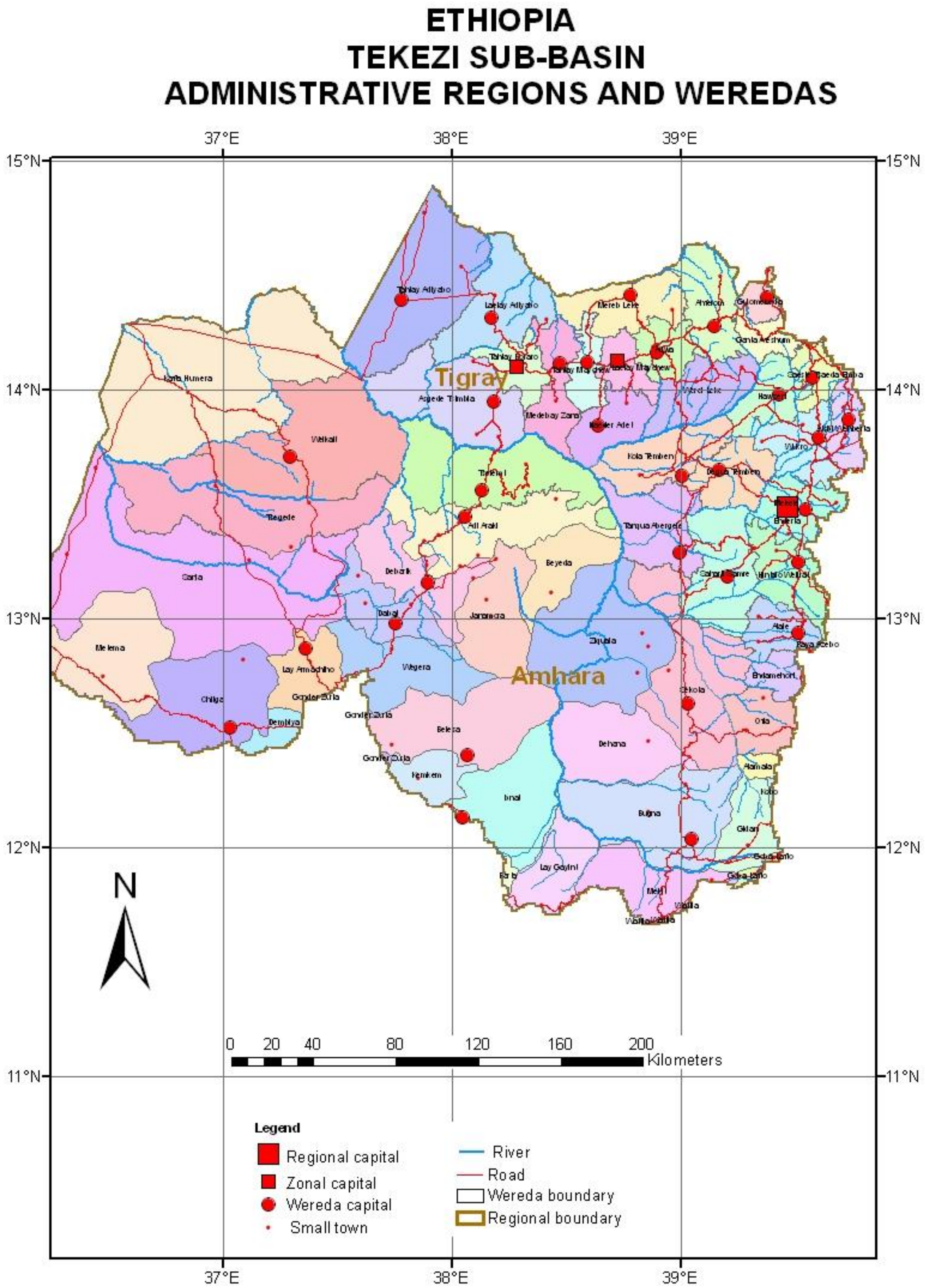
Groundwater depth varies directly in accordance with landscape units, rainfall regions, seasons and geological basement. In general, the groundwater water table is located between 2 and 6 meters in valley bottoms, along main streams. This depth rapidly increases as landscape becomes mountainous or in the northern region, when rainfall conditions are more arid. The most common depth in the north eastern part of the basins is about 12 meters, while water depths in the plateau plains from Adwa to Endaslasie to Gondar are at about 4 meters.

Water yields in these basins range from 0.1 to 10 l/s, with mean values of about 2.6 l/s. The absence of uniform permeable sediments extending over large areas implies that extensive good aquifers do not exist in the basins of the Tekeze, Angereb and Goang rivers. Instead, exploitable groundwater occurrence is limited to isolated areas where groundwater potential may be the result of faulted and fractured zones in the rocks and weathered rocks. About 70 % of the total area of the basins is covered by non-porous volcanic and Precambrian rocks. The remaining part consists of Mesozoic limestones, shales and sandstones of Antalo group and Jurassic Adigrat sandstone. Only some minor Quaternary alluvium exists in the western lowlands. Except for the Quaternary alluvium and tuff deposits, the storage and transport of the groundwater in all these rocks is limited and restricted to the faults, fracture joints and fissures. This means that water is transported not through primary porosity (as this is already filled up with cement of silica, calcium or other minerals), but through tectonic and karst features, broken dykes and dolerites.

5.2 Socio-economic Characteristics

5.2.1 Population Distribution

(i) Administrative units and population



Map 25. Administrative Regions and Weredas in the Tekezi River Basin

The Tekeze basin extends within two administrative regions: Amhara and Tigray (Map 25). Both regions share approximately the same proportion of Tekeze basin, 49 % and 51 % for Amhara and Tigray respectively. The Tekeze basin includes 26 weredas from Amhara and 34 from Tigray. However, some of these weredas also extend into the Abbay basin.

The total population of the Basin is 5.87 million. The proportion of rural population is approximately 88 percent in the Tekezi Basin, with the proportion being 94 percent in the Amhara region and 83 percent in Tigray region. With an urban population proportion of 17 percent Tigray is significantly more urbanized than Amhara Region (tables 33 and 34).

The Tekeze basin extends within two administrative regions: Amhara and Tigray (Map 23). Both regions share approximately the same proportion of Tekeze basin, 49 % and 51 % for Amhara and Tigray respectively. The Tekeze basin includes 26 weredas from Amhara and 34 from Tigray. However, some of these weredas also extend into the Abbay basin.

Table 33a. Ethiopia – Tekezi Sub-basin: Rural and Urban Population (2000)

Basin/Region	Rural population	Urban population	Total population
Tekezi Basin			
Amhara	2,632,694	157,692	2,790,386
Tigray	2,564,362	523,903	3,088,265
Total: Tekezi Basin	**5,197,056**	**681,595**	**5,878,655**

Table 33b. Ethiopia – Tekezi Sub-basin: Percent Rural and Urban Population (2000)

Basin/Region	Rural %	Urban %
Tekezi Basin		
Amhara	94%	6%
Tigray	83%	17%
Total: Tekezi Basin	**88%**	**12%**

Table 34. Population of the Tekezi Basin by wereda

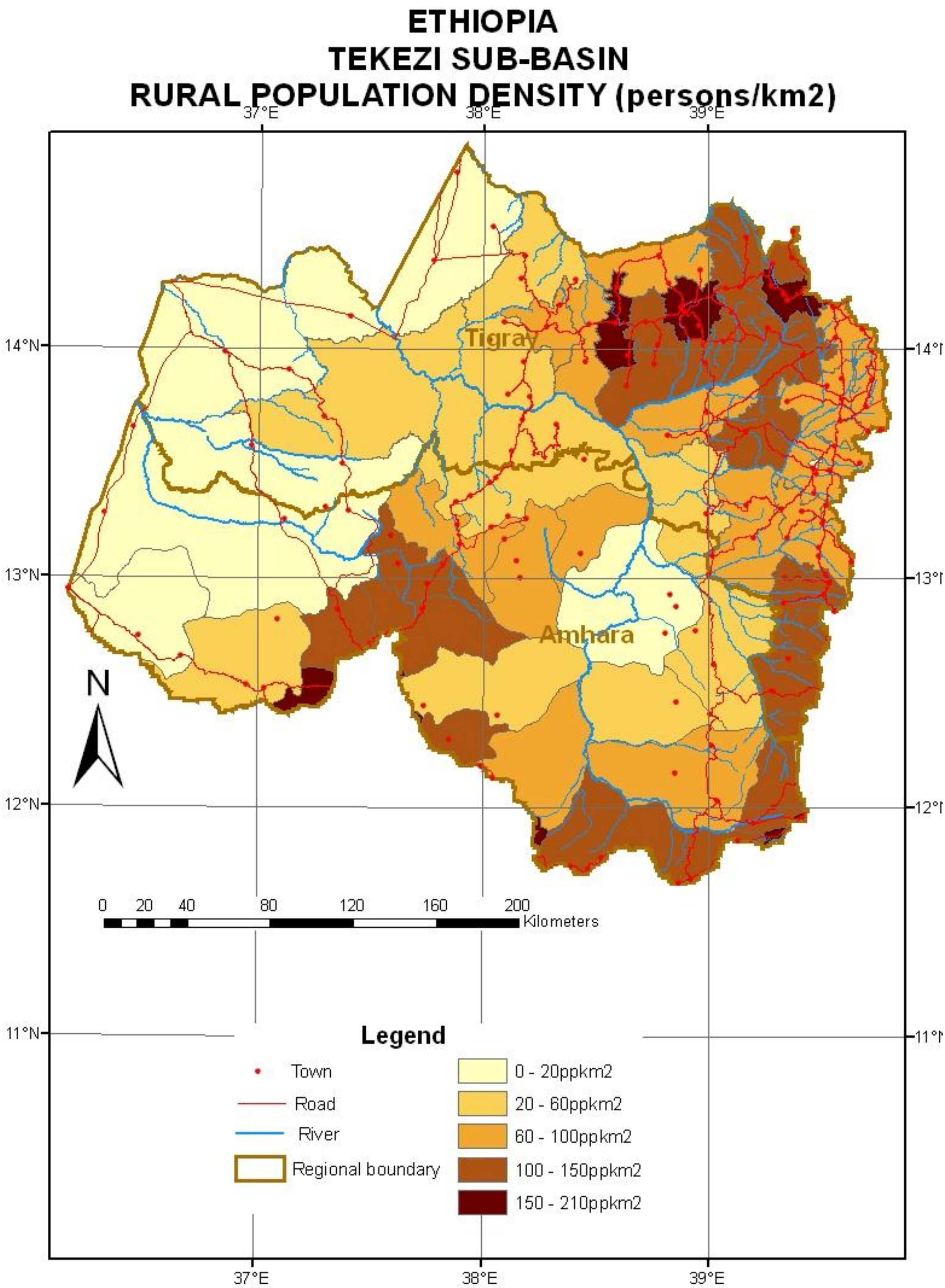
Region	Zone	Wereda	Pop rural 2000	Pop urban 2000	Pop total 2000	Density (hb/km2)	Area (km2)
Amhara	Debub Gonder	Farta	127776	4348	132124	204,95	79,7
Amhara	Debub Gonder	Ibnat	229456	11869	241325	77,89	2071,43
Amhara	Debub Gonder	Kemkem	163712	22660	186372	143,39	699,95
Amhara	Debub Gonder	Lay Gayint	146752	16613	163365	121,66	1167,33
Amhara	Semen Gonder	Adi Araki	116207	8616	124823	45,12	2244,03
Amhara	Semen Gonder	Belesa	156228	7164	163392	59,65	2557,24
Amhara	Semen Gonder	Beyeda	87998	1224	89223	75,88	1154,15
Amhara	Semen Gonder	Chilga	181938	11764	193702	56,63	2592,54
Amhara	Semen Gonder	Dabat	125086	3398	128484	105,55	1178,57
Amhara	Semen Gonder	Debarik	123581	17703	141284	80,77	1510,28
Amhara	Semen Gonder	Dembiya	232960	21609	254569	185,37	357,12
Amhara	Semen Gonder	Gonder Zuria	205387	156498	361885	153,38	29,52
Amhara	Semen Gonder	Janamora	144106	1584	145690	84	1702,4
Amhara	Semen Gonder	Lay Armachiho	131031	5851	136882	123,98	978,81
Amhara	Semen Gonder	Metema	51002	13516	64518	13,43	2523,4
Amhara	Semen Gonder	Sanja	118441	4759	123200	14,52	7136,28
Amhara	Semen Gonder	Wegera	203695	10286	213982	106,34	1775,08
Amhara	Semen Wello	Bugna	189358	10377	199735	64,52	2901,28
Amhara	Semen Wello	Gidan	153113	5048	158161	134,38	960,53
Amhara	Semen Wello	Goba Lafto	164226	30006	194232	165,78	91,27
Amhara	Semen Wello	Kobo	170757	35110	205867	92,68	26,91
Amhara	Semen Wello	Mekit	219675	5823	225499	114,42	1320,32
Amhara	Semen Wello	Wadila	122296	1842	124138	123,6	20,52
Amhara	Wag Hemra	Dehana	109816	2549	112365	55,14	1972,85
Amhara	Wag Hemra	Sekota	141105	10859	151964	44,31	2949,28
Amhara	Wag Hemra	Ziquala	56022	833	56855	16,22	3418,83
Tigray	Central	Adwa	107287	32525	139812	161,16	665,43
Tigray	Central	Ahferom	156808	9811	166619	124,62	1252,69
Tigray	Central	Degua Temben	107820	5216	113036	104,33	1033,56
Tigray	Central	Kola Temben	132824	11767	144591	96,48	1377,55
Tigray	Central	Laelay Maychew	78738	37106	115845	141,54	556,51
Tigray	Central	Mereb Leke	92479	6763	99242	74,05	1229,69
Tigray	Central	Naeder Adet	106188	1492	107681	113,21	937,49
Tigray	Central	Tahtay Maychew	92852	6993	99845	163,03	569,79
Tigray	Central	Tanqua Abergele	70996	3096	74092	49,11	1445,6
Tigray	Central	Werei Leke	129040	6020	135059	107,18	1254,69
Tigray	East	Atsbi Wenberta	80107	6309	86416	70,41	604,06
Tigray	East	Ganta Afeshum	83266	52478	135744	151,6	452,87
Tigray	East	Gulomekeda	72712	8528	81240	117,12	301,86
Tigray	East	Hawzen	89465	5087	94552	105,19	849,59
Tigray	East	Saesie Tsaeda Emba	90935	13985	104920	78,44	512,78
Tigray	East	Wukro	65667	26390	92057	64,8	1004,96
Tigray	Mekele	Mekele	0	128589	128589	0	24,28
Tigray	North West	Asgede Tsimbla	89067	9349	98416	37,12	2399,55
Tigray	North West	Laelay Adiyabo	73903	7865	81768	41,71	1757,96
Tigray	North West	Medebay Zana	90933	8362	99295	86,18	1055,68
Tigray	North West	Tahtay Adiyabo	68173	16928	85101	16,69	3104,5
Tigray	North West	Tahtay Koraro	57501	34477	91978	85,85	669,55
Tigray	South	Alaje	98046	8360	106406	127,81	754,43
Tigray	South	Alamata	78604	42752	121357	107,37	201,18
Tigray	South	Endamehoni	77648	27018	104666	123,52	453,59
Tigray	South	Enderta	118379	16416	134794	81,88	962,68
Tigray	South	Hintalo Wejirat	127987	13136	141123	66,2	1042,08
Tigray	South	Ofla	135980	22752	158732	123,81	842,47
Tigray	South	Raya Azebo	100834	10674	111509	57,08	2,29
Tigray	South	Saharti Samre	107260	5356	112617	62,45	1716,73
Tigray	West	Kafta Humera	32248	21810	54058	5,22	6117,89
Tigray	West	Tsegede	59659	248	59907	18,45	3233,48
Tigray	West	Tselemti	92329	7032	99361	34,16	2703,27
Tigray	West	Welkait	85589	6098	91687	22,46	3811,18

(ii) Distribution of Population

Rural population densities vary from 2 to 250 person/km^2. The highest population densities are found in the highland areas (map 26). The upper Tekezi River valley lies within the rain shadow of the Ras Dejen massive and here densities are lower than the surrounding highlands. The low densities in the western lowlands are caused by the prevalence of malaria. A more appropriate measure of density is persons per unit of arable land or hectares of arable per capita. These are also shown in table 35.

Table 35. Ethiopia – Tekezi Sub-basin: Rural population density (p.p.km2), density per km2 of arable land and hectares of arable land per capita.

Basin/Region	Density total land (ppkm2)	Density arable land (ppkm2 arable)	Hectares arable per capita (rural)
Tekezi Basin			
Amhara	61	77	1.31
Tigray	57		1.61
Total: Tekezi Basin	**59**	**68**	**1.47**



Map 26. Eastern Nile Basin – Ethiopia. Population density by wereda.

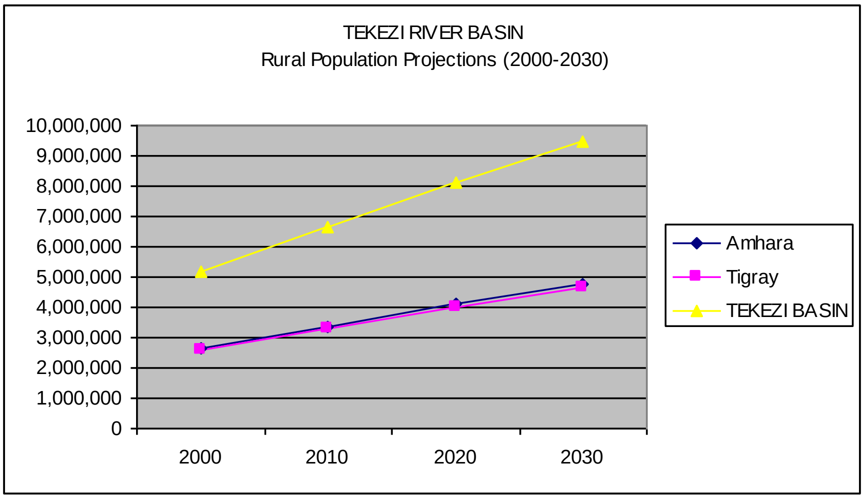
5.2.2 Population Projections

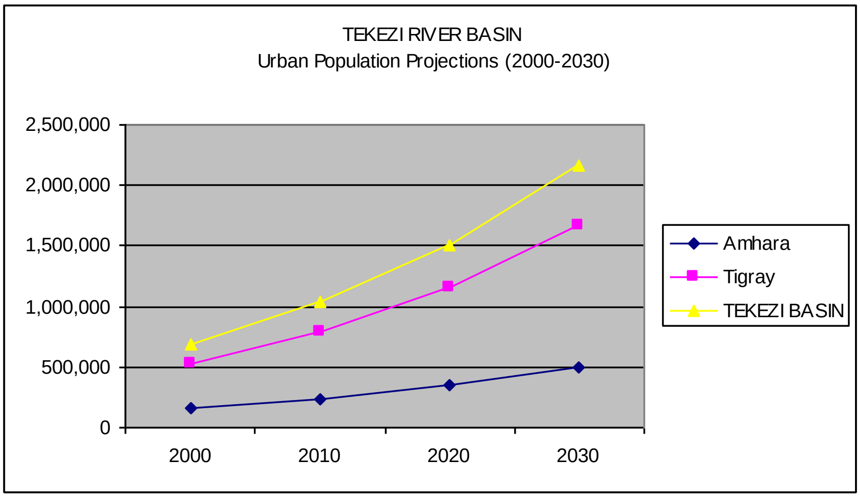
The estimated rural population growth rate (1995-2000) was 2.8 percent per annum and the urban rate was 4.5 percent. These growth rates are projected by the Central Statistical Authority (CSA) to decline between 2000 and 2030 as follows:

	Rural	Urban
2000 – 2010	2.49%	4.25%
2010 – 2020	2.00%	3.85%
2020 – 2030	1.55%	3.70%

The impact on the population of the Tekezi sub-basin is shown in figure 10. Although the rural population shows a distinct reduction in the rate of growth the rural population of the sub-basin is expected to rise from 5.2 million to 10.2 million by 2030, a doubling of the 2000 population. Urban population is projected to increase from 0.7 million to 2.6 million by 2030, nearly a fourfold increase. Despite the rapid increases in the urban population the proportion of the rural population in the sub-basin only decreases from 88 to 80 percent.

Figure 10. Tekezi River Basin: Projected Rural and Urban 2000 - 2030





There is an attendant impact on rural population densities that has important implications for natural resource management and use. Table 36 indicates the increases on gross rural population densities in the sub-basin that will occur.

Table 36. Ethiopia – Tekezi Sub-basin: Changes in Rural Population Densities (persons/km2): 2000 – 2030

BASIN/region	2000	2010	2020	2030
TEKEZI BASIN				
Amhara	61	77	94	110
Tigray	57	73	89	104
Total	**59**	**75**	**92**	**107**

In terms of population support capacity the picture is similar.

Table 37. Ethiopia – Tekezi Sub-basin: Population Support Capacity Assessment for Tekezi Sub-basin: Percent of Weredas in excess ("Critical"), At capacity and will reach capacity in 2010 and 2020.

BASIN/Region	At capacity after 2020	At capacity 2010-2020	At capacity by 2010	At capacity 2000	Critical 2000	Critical 2020
TEKEZI BASIN						
Amhara	42%	8%	23%	15%	**12%**	**58%**
Tigray	33%	15%	24%	21%	**6%**	**67%**
Total	**37%**	**12%**	**23%**	**18%**	**10%**	**63%**

This indicates that at the present time 28 percent of weredas in the Tekezi Sub-basin are at or have exceeded their population support capacities. By 2020 some this will have risen to 63% at the current levels of crop productivity. Most of those weredas that will only reach capacity after 2020 are located in the western Lowlands.

5.2.3 Socio-cultural Aspects of population

In both Regions located within the sub-basin one ethnic group tends to be predominant. In Tigray there are 8 ethnic groups represented in the Region. However, the majority group is Tigray comprising 95 percent of the rural population. There are over 55 ethnic groups represented in the Amhara Region. However, the main groups are Amhara with 91 percent and Agew with 4% of the rural population

5.3 Farming Systems

5.3.1 Classification

The Tekezi Sub-basin exhibits a wide range of farming systems given the range of agro-ecological and socio-cultural conditions. They can be conveniently divided at the highest level into Highland and Lowland systems (an approximate dividing line being the 1,500 masl contour[23]). Further subdivisions are made on the major food crops cultivated. These are indicated in table 38.

Table 38. Outline of farming Systems in the Tekezi Sub-basin.

AGRO-ECOLOGICAL ZONE	MAJOR CROPS	LIVESTOCK
NORTHERN HIGHLANDS		
Moist Dega-Wurch	Wheat+barley+peas/beans (only Barley >2900 masl)	Draught oxen, cows, sheep
Wet-Moist Woina Dega	Tef+maize+sorghum+finger millet+pulses	Draught oxen, cows, sheep, goats
Dry Woina Dega	Tef+wheat+sorghum+pulses	Draught oxen, cows, sheep, goats
LOWLAND		
Dry/Moist Kolla	Shifting Sorghum+maize+beans	Goats
Dry/Moist Kolla	Sorghum, millet, teff	Cattle, sheep

Their distribution is shown in map 27.

5.3.2 Northern Highlands

In the Highlands of Tigray and Amhara Regions wheat-barley systems are found above 2,500 masl with only barley above 2,900 masl. Pulses comprise horsebean and pea. At lower altitudes some maize and sorghum is cultivated. Average farm size ranges from 0.9 ha in Tigray to 1.3 ha in Amhara Region, although the distribution is skewed to the smaller farm size. More than 80 percent of households have 2 or more plots, although where there is considerable variation in land quality this helps to spread risk. Rainfall is extremely variable and soils are generally of low fertility and as a consequence crop yields are lower and more variable than the national average. There is a major structural (i.e. permanent) grain deficit in this farming system ranging between 240 and 580 kgs of grain per family. Some grain is purchased from sales of livestock. Increasingly, deficits are being made up from food aid and food for work.

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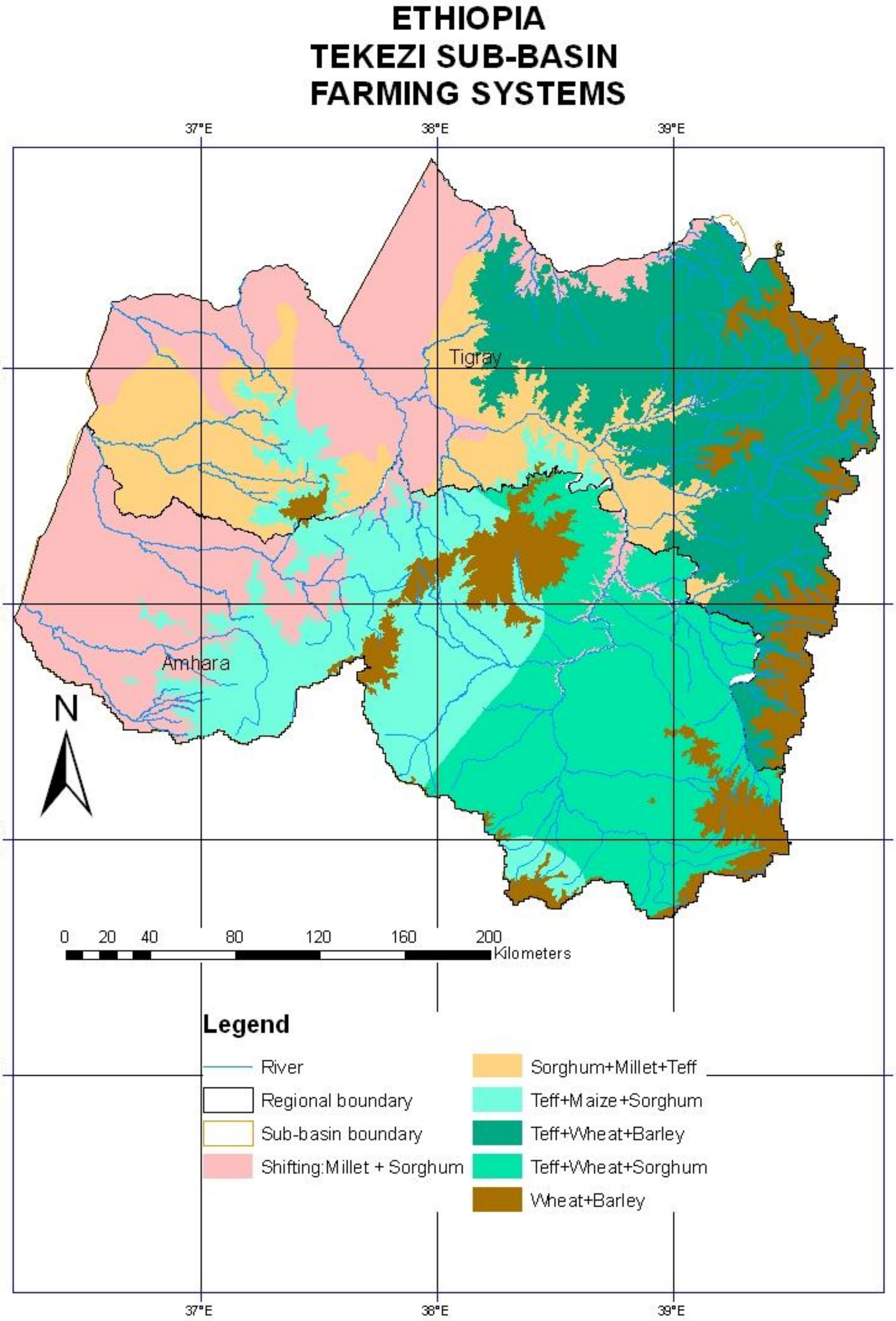
[23] H. Hurni & Kebede Tatu (1990) "Agro-ecological Zones of Ethiopia", 1:1 million Map, University of Berne, Switzerland.



Map 27. Ethiopia – Tekezi Sub-basin: Farming Systems.

Ox:cow ratios of 1.4 and above indicate the emphasis on draught power rather than milk production. Cattle holdings average about 2.6 in Amhara to 3.6 animals in Tigray. Sheep to goat ratios are above 5 indicating a clear preference for sheep. Some 85 percent of livestock feed comes from open and tethered grazing with the balance from aftermath grazing and crop residues. Tethered grazing is particularly important during the wet season when crops are in the ground. The main livestock feed deficits occur between March and June when crop residues are becoming exhausted and pastures are dry and overgrazed.

Some 95 percent of farmers have trees on their farms of which 90 percent are Eucalyptus spp. These are planted mainly around their homesteads. In Tigray the average number of trees is 140 and 260 in Amhara. On-farm tree planting accelerated after 1990 following the change in government policy with respect to tree planting.

(ii) Teff Systems

In the Woina Dega agro-ecological zone between 1,500 masl to 2,300 masl the teff-based farming system predominates in Amhara and Tigray Regions. Within this broad category are three variants: a teff-maize-sorghum system in the high rainfall areas of west Amhara Region; a teff-wheat-sorghum system in the drier areas of eastern Amhara region; and a teff-wheat-barley system in eastern and central Tigray.

Average farm sizes vary from 2.07 ha in western Amhara, 1.26 ha in eastern Amhara and 1.22 ha in Tigray. Crop yields in eastern Amhara and Tigray are lower than western Amhara. In the latter farms produce an average surplus over subsistence requirements of 750 kgs of grain compared with a deficit of 96kgs per household in eastern Amhara and Tigray. As in the previous farming system some grain is purchased from sales of livestock. Increasingly, deficits are being made up from food aid and food for work.

Ox:cow ratios vary between 1.35 to 1.47 indicating an emphasis on draught power. Cattle herd sizes are between 3.6 and 4.2 animals. Sheep to goat ratios on western Amhara are very high at 4.4 but lower in the drier areas of eastern Amhara and Tigray at 1.7 indicating a larger proportion of goats. In many areas hay on private plots is an important source of livestock feed.

There are distinct differences among the three systems with respect to on-farm tree planting. In eastern and western Amhara region Eucalyptus species constitute 90 percent of on-farm trees whilst in Tigray 53 percent are indigenous and only 46 percent Eucalyptus. The number of Eucalyptus trees per farmer varies considerably: 225, 180 and 78 trees in western Amhara, eastern Amhara and Tigray respectively. Over the past 15 years the rate of on-farm Eucalyptus planting has varied among the systems. In western Amhara the rate has steadily increased to 33 trees per year; in eastern Amhara it peaked at 19 trees/annum between 1994-97 and since declined. In Tigray Eucalyptus planting started much later than in Amhara region but has since steadily increased, although at much lower rates to a current 14 trees/annum.

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5.3.3 Western Lowlands

Within the Western Lowlands two major farming systems have been recognized[24].

(i) Sorghum-Millet-Teff land use systems of the North-western Lowlands

Sorghum dominates the crop mix, followed by finger millet and teff. Sesame dominates the pulses. Crop production in an average year provides a daily per capita calorie supply of 1,912 Kcals a deficit (of the 2000 Kcals minimum requirement) of 88 Kcals. This is equivalent to a deficit in grain equivalent of 51 kgs per annum per farm family.

More households own cows than own oxen. The ox:cow ratio is 0.82 indicating an emphasis on either milk or cattle rearing in this farming system. The goat:sheep ratio of 43.2 indicates a clear preference for goats in the system.

Farmers use oxen and grow finger millet, noug (niger seed), sorghum, maize and

(ii) Land Use System 2: Shifting cultivation (Millet, sorghum)

These land use systems are found in the Kolla agro-ecological zone. Finger millet dominates the crop mix, followed by maize and sorghum. Sesame and groundnuts dominate the pulses.

Only 11 percent of farmers use manure, none use compost and only 4 percent weed compost in the cropping system. Some 20 percent of the farmland is under bush fallow, although only 28 percent of all trees are left in fields or placed on field boundaries. No farmers have multi-purpose trees (i.e. for fuelwood/fodder). Only 11 percent of farmers feed livestock with leaves from indigenous trees. Most households obtain most of the two major types of fuel

[24] WBISPP (2003) BeneShangul-Gumuz Regional State: A Strategic Plan for the Sustainable Use and Management of Woody Biomass Resources., MoARD, Addis Ababa.

for energy from Communal Lands and Communal woodlands, with only 15 percent coming from their own farms. Crop residues are relatively small contributor to household energy consumption, and dung not at all.

Communal lands are found on the extensive margins to the main village area. The main croplands are often found on or close to streams and rivers on flat slopes and deep soils. Beyond the intensively cropped areas are more extensive lands on steeper slopes and shallower soils. These lands may be cropped using a bush fallowing system. They also provide the main grazing and browsing areas for livestock, and the main sources of fuel wood.

Overall, this farming system is extensive with changes mainly taking occurring as population expands the cultivated area into shrubland and woodland. The expansion of the market for sesame seed for sale has probably led to an expansion of cropland in this important cash crop[25].

5.3 Social Infrastructure: Health and Education

5.3.1 Health Infrastructure and Health

The data of health infrastructure and health status was taken from the data base of the World Bank's Country Economic memorandum, and adjusted to take account of the area and populations of the two river basins.

Details of health infrastructure and health workers are shown in table 39.

Table 39. Ethiopia – Tekezi Sub-basin: Details of health Infrastructure and Workers.

BASIN/REGION	**Health Professional/'000 pop.**	**No. Health Professionals**	**Health Infrastructure (hospitals, clinics, dispensaries/'000 pop.**	No. of health infrastructures
TEKEZI BASIN				
Amhara	0.21	600	0.08	**22**
Tigray	2.53	7,499	0.08	**24**
Total	**1.41**	**8,099**	**0.08**	**46**

The number of health professionals is much higher in Tigray than the Amhara Region. Health infrastructure is relatively evenly spread across the two Regions. Accessibility and the ratio of health workers to the population are key

[25] Although the recent fall in the world market price may have slowed this process down.

determinants in the number of people who are immunized. This is shown clearly in table 40 where the very high rate of immunization in Tigray region and the lower rate in Amhara Region stand out clearly.

Malaria is prevalent below 1,500 masl and possibly in areas just above this altitude. The percent area exposed to and the percent of the population vulnerable to malaria are also indicated in table 40.

Table 40. Ethiopia – Tekezi Sub-basin: Percent Population Immunized, Percent Population vulnerable to and Area Exposed to Malaria.

BASIN/Region	% Pop. immunized	% Pop. vulnerable to malaria	% Area exposed to malaria
TEKEZI BASIN			
Amhara	55%	50%	**61%**
Tigray	90%	69%	**85%**
Total	**53%**	**60%**	**73%**

Tigray Region has the highest proportion of the population vulnerable to malaria. Just half the population in Amhara Region are so vulnerable.

5.3.2 Educational Infrastructure and Educational Enrolment

The data of education infrastructure and health status was also taken from the data base of the World Bank's Country Economic memorandum and adjusted to take account of the area and populations of the two river basins.

The number of Primary and Secondary Schools and the population in the generally accepted age groups for Primary (>5 and <12 years) and Secondary school (>11 and <20 years) per School are shown in table 41.

Table 41. Ethiopia – Tekezi Sub-basin: Number of Primary and Secondary Schools and Percent Enrolment

BASIN/Region	No. Primary schools	Pop >3 & <12 yrs/Primary school	No. Secondary Schools	Pop. >11 & <20yrs/Secondary School
TEKEZI BASIN				
Amhara	460	2,428	12	**69,529**
Tigray	705	1,679	32	**27,504**
Total	**1,165**	**1,975**	**44**	**38,922**

Generally, the Tigray Region appears to be better endowed with Primary and Secondary schools in relation to the target population. Enrolment rates for Primary and Secondary Schools within the two basins are shown in Table 42.

Table 42. Ethiopia – Tekezi Sub-basin: Gross Primary and Secondary School Enrolment Rates

BASIN/Region	% Enrolment Primary School	% Enrolment Secondary School
TEKEZI BASIN		
Amhara	47%	**10%**
Tigray	69%	**25%**
Total	**59%**	**17%**

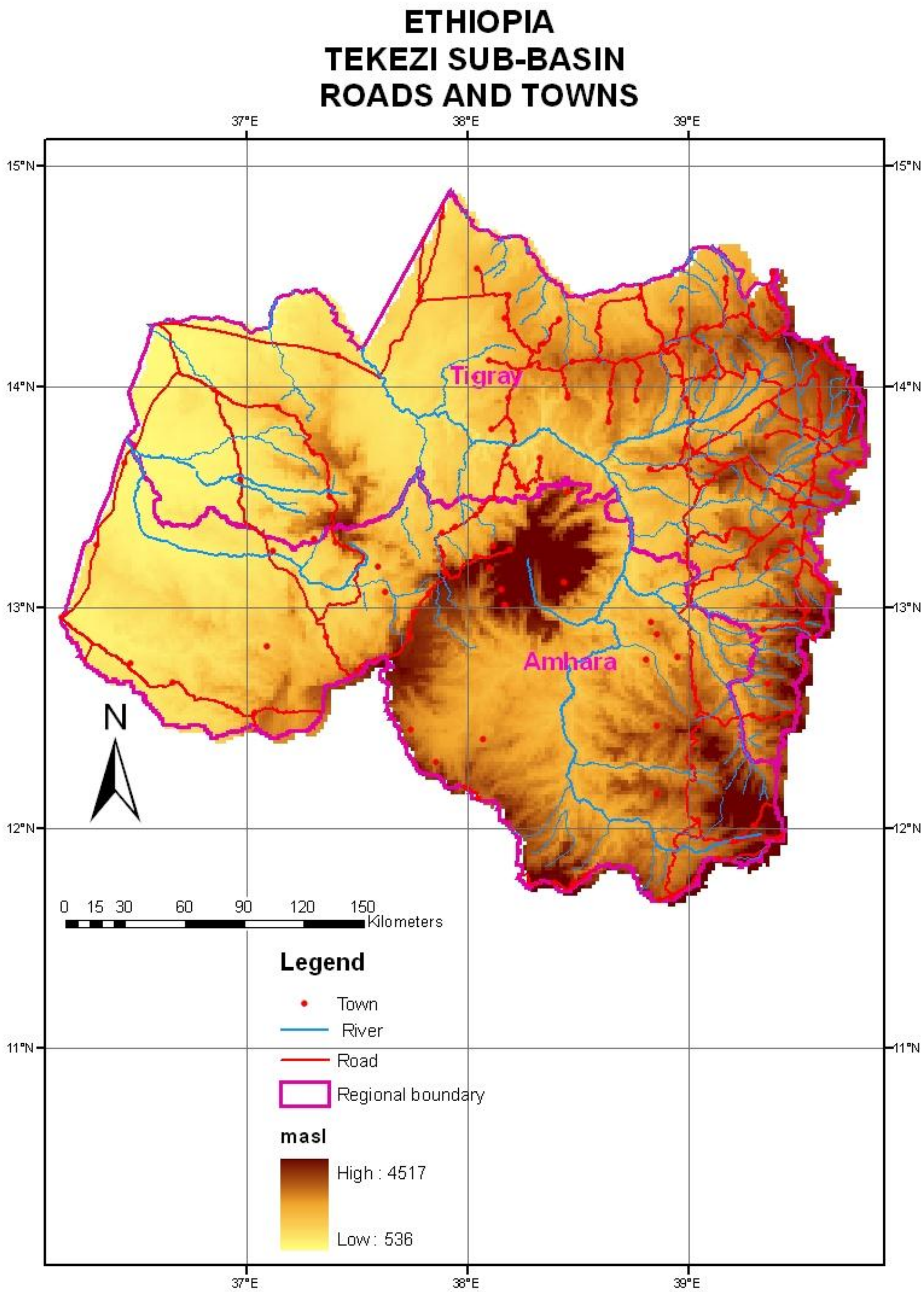
Tigray has the highest Primary and Secondary School enrolment rates.

5.4 Transport Infrastructure and Markets

5.4.1 Transport Infrastructure

Given the extreme dissection of the highlands by the Tekezi River and its tributaries road infrastructure is not well developed. As can be seen on map 28 the all-weather roads tend to be confined to the ridges and plateaus between the deeply incised rivers. For example, the Tekezi has only two and the Abay only three road crossings. Thus both road construction and vehicle running costs are high.

Within the Tekezi Sub-basin the length and density of all weather and dry weather roads is as follows:



Map 28. Ethiopia – Tekezi Sub-basin: Roads Network and Towns.

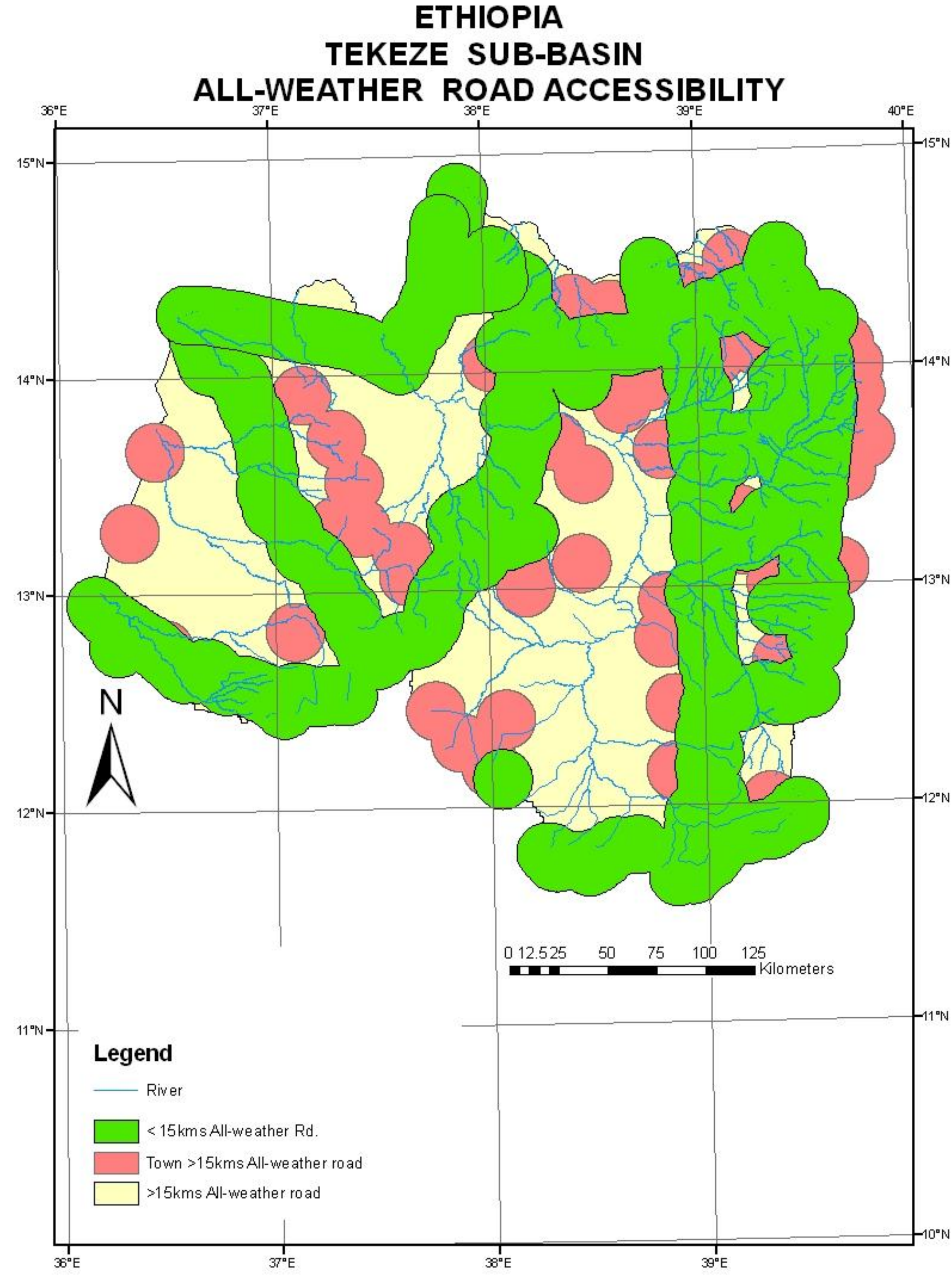
Table 43. Ethiopia – Tekezi sub-basin: Length and density of All-weather and Dry-weather Roads.

BASIN	TYPE	LENGTH (KM)	DENSITY (KM/1000KM2)
TEKEZI	All weather	2,780	**32**
	Dry weather	1,171	**13**
	Total	**3,951**	46

The length of all-weather roads in the two basins is significantly greater than dry-weather roads. This may be a reflection of the degree to which dry weather roads have been mapped. The road density for Tigray and Amhara Regions are as follows:

Tigray - 44km/1000km2
Amhara - 46 "
National - 31 "

In terms of accessibility to all-weather roads some 39 percent of the Sub-basin area is further than 15 kms, which compares with 45percent for the Abay Sub-basin and 63 percent for the Baro-Akobo Sub-basin. The areas of inaccessibility are located in the upper Tekeze Sub-basin and in the western Lowlands (Map 29).



Map 29. Ethiopia – Tekeze Sub-basin: Accessibility to All-weather roads.

6. BARO-AKOBO RIVER BASIN - BIOPHYSICAL AND SOCIO-ECONOMIC SITUATION

6.1 Bio-physical Characteristics

6.1.1 Location and Physiography

The Baro – Akobo basin lies in the southwest of Ethiopia between latitudes 5^{o} 31’ and 10^{o} 54’ north and longitude 33^{o} and 36^{o} 17’ east covering some 76,103 km^{2}. It covers the whole of Gambela National Regional State and parts of the Beneshangul-Gumuz, Oromiya and the Southern Nations and Nationalities Peoples’ regions. It is bordered by Sudan in the west and south west, and bounded by the mountainous divide in the east, north east and south east.

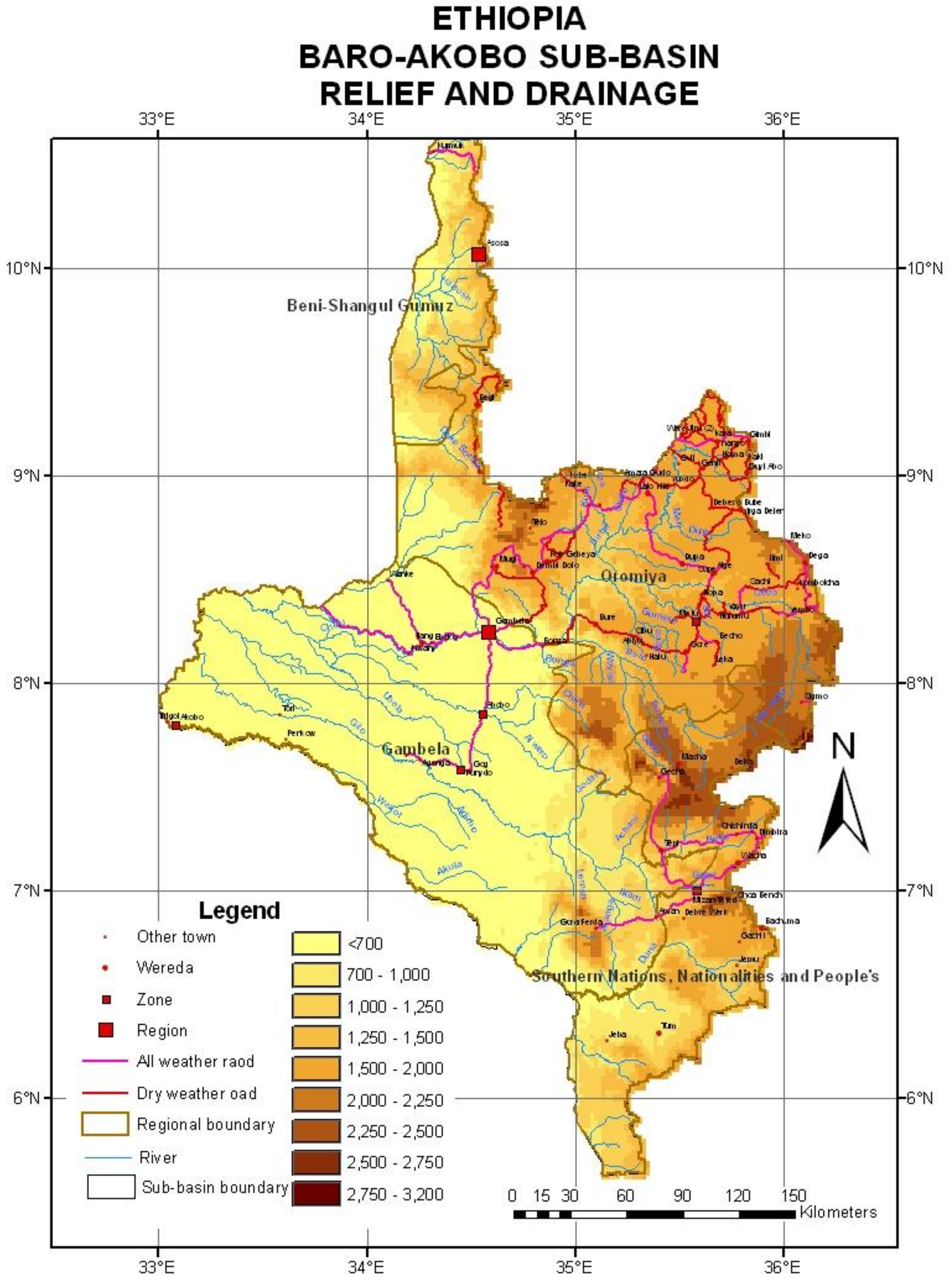
The sub-basin can be divided into two major landscape units of roughly equal size, the western lowlands and the eastern highlands. They are separated by an escarpment and areas of severely dissected highlands. The western half the sub-basin is below 1000m while the highest points in the eastern half of the sub-basin exceed 3000m at Mount Seccia in the east, where the sub-basin watershed is with the Omo-Ghibe River system, and above 3300m at Mount Tulu Welel in Western Wellega.

The Gambela salient in the west lies below 700m masl and comprises gently sloping to almost flat plains that continue into the Sudan crossing the border in the west at an altitude of around 400m masl. The plains are abruptly terminated in the east by a well defined, north-south escarpment. North of the salient the foot of the escarpment is less precise and forms a belt of lower altitude broken highlands in BeneShangul-Gumuz RS. A similar area of broken highland terrain is found in the western part of SNNPRS around Mizan Teferi and reaching out to Gurafarda, a highand outlier. The highland part of the sub-basin in the east is above 1,500m masl. It is an undulating to rolling plateau, mostly between 1,600 and 2,100masl, deeply incised by the major rivers with isolated high mountains such as Mount Tulu Welwel and Seccia.

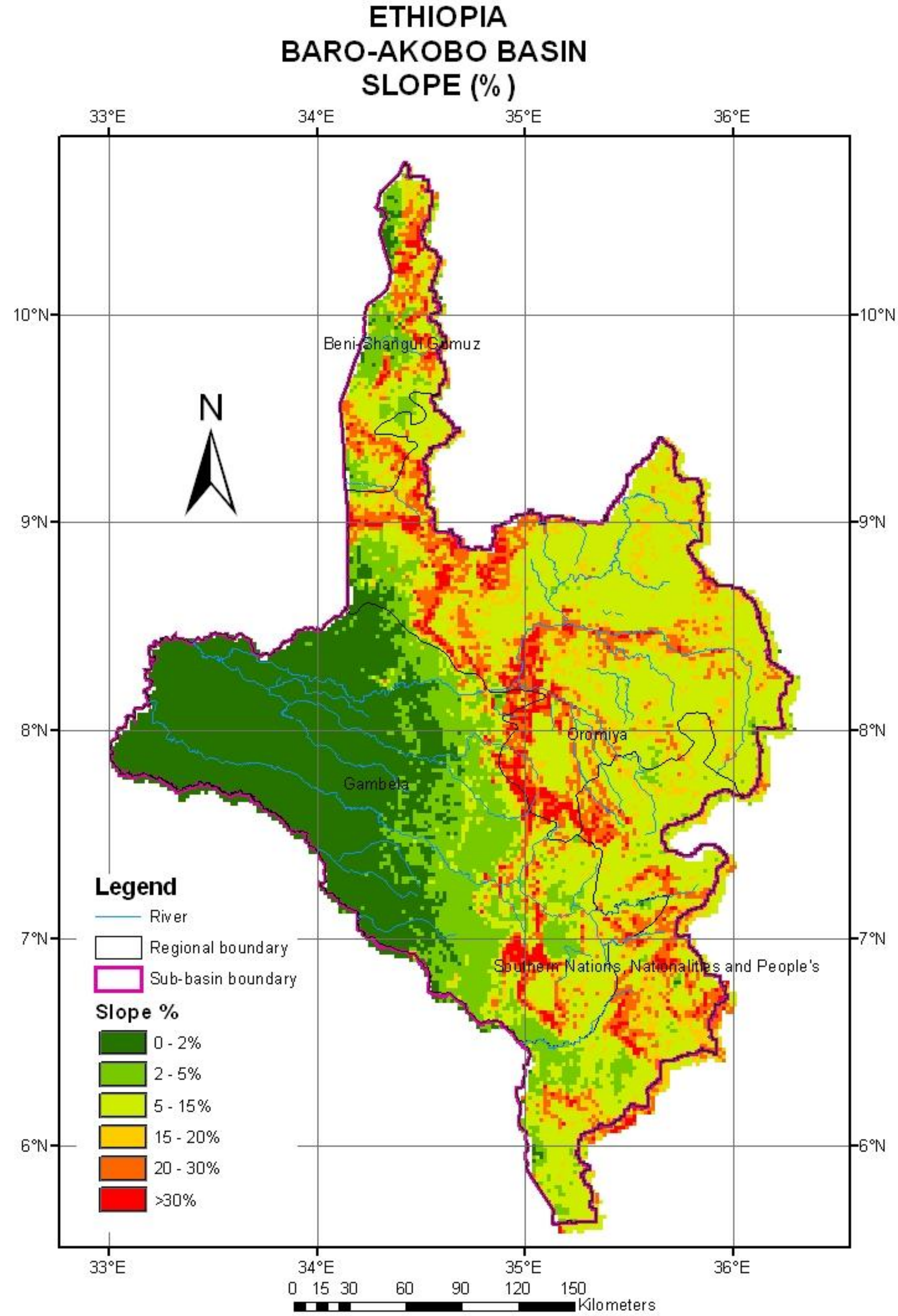
Table 44. Elevation classes of the Baro-Akobo basin and distribution of land area per class

Elevation (m)	Area (km^2)	% of the area
>3,000	27	<1
2,500 – 3,000	146	<1
2,000 – 2,500	6,280	8
1,500 – 2,000	16,129	21
1,000 – 1,500	15,662	21
500 – 1,000	18,699	25
0 – 500	19,160	25
	76,103	

Source: The Baro-Akobo River Basin Integrated Development Master Plan Study (1997), Annex 2C.



Map 30. **Ethiopia – Baro-Akobo Sub-basin: Relief and Drainage.**



Map 31. Ethiopia - Baro-Akobo Sub-basin: Slope distribution pattern.

The slope map (Map 31) reflects the main physiographic regions of Baro-Akobo sub-basin, in the sense that most of the virtually flat areas are located in the western lowlands of Gambela RS, while the highlands in the east have slopes of between 5% and 15%. The majority of the steep slopes are found in the north-south escarpment zone in the centre, and in the broken highland areas to the north and south of that zone. Other steep slopes are found in the incised valleys of the rivers in the highlands, such as the Baro and Gabba.

Table 45. Slope classes of the Baro-Akobo basin and distribution of land area per class

Slope class	Description	Area in percent
0 – 2	Flat	25.6
2 – 8	Flat	31.5
8 – 16	Hilly	19.7
16 – 30	Hilly	14.2
30 – 50	Hilly	6.6
>50	Steep	2.4

Source: Source: The Baro-Akobo River Basin Integrated Development Master Plan Study (1997), Annex 4, Environment.

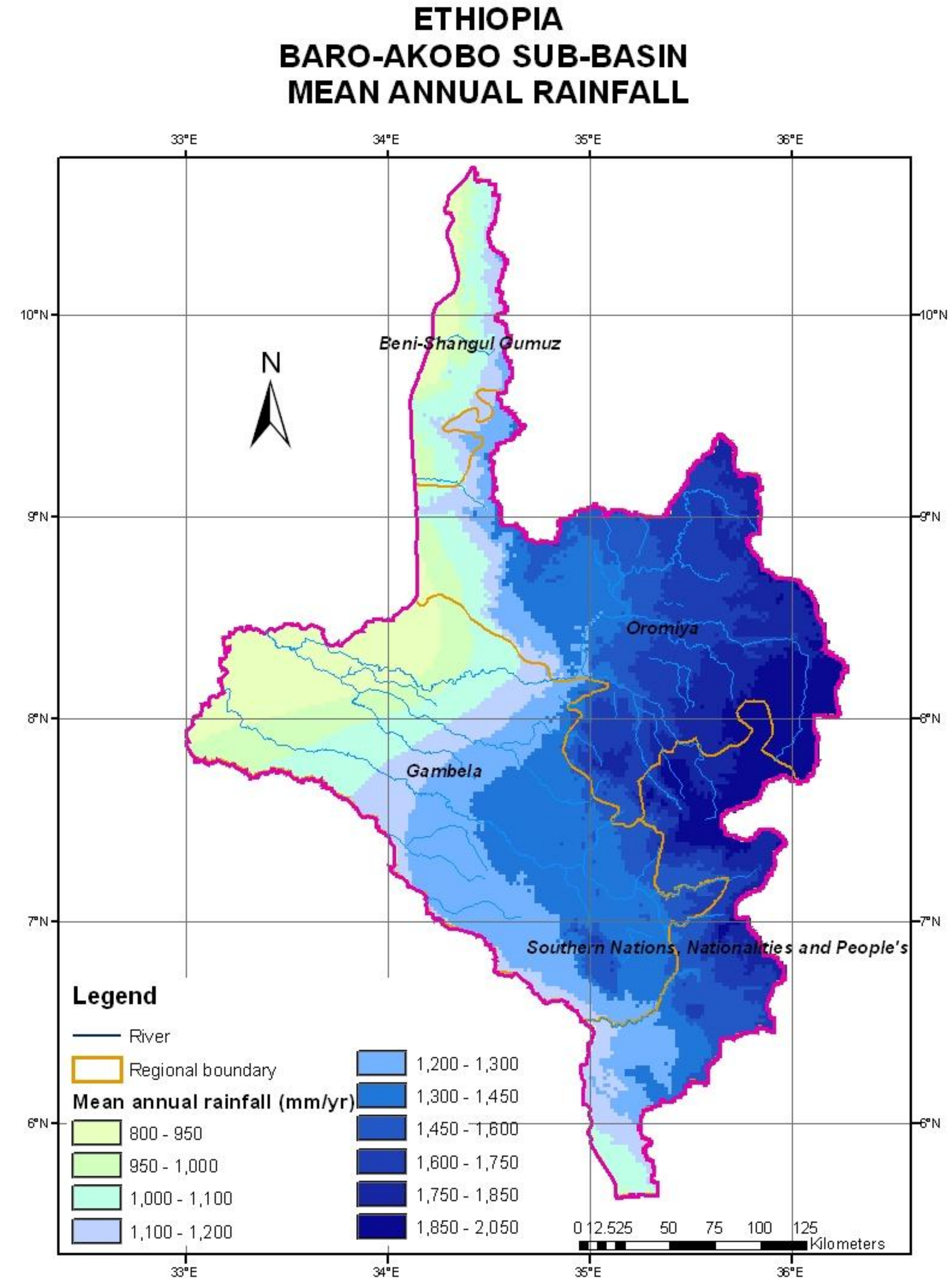
6.1.2 Climate

(i) Rainfall

The Baro – Akobo basin is a particularly well-watered region of Ethiopia. However, the spatial variation of the mean annual rainfall is considerable due to the great range of difference in elevation across the basin (map 32). Average annual precipitation is as low as 600 mm in the lowlands (less than 500 masl), while it reaches as high as 3,000 mm over the highlands (over 2,000 masl). Most of the upper basin has an annual total of more than 1,800 mm while Gore has an average annual total of over 2,200 mm.

Over the basin, the rainy period is from May to October when 85% of the annual precipitation occurs. The average monthly rainfall over the basin has a single peak with a maximum value (275.8 mm) in July. Average rainfall greater than 100 mm occurs from May to October (a six months rainy season). Months with average rainfall greater than 200 mm are June, July, August and September. On average, November, December, January and February are dry months over the Baro – Akobo basin.

On the Gambela plain below 500 meters elevation only about six years in ten have a dependable rainfall of at least four months, which is sufficient to support good yields of most annual crops. Above about 1,000 meters elevation the dependable growing season for annual crops is reliable and failures would occur in only about one year in twenty, and even longer than that above 2,000 meters elevation. In an average season and better, a second rainfed crop should yield well during a dependable growing season of seven and more months in the Highlands.



Map 32. **Ethiopia - Baro-Akobo Sub-basin: Mean annual rainfall;**

(ii) Temperature

The temperature range in the Baro – Akobo basin is from about 27.5 ^{0}C below 500 meters elevation on the flood plain to about 17.5 ^{0}C at 2,500 meters in the highlands (Map 33). Mean monthly maximum temperatures range from below 22 ^{0}C, in the highlands around Kombolcha (Wellega) to about 40 ^{0}C, in the lowlands of Gambela around Akobo. Maximum seasonal temperatures in the highlands rarely exceed 25 ^{0}C, whereas in the lowlands they generally exceed 36 ^{0}C during the hotter months of January to April. Mean maximum temperatures greater than 30 ^{0}C occur from February to April in the Lowlands while July and August have the mean maximum temperature values less than 25^{o}C.

The mean monthly minimum temperatures generally range from 14 – 16 ^{0}C in the highlands of Illubabor and western Wellega, but they sometimes drop to below 10 ^{0}C in isolated locations of the highlands during November-February. The mean monthly minimum temperature pattern shows a maximum temperature value in April and a minimum temperature value in December. The mean minimum temperature values greater than 15.5 ^{0}C occur from January to May while the mean minimum temperature values ranging from 14 ^{0}C to 15.4 ^{0}C occur from June to December.

(iii) Wind

The general trend of the wind speed in the Baro – Akobo basin decreases from January to October and then increases significantly in November and December. The maximum wind speed is about 3m/s in February. The minimum average monthly wind speed occurs in October and has a speed of about 1.8m/s.

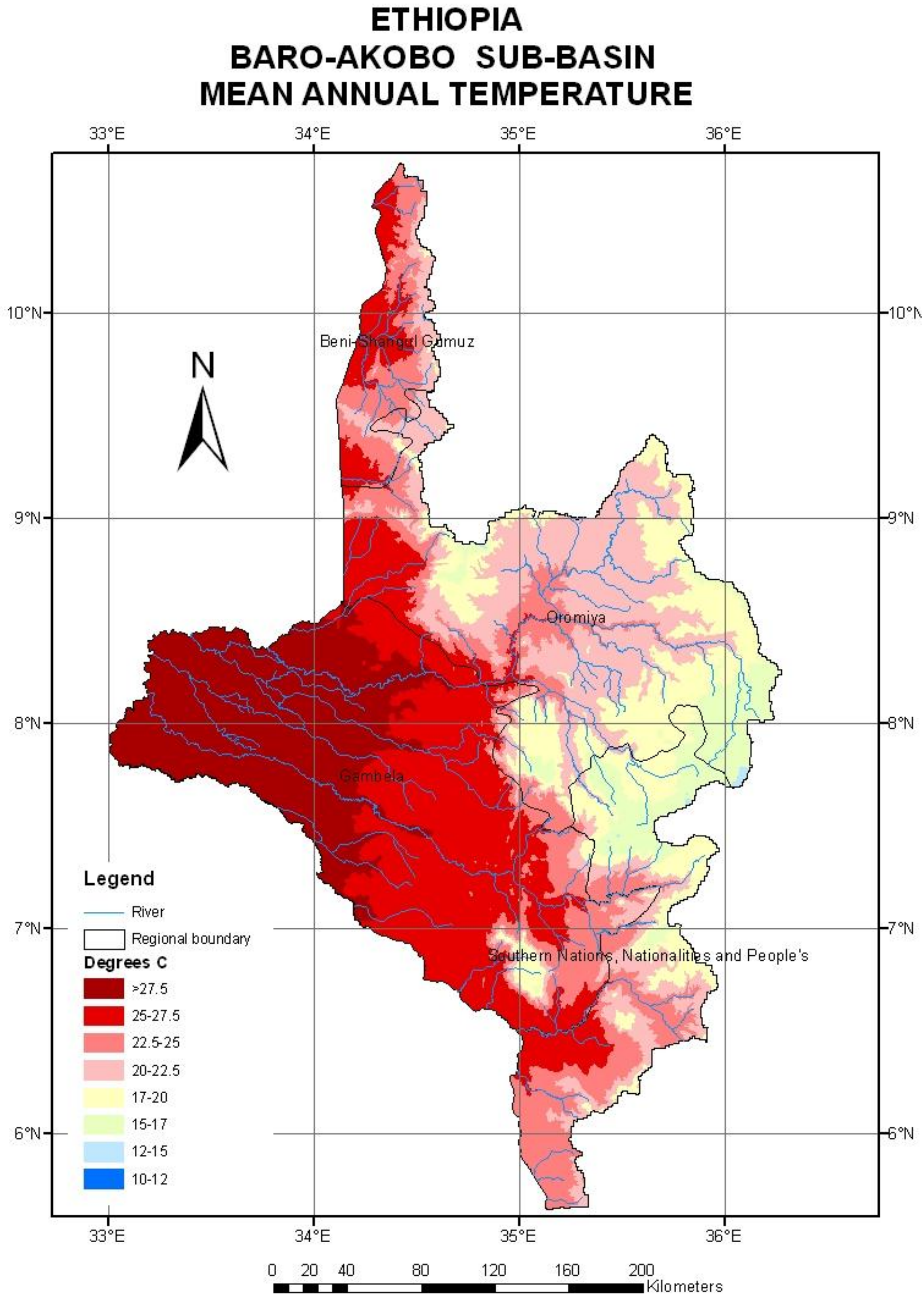
The predominant wind in the wet season is from the west, with warm, moist south-westerlies from the Guinea and Congo basin (the West African Monsoon) bringing moist air masses. This causes most of the rainfall, especially in the highlands, following orographic uplift as the air masses rise up the escarpment. During the dry season the situation is different with low-level dry and warm north-easterly trade winds.

(iv) Sunshine

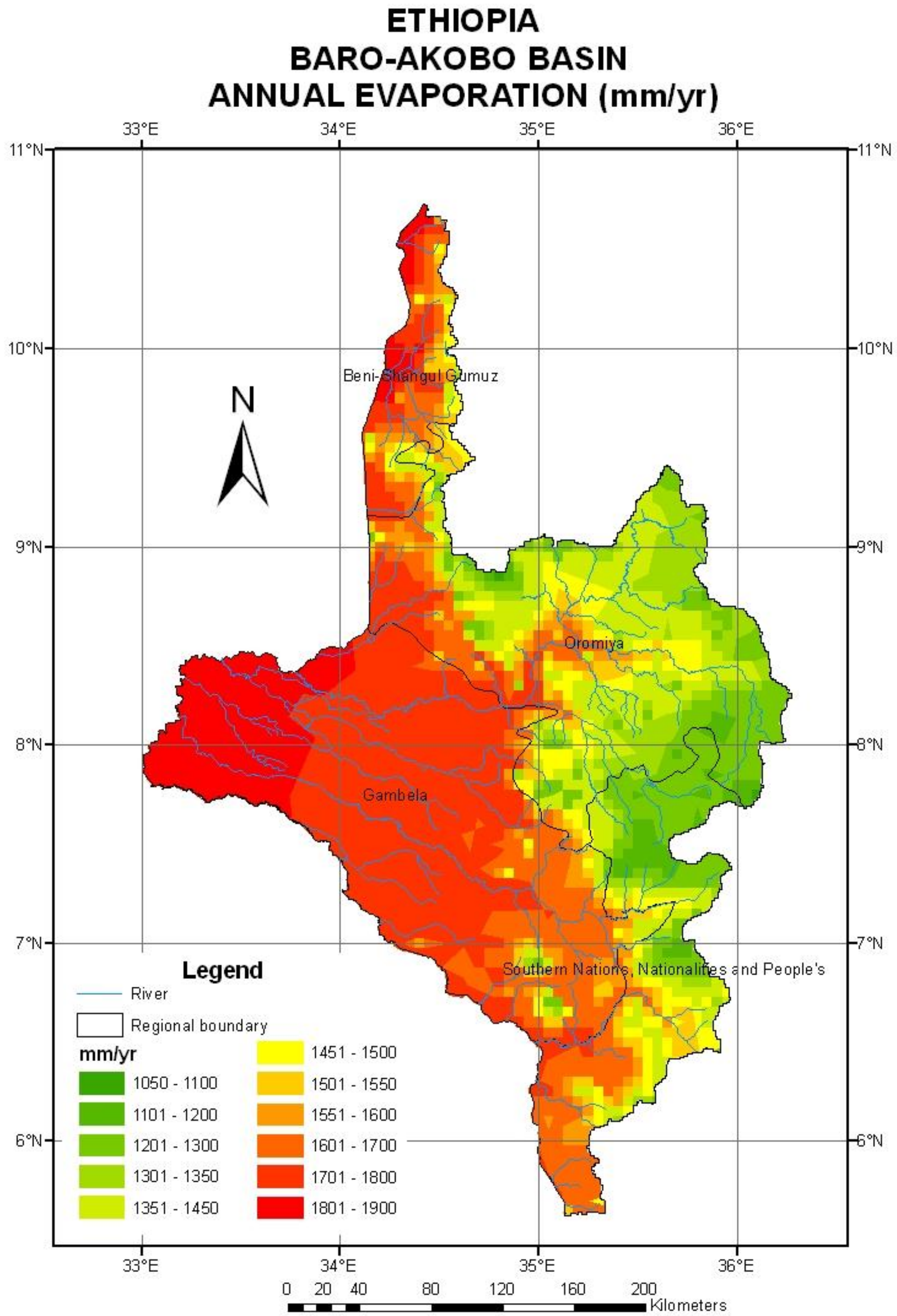
The maximum average monthly sunshine (around 8 hours) occurs in the Baro-Akobo basin from November to February and the minimum from June to September (slightly above 4 hours).

(v) Evapotranspiration

Evaporation: The temporal pattern of the average monthly evaporation of the Baro – Akobo basin correlates well with the monthly mean maximum temperature distribution over the basin (map 34). The average monthly maximum evaporation occurs from February to May and the minimum from June to September. As may be expected, potential evapotranspiration is lowest over the highlands and increases progressively towards and onto the Gambela lowlands. For example, Gore (2,130 masl) has a total evapotranspiration of 1,263 mm/yr while Jikawo (410 masl) has a total evapotranspiration of 1,545 mm/yr.



Map 33. Ethiopia - Baro-Akobo Sub-basin: Mean Annual Temperature



Map 34. Ethiopia - Baro-Akobo Sub-basin: Annual Evaporation (mm)

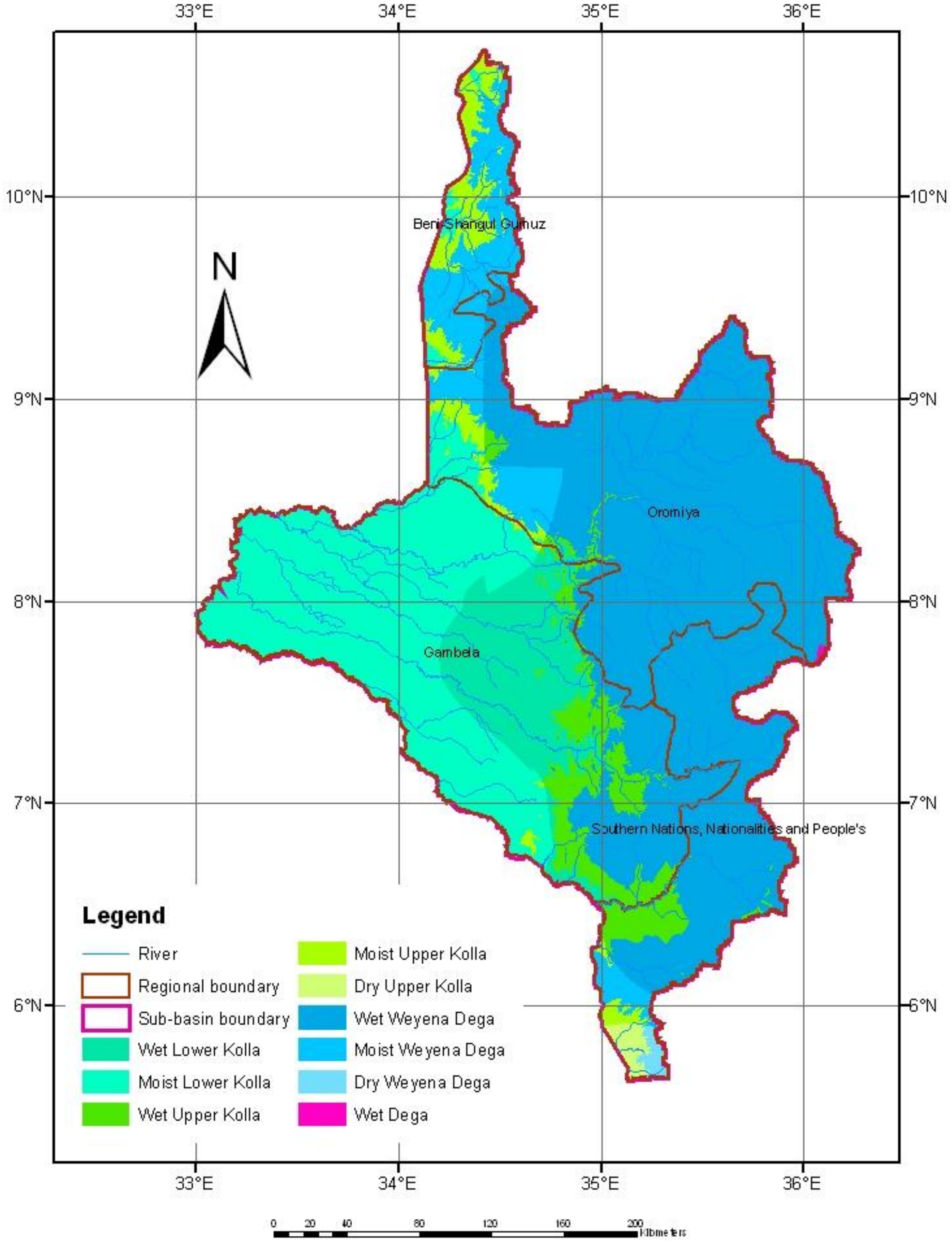
(vi) Agroecological zones

The three most extensive zones are the Wet Woina Dega on the plateau (48 percent) and the Moist and Wet Lower Kolla Zones (29 and 9 percent respectively) located on the plains. There are also areas of Moist Woina Dega in the lower rainfall parts of the Highlands and Wet and Moist Upper Kolla mostly on the escarpment.

Table 46. Ethiopia – Baro-Akobo Sub-basin: Traditional Agro-ecological Zones – Area (km2) and % of Total Area (%)

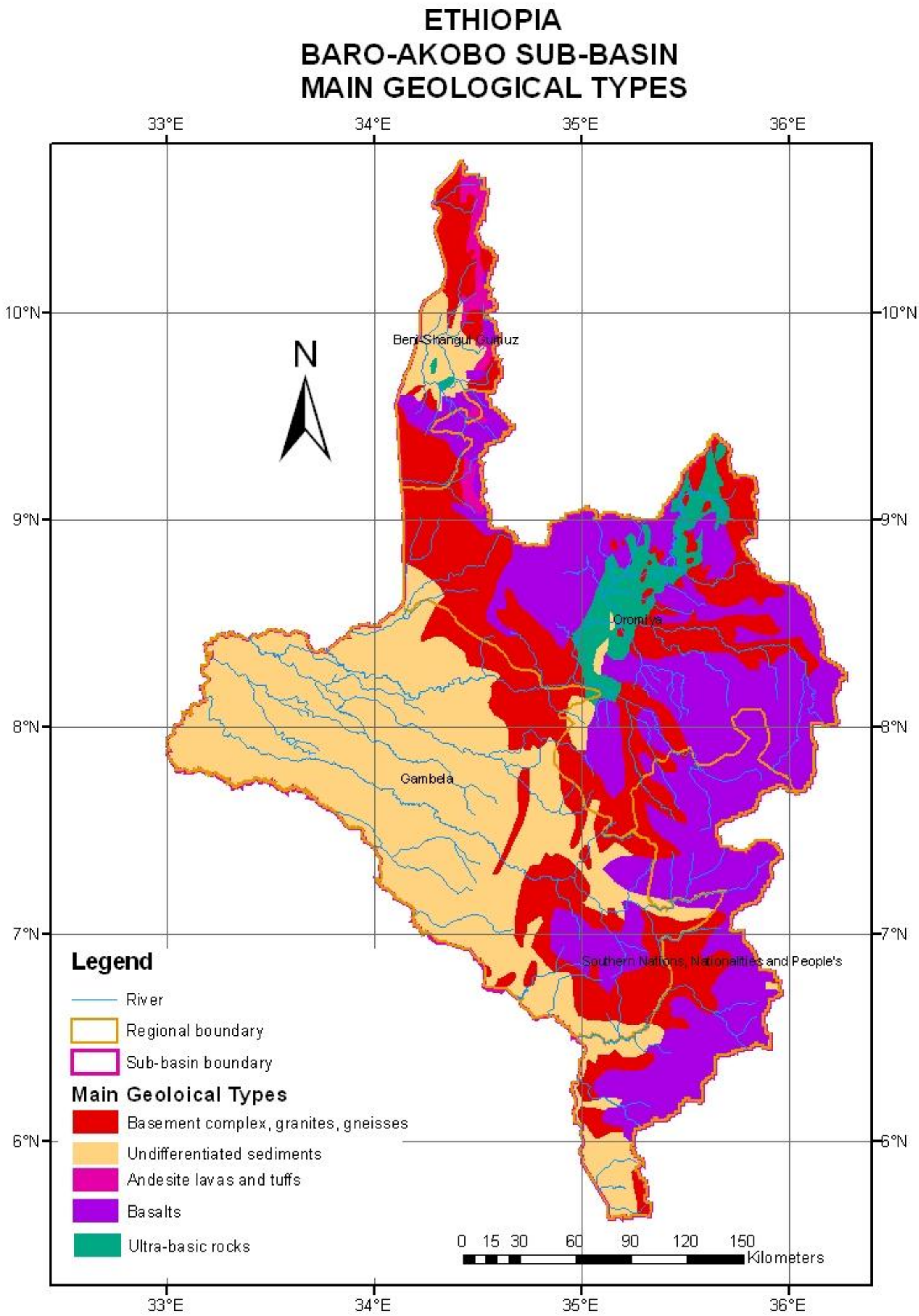
Agro-ecological Zone	Area (km^2)	% of Total Area
Wet Woina Dega	36,700	48.2%
Moist Lower Kolla	18,372	24.1%
Wet Lower Kolla	6,911	9.1%
Moist Woina Dega	5,729	7.5%
Wet Upper Kolla	4,703	6.2%
Moist Upper Kolla	2,903	3.8%
Dry Upper Kolla	456	0.6%
Dry Woina Dega	282	0.4%
Wet Dega	47	0.1%
TOTAL	**76,103**	

ETHIOPIA
BARO-AKOBO SUB-BASIN
TRADITIONAL AGRO-ECOLOGICAL ZONES



Map 35. Ethiopia - Baro-Akobo Sub-basin: Distribution of Agro-ecological Zones

6.1.3 Geology



Map 36. Ethiopia - Baro-Akobo Sub-basin: Solid geology

The Baro – Akobo sub-basin consists primarily of Basement crystalline rocks in the eastern uplands with covering Tertiary lavas in places and Quaternary sediments in the lowlands to the west.

The surface and near surface geology of the high mountains zone (2,400 to 3,300 masl) is formed by weathered Tertiary basalts capped in places by resistant Quaternary volcanic rocks. West of the high mountainous area lies a high plateau ranging from about 1,300 to 2,400 masl, which is underlain by basalts and granites. Next in westward succession are the crystalline basement complex rocks that form the Masongo Ranges and vary in elevation from about 800 to 1,400 masl. The western-most geomorphic zone in the basin is occupied by the gradually westward slopping surface of the Gambela Plain. This plain is formed and underlain by unconsolidated and undifferentiated Plio-Quaternary sediments that grade westward from about 495 masl at Gambela to 400 masl at the Ethiopia – Sudan border.

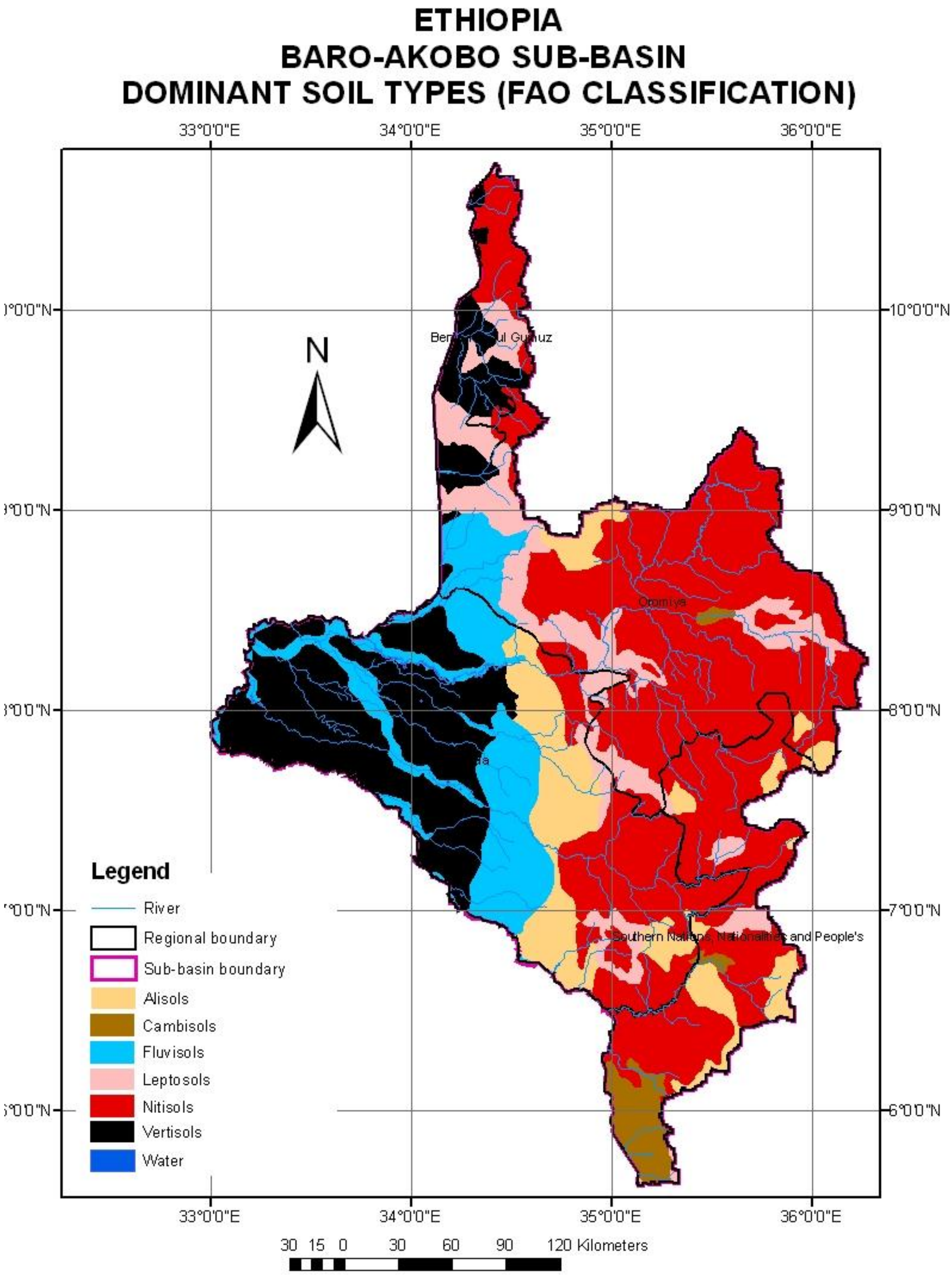
6.1.4 Soils

The major soil units in the Baro - Akobo basin are summarized in the table below:

Table 47. Ethiopia – Baro-Akobo Sub-Basin: Major soil units of the Baro – Akobo basin

Classification (FAO, 1988)	Area (km2)	Area (%)	Common Properties
Lithic and Eutric Leptosols	6,849	9	Very high erosion hazard
Lithic and stony Dystric, Eutric and Chromic Cambisols; Haplic Acrisols (shallow and stony)	8,371	11	High and very high erosion hazard
Haplic Lixisols	2,283	3	Often shallow, over gravels and strongly weathered soils
Dystric and Chromic Cambisols	9,132	11	Weathered and often shallow with coarse top soils
Eutric Vertisols	7,610	9	Seasonally waterlogged, generally fertile, often flooded in lower basin, risk of sodic condition
Chromic and Haplic Luvisols	3,805	5	Weathered soils, erosion hazard
Haplic Nitosols	10,654	14	Usually deep, fine textured, over basalt, “Red forest” soils. Slight erosion hazard.
Rhodic Nitosols	6,088	8	Usually deep, fine textured over basalt, “Forest Soils”, strong red colour. Slight erosion hazard.
Dystric and Eutric Fluvisols	9,893	13	Variable textures, usually deep. Slight erosion hazard.
Eutric Gleysols	6,849	9	Seasonally waterlogged. Low erosion hazard.
Dystric and Eutric Plinthosols	2,283	3	Variable depth over laterite/gravels. Erosion hazard
Planosols	2,283	3	Associated with drainage lines and swamps, waterlogged for part or all year. Coarse profiles on shallow slopes. Slight erosion hazard.
	76,103		

Source: The Baro-Akobo River Basin Integrated Development Master Plan Study (1997), Annex 2B, Appendix A. Table A.1.



Map 37. Ethiopia - Baro-Akobo Sub-basin: Soil Pattern (FAO Classification)

The predominant soils in the highlands are the Nitosols which usually are deep and have a low erosion hazard, although there are also small areas of Leptosols with a very high erosion hazard in some areas. In the lowlands the major soil types are Fluvisols and Vertisols (Gleysols /Planosols) which have low erosion hazards, but are difficult for cultivation due to waterlogging.

6.1.5 Land Cover/Land Use

(i) Summary of land Cover

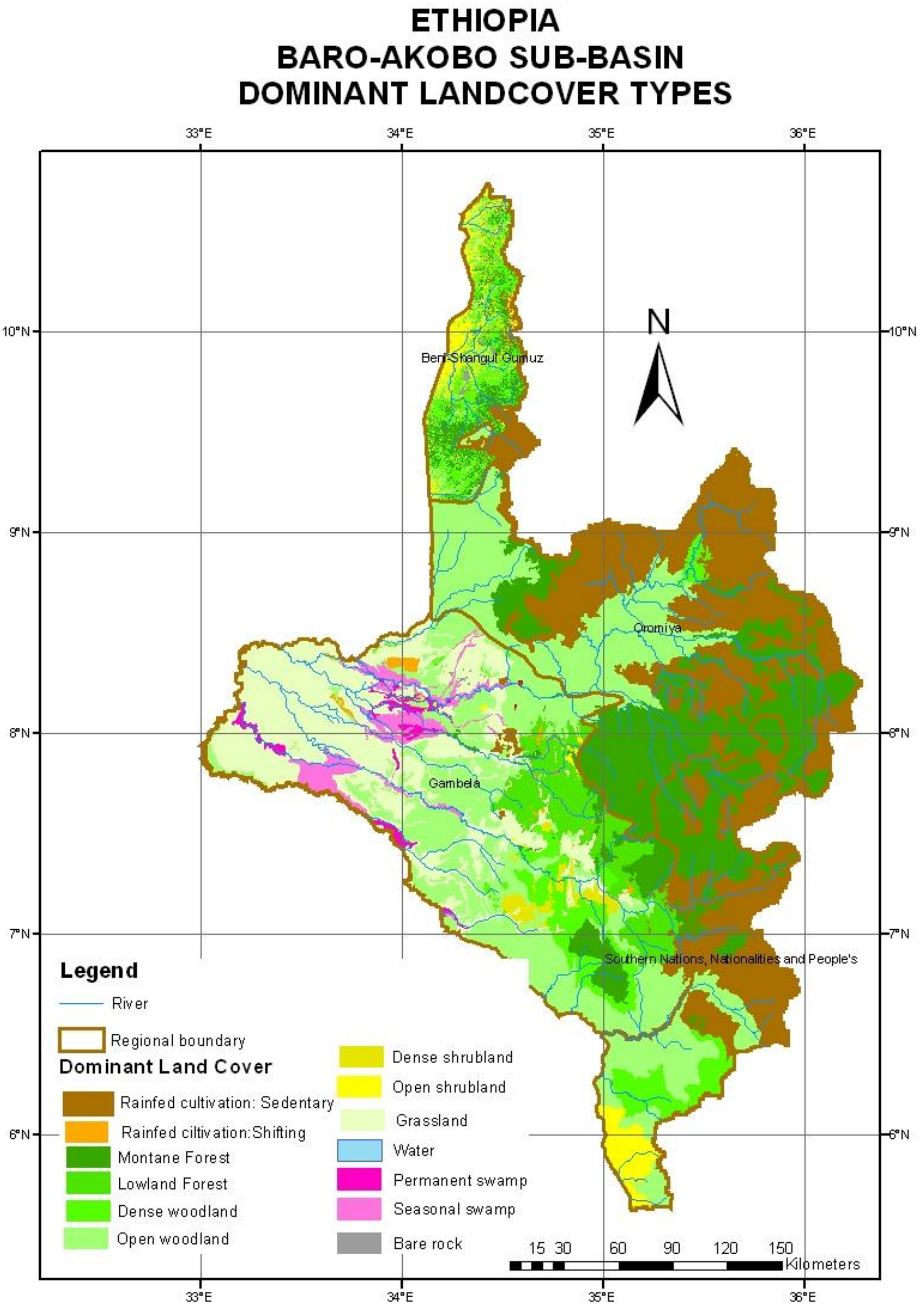
The available land cover/use information of the Baro-Akobo basin is summarized below. It is based on the revised land cover map of the WBISPP (2001).

Table 48. Land Cover/Use in Baro-Akobo basin

Description	Area (Km2)	Area (%)
Open Woodland	21,003	27.6%
Cultivation: Sedentary	16,130	21.2%
Forest: Montane	14,090	18.5%
Grassland	10,529	13.8%
Dense Woodland	5,129	6.7%
Forest: Lowland	3,620	4.8%
Open Shrubland	1,949	2.6%
Seasonal Swamp	1,773	2.3%
Dense Shrubland	836	1.1%
Permanent Swamp	599	0.8%
Cultivation: Shifting	364	0.5%
Rock	69	0.1%
Urban	13	0.0%
	76,103	

Source: WBISPP (2001) Land cover maps of Gambela, Oromiya, BSG and SNNP Regional States.

Open woodland located on the plains is the most extensive land cover followed by highland sedentary cultivation. Nearly 24 percent of the Sub-basin is covered by montane or Lowland High Forest. Wetlands cover 3 percent of the area although a significant proportion of the grasslands will be flooded for short periods at the height of the rains.



Map 38. **Ethiopia - Baro-Akobo Sub-basin: Landcover**

(ii) Forest and Woodland Types

The various forest and woodland types found in the sub-basin are described below:

(a) Aningeria Forests

Aningeria forests lie between 1600 and 2000 m where the annual rainfall is about 1600-2400 mm. The species composition of this type is high due to its wide range of suitable climate conditions. Important species include *Syzygium guineense, Ficus* spp, *Olea welwitschll, Prunus africana, Albizzia gummifera, Polyscias fulva, Morus mesozygia, Ekbergia capensis, Celtus gomphophylla, Cordia Africana*, and *Croton machrostachyus*.

(b) Olea Forests

Olea forests lie between 1500 and 2000m. Their preference for gentle slopes exposes them to disturbance and exploitation. They comprise a wide range of commercially desirable species: *Olea welwitschii, Bosqueie phoberos, Apodytes dimidiate, Polysicias ferruginea, Olea hochstetteri, Cordia abysinnica* and *Syzygium guineense*.

(c) Baphia Forests

Baphia forests often merge with riparian forest. An open forest type, it contains such species as *Zizyphus pubescens, Diospyrus mesipiliforms, Alstonia boonei, Celtis integrifolia*, and *Chlorophora excelsa*. Woodland species, *Albizzia schimeriana, Croton macrostachyus*, and *Combretum molle*, also occur. Baphia forests are under threat from burning and fuel wood collection.

(d) Evergreen Forests

Evergreen forests occur throughout the highland plateau. Remnants of the forests which once clothed Ethiopia’s uplands, they are now made up of islands of trees whose under-storey has been removed to provide space for coffee; there is no forest regeneration. Nonetheless, the trees continue to provide a low intensity of habitat for birds and other life as well as some slight hydrological benefit.

(e) Highland and Lowland Bamboo

Highland bamboo thicket (Arundaria alpine)

This occurs on gentle slopes above 2,400masl in the high rainfall areas. It is generally in pure stands or occasionally interspersed with trees.

Lowland bamboo (Oxytenanthera abyssinicus)

Within the Baro-Akobo Sub-basin 127,400 ha of lowland bamboo are found in Assossa Zone of BS-G Region. It occurs in two man forms: in pure continuous stands with few or no trees or shrubs, and as clumps scattered with woodland and shrubland.

In the dense pure stand bamboo area of Ambessa Chaka Forest, LusoConsult estimated an average of 8,124 live culms per hectare, weighing 19.53 tons per hectare. The density of culms in open "clumped bamboo/woodland-shrubland" is probably about 20 percent of that in the dense pure stands

(f) Mixed Deciduous Woodlands

Mixed deciduous woodlands extend along the south-western and north-western edges of the plateau at about 1200m altitude. Their species include *Albizzia schimperiana, Croton macrostachyus, Euphorbia abyssinica, E. candelabrum, Grewia bicolour, Bersama abyssinica,* and *Acacia* spp, among others.

(g) Combretum and Acacia Woodlands

The Combretum and Acacia woodlands (or wooded savannahs) occupy the low and upper basin between 500 and 1500 m altitude. In the far western part of the project area, gum-bearing *Acacia seyal* and *A. sieveriana* occur; *combretum* grows in the Omo, Gambela, and Asosa regions. Heavy grazing and charcoal making encroach into these woodlands, reducing the area of the gum belt, which extends from Anifilo *wereda* north to Kurmuk *wereda*

(h) Riparian Forests and Woodlands

Riparian forests extend throughout the plateau drainage pattern, dropping down to the flood plains. Like woodlands of the savannah and upland basin, riparian forests are under enormous pressure from local and refugee populations. Important species include *Celtis kraussiana, Ficus sycamorus, Mimusops aethiopum, Tamarindus indica, Maytenus senegalensis, Kigelia aethiopum, Syzgium guinenses* and Acacia spp.

In many parts of the Sub-basin bee keeping and wild honey collection provide a significant contribution to livelihoods. Table 49 indicates the suitability of the various forest and woodland types for honey production.

Table 49. Resources for beekeeping provided by forests within the Baro-Akobo Sub-basin (Baro-Akobo Master Plan)

Forest Type	Beekeeping potential
Aningeria forest	High
Olea forest	High
Baphia forest	High
Mixed deciduous woodland	High
Combretum and *Acacia* woodlands	High
Riparian forest	High
Bamboo forest and/or woodland	Medium/High
Plantations	Depends on plantation type, but in general low potential. Eucalyptus plantations can be excellent for beekeeping, but can also be of nil value, depending on water availability & humidity.

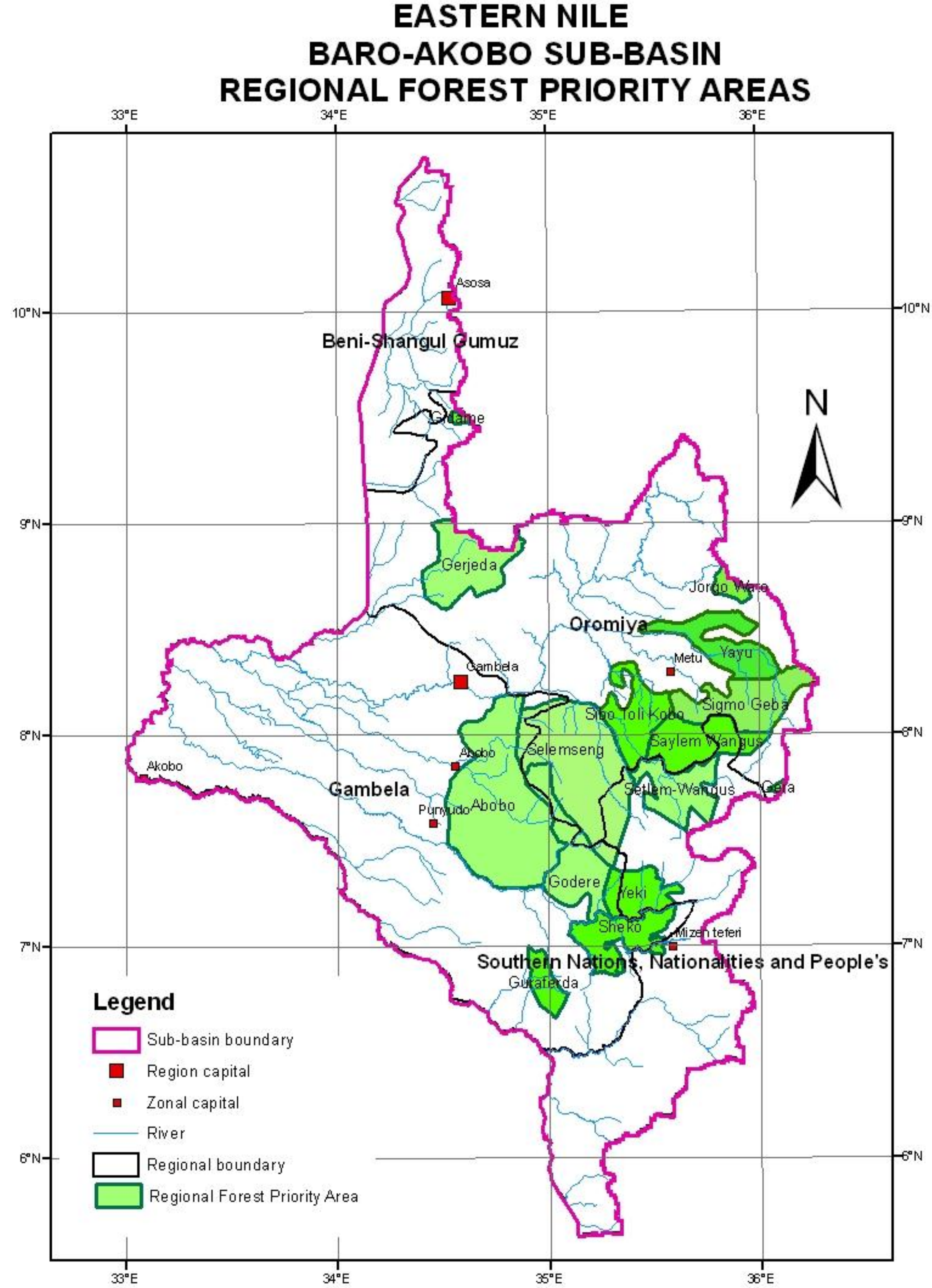
(iii) Regional Forest priority Areas

There are 15 formerly National Forest Priority Areas (NFPA's) covering some 1.76million ha or 23 percent of the Sub-basin area (table 50 and Map 39). Some 9 of the 15 RFPA's straddle two or even three Regions. When these were "National" Forest Priority Areas this was not a problem. Now control has been assumed by each regional administration there are in practice there are 25 "Regional" Forest priority Areas (RFPA's).

Table 50. National Priority Forestry Areas in Baro-Akobo Sub-basin

NFPA	AREA (HA)	STATUS	% of Total Area under natural Forest
Abobo	382,195	Undemarcated	57%
Gera	2,847	Demarcated	97%
Gerjeda	130,108	Demarcated	51%
Gidame	4,726	Undemarcated	0%
Godere	134,176	Undemarcated	90%
Guraferda	39,917	Demarcated	72%
Jorgo Wato	18,873	Demarcated	32%
Saylem Wangus	116,807	Undemarcated	85%
Selemseng	308,479	Undemarcated	93%
Setlem-Wangus	98,897	Undemarcated	65%
Sheko	100,369	Undemarcated	78%
Sibo Toli Kobo	103,354	Undemarcated	75%
Sigmo Geba	134,483	Undemarcated	81%
Yayu	108,754	Demarcated	54%
Yeki	77,681	Demarcated	54%
	1,761,666		**71%**

Only 6 of these have been demarcated on the ground. The area of forest remaining within the RFPA's varies considerably from zero to 97 percent. Overall, 71 percent of the RFPA's are still under natural forest cover. However, it is important to note that the mapping was undertaken using 1988-89 Landsat imagery. This data is thus 18 years old.



Map 39. Ethiopia – Baro-Akobo: Regional Forest Priority Areas

(iv) Wetlands

There are two major types of wetland within the Sub-basin: (a) relatively narrow valley bottom wetlands in the Highlands, and (b) Lowland Wetlands of the Baro and Akobo plains.

(a) Highland Wetlands

These generally comprise valley bottom swamps 50 to 300 m wide and range in size from 10 to 300 ha, although smaller wetlands at the heads of valleys are the most abundant[26]. (Map 40) The soils are generally highly acidic (pH 3.0 – 6.0) with a high organic content, but peat soils are only found in a minority of swamps reflecting the long history of wetland cultivation and sediment deposition from upslope.

A survey of vegetation in the Highland swamps[27] found six plant communities at the end of the wet season and six communities in the dry season, indicating the seasonal dynamics of swamp vegetation due to seasonal changes in hydrology. Floristically, the swamps are dominated by grass species (Poaceae) and sedges (Cyperaceae). Two distinct groups of plant communities were identified: one representing "pristine" and "partially" cultivated swamps that were subject to heavy flooding and high watertables, and a second plant community where the swamp had been substantially cultivated and watertables were much lower. The species composition of these two groups was as follows:

- *Cyperus latifolius, Leersia hexandra* and *Panicum hymeniochilum* were common to all swamps.

- *Guizotia scarba, Phyllanthus boehmeii* and *Snowdenia petitiana* were common in pristine wetlands and in cultivated wetlands only at the end of the rainy season; and

- *Anagallis serpens*, *Cyperus brevifolius*, *Fuirena stricta* and *Hygrofila auriculata* were common in degraded wetlands and in cultivated wetlands at the end of the dry season.

Many of the swamps are being converted to cultivation with significant impacts of the drainage and hydrological characteristics. In some areas over 2 m of wetland sediment have been lost because of a combination of erosion, gulling and microbial degradation of swamp peat. As the swamp soils loose their organic matter crop productivity declines. A traditional system of seasonal or

[26] Aferwork Haile et al (2000) "Nature, Extent and Trends in Wetland Drainage and Use in Illubabor Zone, Southwest Ethiopia", in "Sustainable Wetland Management in Illubabor Zone – Research Report Summaries", Univ. Huddersfield, Univ. Addis Ababa, Univ. East Anglia and IUCN.

[27] Zerihun Woldu (2000) "Plant Biodiversity in Wetlands of Illubabor Zone", in "Sustainable Wetland Management in Illubabor Zone – Research Report Summaries"

multi-year resting and flooding of the swamps, allowing the original "cheffe" vegetation to regenerate restores the swamps to their original fertility levels and allows continued cultivation.

ETHIOPIA
BARO-AKOBO SUB-BASIN
HIGHLAND VALLEY BOTTOM SWAMPS
(NR. METU)

Map 40. Ethiopia – Baro-Akobo: Highland Valley Swamps near Metu, Oromiya region.

(b) Lowland Swamps (Map 41)

Seasonally River-flooded Grasslands

These grasslands, which are flooded annually to varying depths and for varying periods which yields dry season grazing essential for the Nuer agro-pastoralists. Two main types can be distinguished: (a) *Oryza longistaminata* dominant, and (b) *Echinochloa pyramidalis* dominant[28].

Oryza longistaminata Dominant Grassland:

The dominant species constitutes 80-90 percent of the standing crop. Oryza does not flower or reach maximum production unless it has been deeply flooded for several months. It yield 1t/ha when not flooded to 7 tons/ha when deeply flooded for a long period. They provide high quality grazing for much of the year even into the dry season. These grasslands are burnt each year early in the dry season. Although a perennial it can produce abundant seed.

Echinochloa pyramidalis Dominant Grassland:

These grasslands are further away from the river and thus flooded less frequently (although a tall variant grows close to the river). They occupy Vertisols with much *gilgai* micro-relief. The species produces growth even during the dry season and is thus a year-round pasture. Associated species include *O. longistaminata*, Sporobulus *pyramidalis*, Digitaria *debilis* and *Echinochloa haploclada*.

Seasonally Rain-flooded Grasslands

Three types are recognized: (a) *Echinoochloa haploclada* grassland, (b) *Sporobolus pyramidalis* grassland, and (c) *Hyperhennia rufa* grassland.

Echinochloa haploclada Grassland:

Between the river-flooded and the rain-flooded grasslands there is often a strip of land with light textured soils and slightly elevated, which is used for settlement and cultivation. As livestock are concentrated here for long periods this grassland is heavily grazed. Nutritionally the grassland is of very high quality during the wet season but quality falls off during the dry season.

[28] Howell, P et al (1988) "The Jonglei Canal: Impact and Opportunity", Cambridge Univ. press.

***Sprobolus pyramidalis* Grassland:**

This tussock-forming species is not widespread. It is characteristic of heavily grazed areas. It makes no growth during the dry season, is low in protein and during the dry season nutrient levels fall below those needed for maintenance. It is used to make string used in house construction.

***Hyperrhenia rufa* Grassland:**

These grasslands occupy level ground out of reach of river-flooding but are inundated by rain for varying periods. In some northern areas Hyperrhenia may be replaced by *Setaria incrassata*. Although biomass attains 6-7 tons/ha at the end of the wet season, 90 percent of this is stem and contains little of value to livestock. A high proportion of these grasslands are burnt each year. They are generally used at the beginning of the wet season and at the beginning of the dry season after burning. The grass provides a major source of thatching material.

<u>Swamp vegetation</u>

Three types of swamp vegetation are distinguished: (a) *Cyperus papyrus* swamp, (b) *Typha domingensis* swamp, and (c) *Vosia cuspidata* swamp.

***Cyperus papyrus* Swamps:**

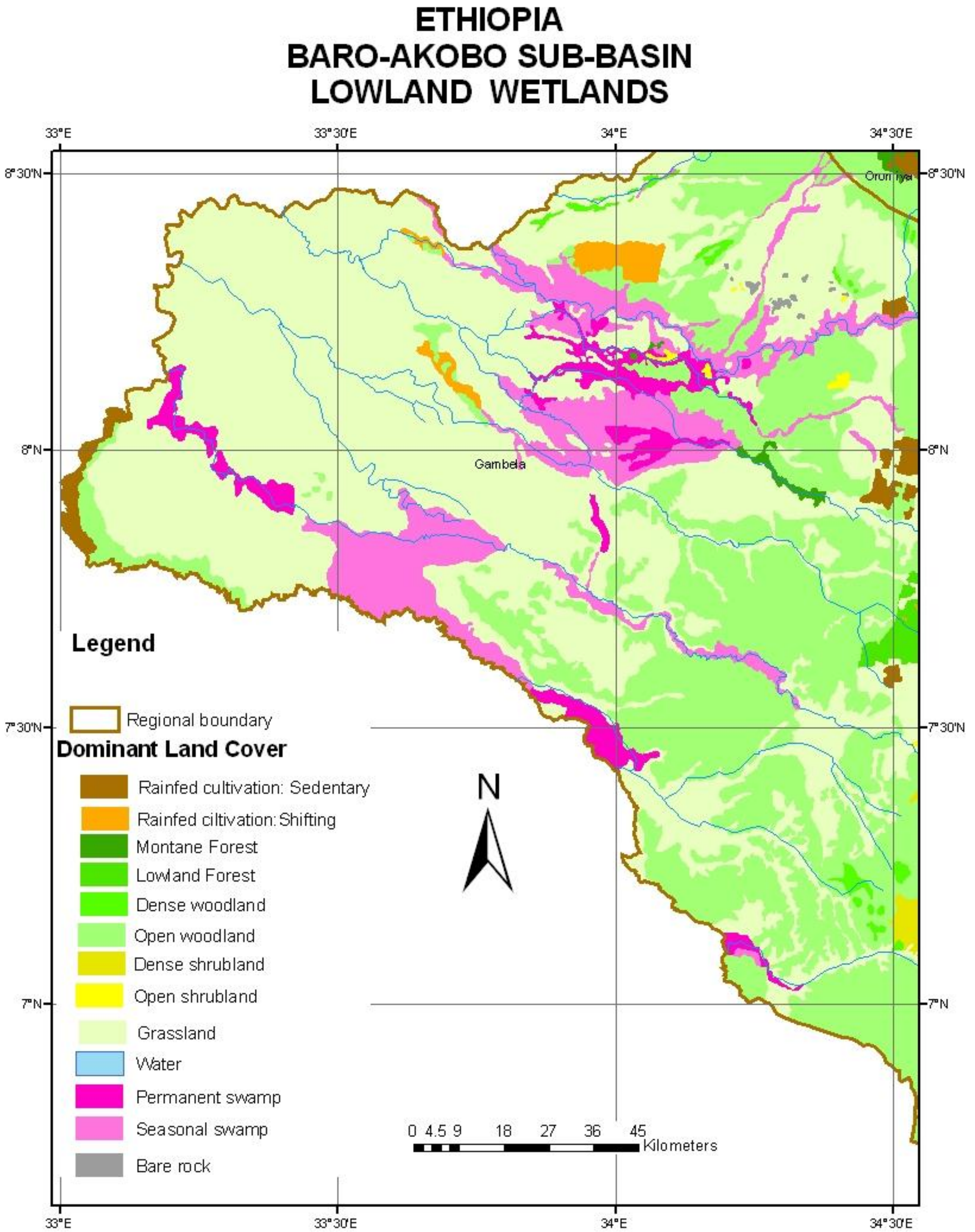
These swamps form a fringe along water courses, pools and other water with deep and constant depth. The plants form a floating mat upon which other species – mainly climbers are found.

***Typha domingensis* Swamps:**

These are most extensive away from the river channels. It is most likely that the vegetation is not floating but rooted into the substrate covered by very shallow water. There are few other plant species.

***Vosia cuspidata* Swamps:**

This vegetation is found next to flowing water and forms floating mats over the water.



Map 41. Ethiopia – Baro-Akobo Sub-basin: Lowland Wetlands: Gambela Region

6.1.6 Water resources

(i) Surface water hydrology:

The major rivers within the Baro-Akobo basin are Baro and its tributaries (Birbir, Geba, Sor), Alwero, Gilo with its tributaries (Gecheb, Bitun, Beg) and Akobo with its tributary Kashu. The general direction of the rivers is from the east to the west. Streams with steep gradients originate in the eastern highlands (about 2,000 – 3,500 masl) where rainfall is high and debauch onto western plains (Gambela plain around 500 masl) that have relatively low rainfall and moderate to low river gradients, which ultimately join Sobat river which is a tributary of the White Nile.

The peak flows of the major rivers closely match the rainy season, with peak discharge occurring during September. The mean annual runoff of the basin, which has a total area of 76,103 km2, is estimated to be 23.237 billion m3.

Table 51. Summary of surface water resources

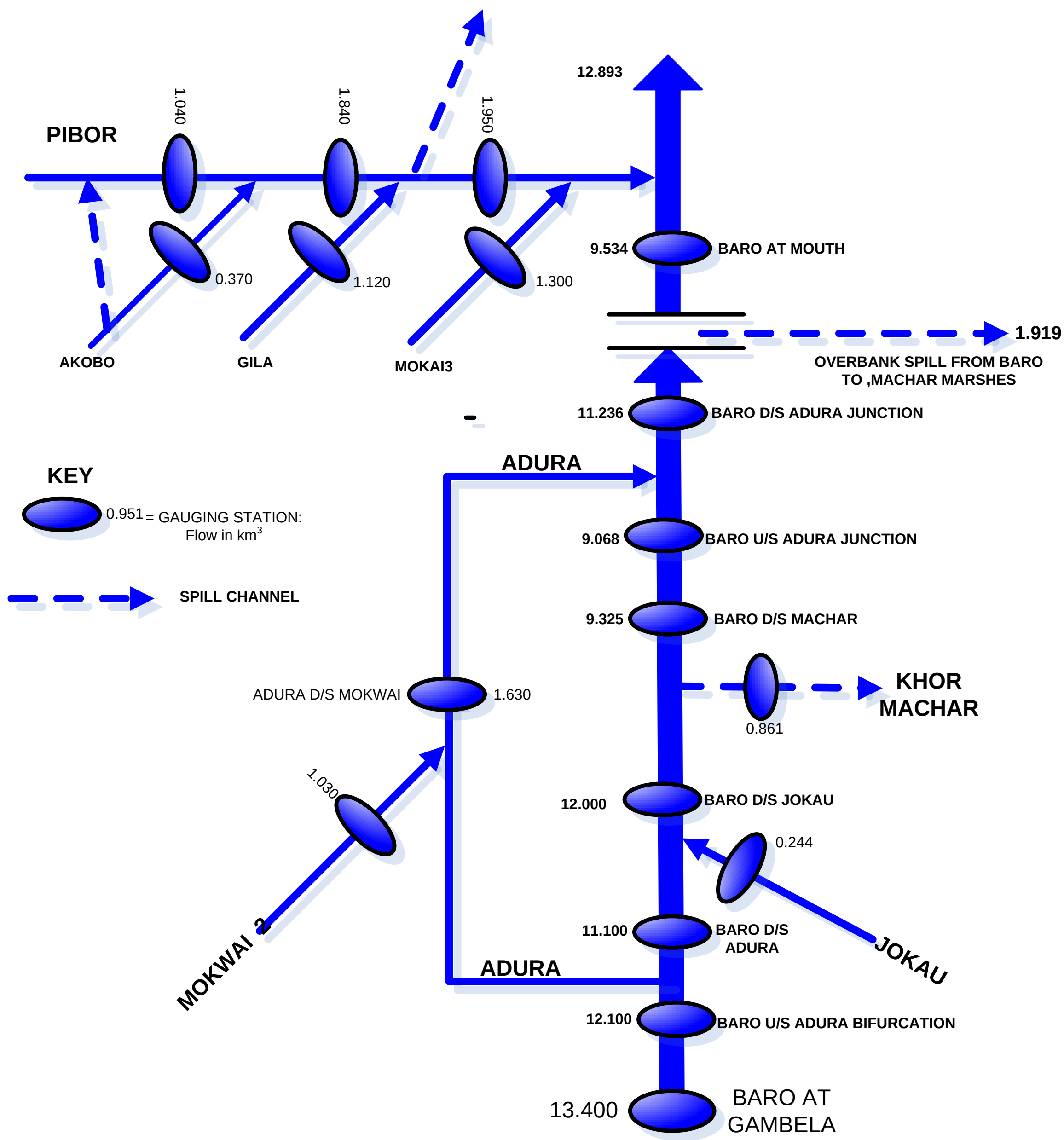
Name of basin	Catchment area (km^2)	Mean annual runoff (MAR) MCM/yr
Baro river (Gambela)	30,080	12,784
Akobo river (upper)	6,051	1,774
Akobo river (lower)	7,227	2,118
Gilo river	12,848	3,224
Alwero river	8,039	1,375
Serkole river	7,722	1,320
Tirmatid river	2,697	419
Pibor river	1,439	224
Total	**76,103**	**23,237**

Source: Master Plan Development (Vol. II, 23).

The Akobo appears to spill across to the Pibot through an extensive area of wetland at its junction with the Akula River, although this fact does not appear in any reports from Ethiopia or Sudan. Just above the Jakau junction the Baro bi-furcates into the Baro to the north and the Adura to the south. They rejoin below the junction with the Khor Machar. The Baro both overflows and spills along the Khor Machar into the Machar marshes. Figure 11 indicates the losses and gains (using 1905-1959 average data) between Gambela and the Baro-Sobat junction[29].

[29] Sutcliffe, J.V. & Y.P.Parks (1999) "The Hydrology of the Nile", IWMI/Gibb, IAHS Special Publication No. 5.

Figure 11. Ethiopia – Baro-Akobo Sub-basin: Hydrology of the Lower Baro-Akobo Sub-basin.



(ii) Ground water:

The Baro-Akobo basin has two basic types of aquifer. One is associated with fracture and crush zones in the Basement Complex rocks and the other in the Pliocene to Quaternary alluvium, an unconsolidated sedimentary porous medium.

Basement Complex aquifers characteristics vary with the degree of fracturing and area continuity that exists in otherwise impermeable bodies of metamorphic and/or igneous rock. Rock type and mode of emplacement usually have little relationship to Basement Complex permeability. The available information indicates production rates to be generally less than one liter per second (1 lt/s).

The alluvium constituting the aquifers in the Gambela Plain is usually fine sand to silt. Water yields from wells constructed in these aquifers range from about 0.01 l/s to 1.0 l/s. Static water levels of wells in these aquifers usually vary from ground surface to about 7.0 meters below ground surface.

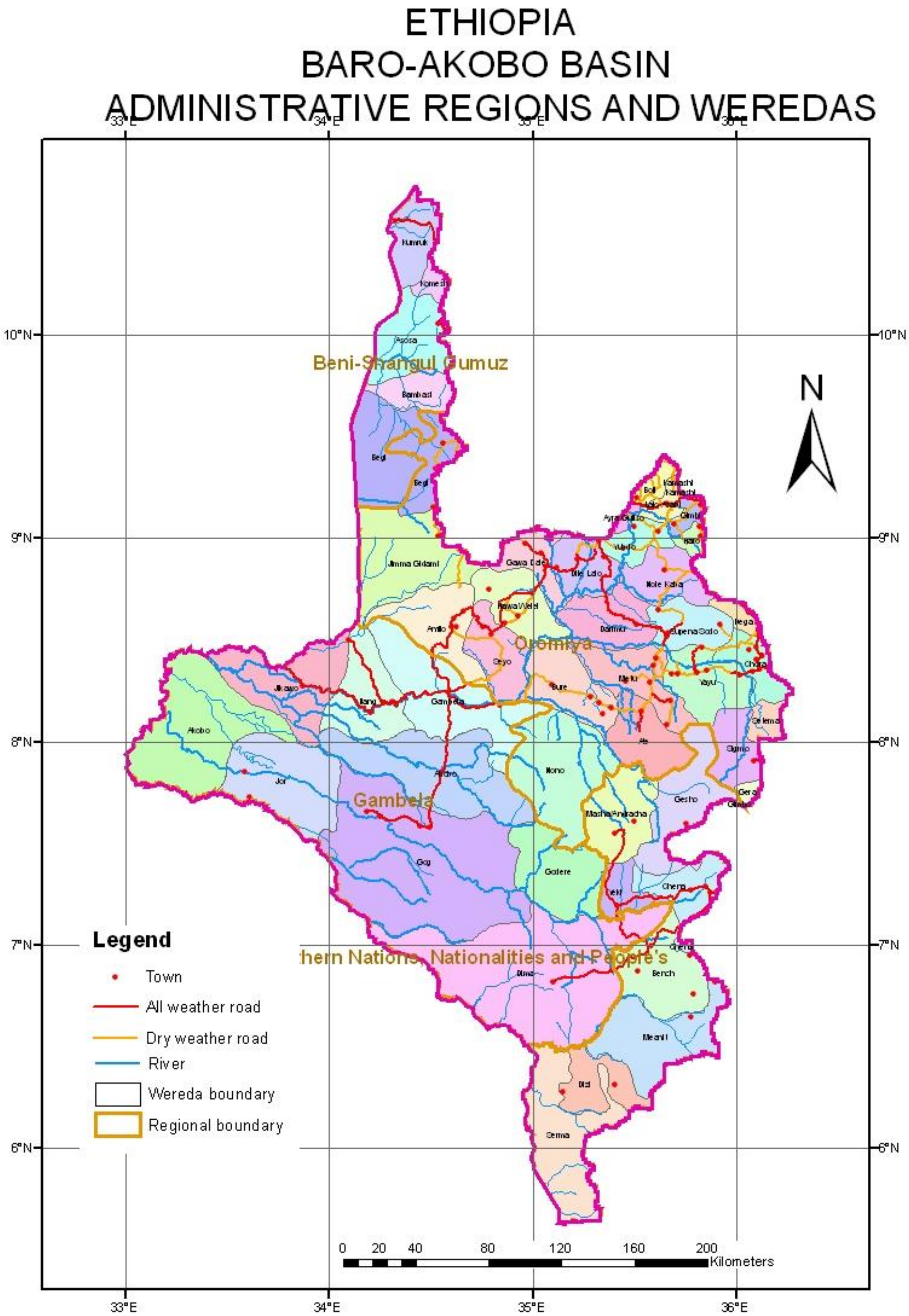
6.2 Socio-economic Characteristics

6.2.1. Population size and Distribution

(i) Administrative units and population

The Baro-Akobo Sub-basin includes four administrative regions, BeneShangul-Gumuz (BSG), Oromiya, Gambela and the Southern Nations, nationalities and Peoples (SNNP) Regions (Map 42). Oromiya Region is located in the northeastern portion of the basin, covering 34 %, BeneShangul-Gumuz in the northwest covering 7 percent, Gambela in the west covering 42 percent and SNNP Region in the southeast covering 17 percent of the area.

In 2000 the population of the Baro – Akobo basin was about 2.37 million in rural areas and 253,694 in urban areas, a total population of 2.63 million. The number of rural families was 431,930 and urban families 52,550. The most recent estimated rural population growth rate (1995-2000) was 2.8 percent per annum and the urban rate was 4.5 percent. Using the latest CSA median population growth estimates the rural population by 2035 will be 4.656 million.



Map 42. Ethiopia – Baro-Akobo Sub-basin: Administrative Regions and Weredas.

Table 52a. Ethiopia – Baro-Akobo Sub-basin: Rural and Urban Population estimates for 2000.

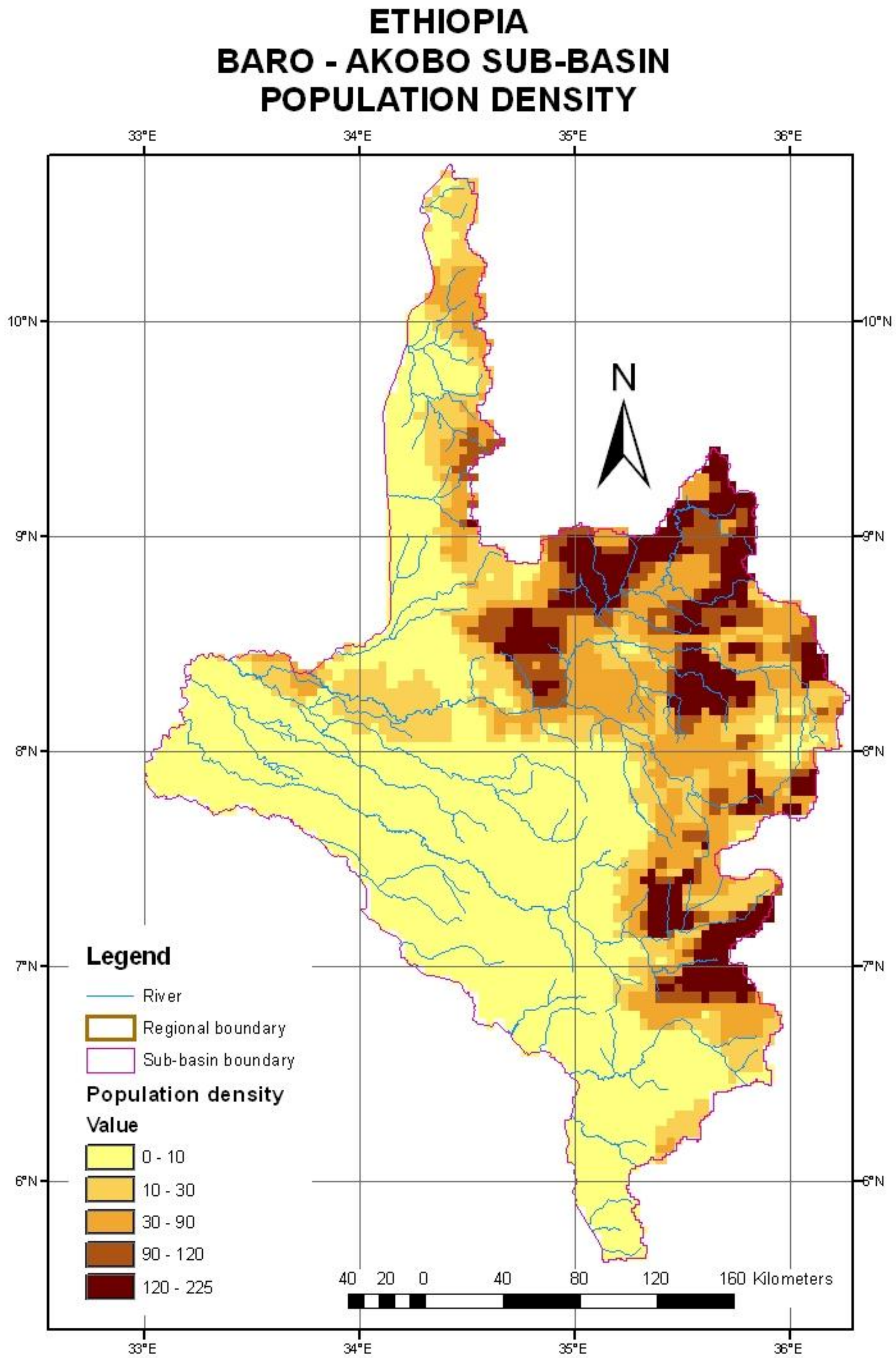
Region	Rural population	Urban population	Total population
BS-G	66,666	13,556	80,222
Gambela	202,287	41,441	243,729
Oromiya	1,356,162	156,284	1,512,446
SNNPR	396,738	42,667	439,404
SUB-BASIN	**2,021,853**	**253,948**	**2,275,801**

Table 52b. Ethiopia – Baro-Akobo Sub-basin: Percent Rural and Urban Population (2000)

Basin/Region	Rural %	Urban %
BS-G	3%	5%
Gambela	10%	16%
Oromiya	67%	62%
SNNPR	20%	17%

One of the major consequences of this population increase will be the increase in rural population densities, which by 2035 will be about 61 persons per km^2, a doubling of the 2000 density. Without parallel economic development in the basin, the big challenge coming would seem to be how to achieve a massive yield increase that will be needed to feed the forecasted 5.3 million people living in the basin. Besides this, the pressure on the declining natural resources will be considerably increased. In fact, the population forecast does not take into account settlers and refugees. The number was close 61,500 in 1996 although with the Comprehensive Peace Agreement in Sudan it is likely that this number will be reduced substantially in the next year or so. However, internal resettlement is likely to grow, either through planned programmes or spontaneous movements.

Map 43 indicates the current population density distribution. The central plateau of the upper basin has the highest density exceeding 122 people per km^2 in some parts. The densities in the deep valleys and the escarpment are very low. In the lower basin densities are low and generally confined to the Baro River.



Map 43. Ethiopia – Baro-Akobo Sub-Basin: Population Densities.

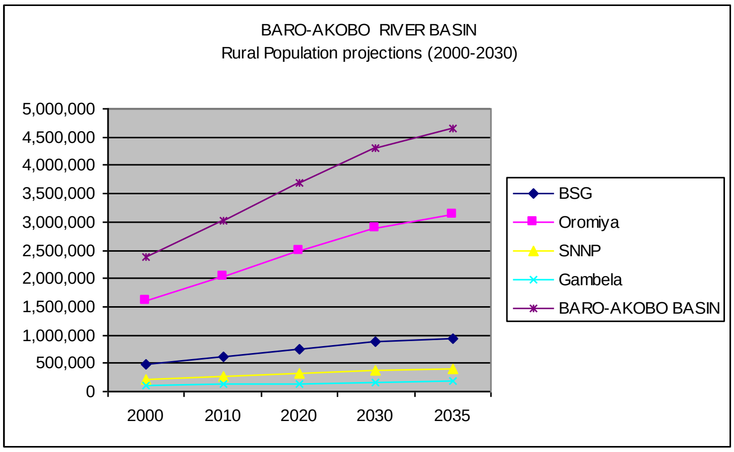
6.2.2 Population Projections

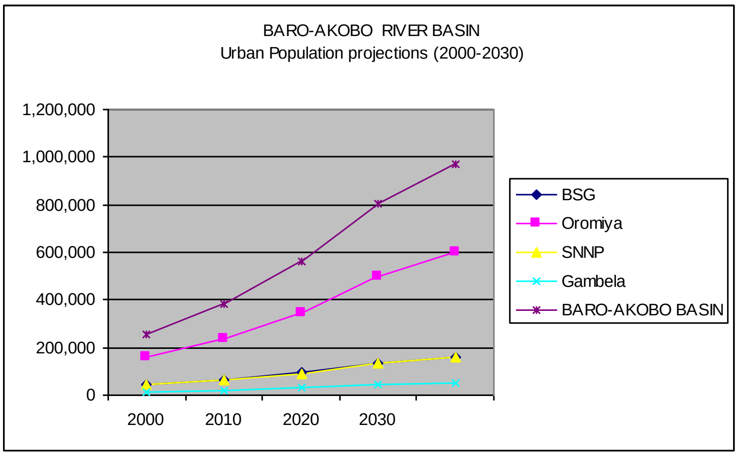
The estimated rural population growth rate (1995-2000) was 2.8 percent per annum and the urban rate was 4.5 percent. These growth rates are projected by the Central Statistical Authority (CSA) to decline between 2000 and 2030 as follows:

	Rural	Urban
2000 – 2010	2.49%	4.25%
2010 – 2020	2.00%	3.85%
2020 – 2030	1.55%	3.70%

The impact on the population of the Baro-Akobo sub-basin is shown in figure 12. Although the rural population shows a distinct reduction in the rate of growth the rural population of the sub-basin is expected to rise from 2.37 million to 4.66 million by 2030, a doubling of the 2000 population. Urban population is projected to increase from 0.25 million to 0.97 million by 2035, nearly a fourfold increase. Despite the rapid increases in the urban population the proportion of the rural population in the sub-basin only decreases from 87 to 78 percent.

Figure 12. Baro-Akobo River Basin: Projected Rural and Urban 2000 - 2030





There is an attendant impact on rural population densities that has important implications for natural resource management and use. Table 53 indicates the increases on gross rural population densities in the sub-basin that will occur.

BSG and Oromiya Regions both see substantial increases in their population densities. Gambela and SNNP Regions see relatively small increases in density, although these may be concentrated in specific areas (e.g. the Anuak along the river banks and Nuer on the higher ridges) and so have serious implications.

Table 53. Ethiopia – Tekezi Sub-basin: Changes in Rural Population Densities (persons/km2): 2000 – 2030

BASIN/region	2000	2010	2020	2030
BS-G	89	114	139	162
Gambela	3	4	5	5
Oromiya	62	79	97	113
SNNPR	16	20	25	29
SUB-BASIN	**31**	**40**	**49**	**57**

6.2.3 Socio-cultural Aspects of population

(i) Major Ethnic Groups

The population of the Baro – Akobo basin is ethnically heterogeneous. There are twenty-seven ethnic groups of individual significance in the basin apart from the settlers who came to the area during the drought years of the 1970's and 80's from the northern part of the country and most of them have returned to their previous locations. However, despite their cultural differences, the major ethnic groups are linked together either by language or mode of cultivation. The major ethnic groups living in the basin belong to one of the following three major language groups:

Omotic group: this is a language identified as one of the six Afro-Asiatic proto languages spoken by indigenous Gimira, Maji, Bench, Majangir, Sheko and Dime peoples and from which Kefana is derived,

Cushitic group: This is the language spoken by Oromo,

Nilo-Saharan group: This includes both the languages of indigenous Bertha (Beneshangul), Gumuz, Uduk, Anfillo and Mao of the northern region of the basin (in Beneshangul, Begi, Gidame and Asosa woredas) and the language of the East Sudanese people, namely, the Anuak, and Nuer of the Gambela Plains (Fleming, 1976).

Table 54. Share of Major Ethnic Groups in Each "1984 Region" in 1984

Ethnic Group	Gambela	Illubabor	Keffa	Wellega
Agnuak	22	2,8	0	0
Amhara	0	3,8	2,6	3,3
Domete	0	0	11,0	0
Gurage	0	0,2	0,5	0
Mocha	9	4,9	0,2	0
Keffa	0	3,2	17,0	0

Oromo	0	78,2	50,1	90,1
Tigray	0	0,2	0,1	0,1
Nuer	39	0	0	0
Seke	7	0	0	0
Majangir	6	0	0	0
Others*	17	6.7	18.5	6,5
Total Rural	**100**	**100.**	**100.**	**100.**

Source: Baro-Akobo MP Study (Illubabor, Keffa, Wellega) & WBISPP (2001) (Gambela)
(*: Includes Amhara, Tigray Oromo)

6.3 Farming Systems

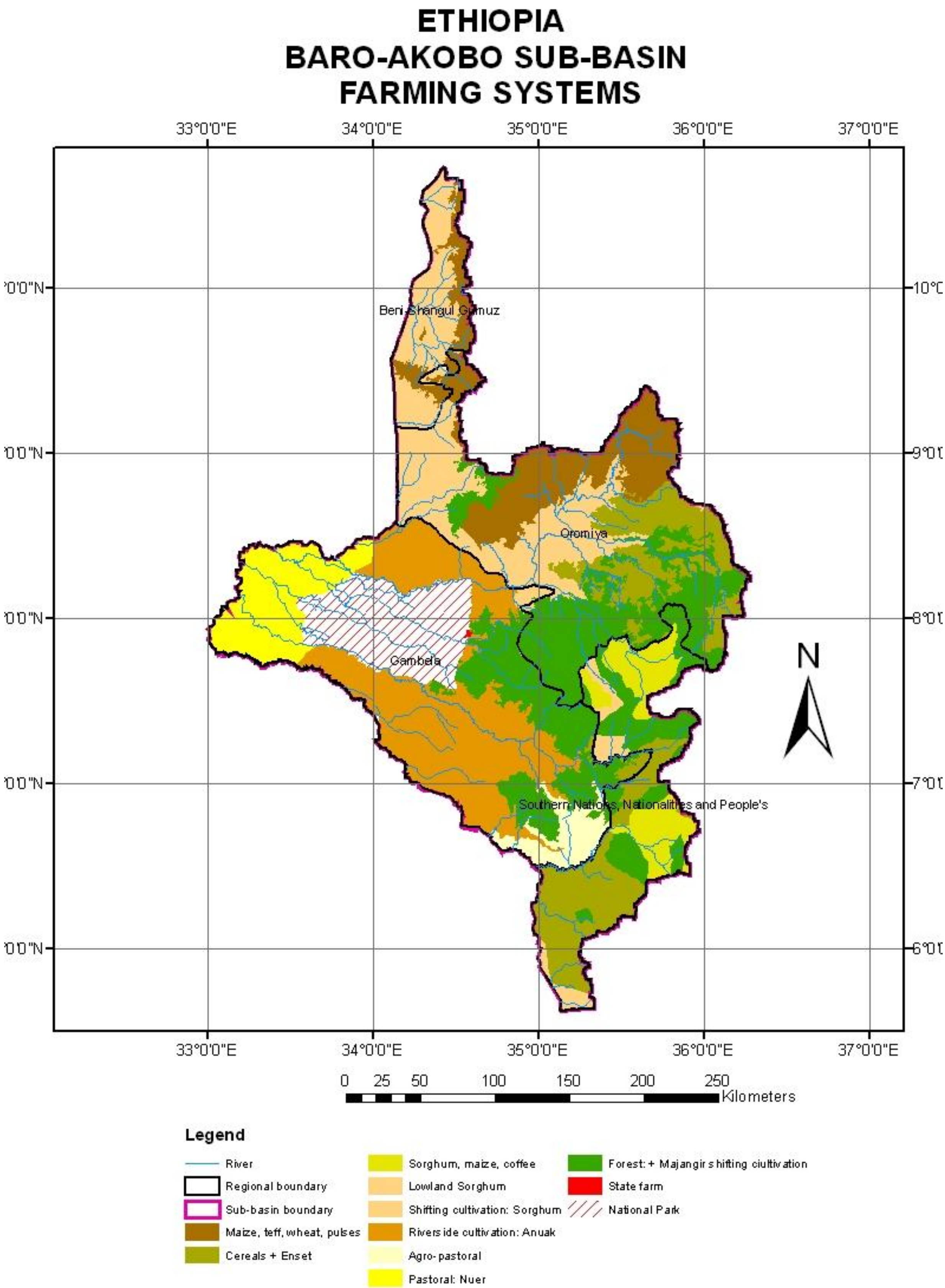
6.3.1 Ethnic Groups and Livelihoods

A broad classification of the livelihood systems of the population in the basin is provided in Table 55. This shows that the bulk of the population in the basin practice sedentary agriculture, with a small number, especially in the escarpment zone practicing forms of shifting cultivation, or transhumant pastoralism.

Table 55. Ethnic Groups by Location and Occupation (Master Plan)

Region	**Agriculture**	**Other Sedentary**	**Transhumant**	**Uncertain**
Gambela R.S.		Anuak Majangir	Nuer	Anfilo, Kome, Majangir, Longe, Opuo
Illubabor Zone, Oromiya RS	Oromo, Amhara	Majangir		
Sheka and Bench Maji Zones, SNNPRS	Sheka, Kefa, Oromo, Amhara, Kefa, Bench, Shuro/Tama, (Majangir)	Shekocha, Majangir, Shuro	Me’enit, Sheko	Bench
Welega Zone, Oromiya R.S.	Oromo, Amhara	Majangir, Mao		
Beni-Shangul Gumuz		Beni-Shangul		

Source: Baro-Akobo River Basin integrated Development Master Plan, Interim Report (1995), Colombi, 1995.



Map 44. Ethiopia – Baro-Akobo Sub-basin: Farming Systems

6.3.2 The Cereals + Enset System

The Mocha (Sheka) people, living mainly in the highest parts of the Sub-basin, especially in Sheka Zone, cultivate Enset as a co-staple crop with cereals and tubers. The system is based on two types of field: a permanent garden around the homestead and the open and rotating fields beyond. The garden crops include enset, root crops (yam, taro and sweet potato), pulses, vegetables, spices and coffee. The open field crops are mainly cereals: teff, maize and sorghum.

The area under crops in the open fields is about 1 to 2 hectares. Fields are cropped for 3 to 4 years, and then as weeds build up beyond the labour capacity to effectively clear them the fields are left under fallow and grazed for about 12 years before being cleared and burnt of secondary growth and cropped again.

Increasingly the maresha plough and not the hoe or digging stick or fork is being used for land preparation allowing a larger area to be clean cultivated and weeded. Thus, it is likely that this system will develop into the permanently cultivated system that has developed in Keficho-Shakiso Zone in SNNPR. Livestock are mostly sheep and goats, with a few cattle, mules and horses.

Many scattered trees from the original high forest remain in the fields. On the expanding edge of cultivation many scattered patches of high forest, some of considerable extent, are found on the steeper slopes and valleys.

6.3.3 Coffee cultivation Systems of the high forest (not mapped)

The CSA 1994 census records some 27,900 Amhara, Oromo and Tigray peoples (about 4,650 farm families) living in the rural areas of Abobo, Godere and Sheko weredas. It is known that these people are cultivating coffee and some food crops, likely to be maize, sorghum, and horsebean. The CSA survey of the enset areas indicates that 1.7 ha is under perennial crops, most of which will be coffee.

It is likely that these people have been moving into the area from the road between Tepid and Masha that runs along the eastern border of the wereda, especially in the area to the northwest of Tepi.

6.3.4 Sorghum-Maize-coffee

The dominant crops are maize and teff and some sorghum. Below 2,000 masl coffee is an important cash crop. Some root crops (sweet potato and Oromo potato) are grown in homestead gardens, occasionally with a small enset plot.

Livestock include cattle, sheep and goats. Cattle are important for draught power, milk and as a store of wealth. Livestock feed supply comprises open grazing, crop residues and grass hay. Because open grazing is still available (although decreasing rapidly), cropping, livestock production and tree growing are not closely integrated.

6.3.5 Lowland Sorghum-maize (sedentary and shifting cultivation) systems of the Berta/Komo/Mao

These systems are practiced by the Berta, Komo and Mao people in BSG Region. Farmers grow sorghum, maize, noug, and haricot beans A few goats are kept.

Livestock holdings in this land use system are very low. Less than 7 percent of households have cattle, but 47 percent have goats. Most of the system lies within areas of high tsetse challenge, and cattle are thus exposed to trypanosomiasis.

Communal lands are found on the extensive margins to the main village area. The main croplands are often found on or close to streams and rivers on flat slopes and deep soils. Beyond the intensively cropped areas are less intensively cultivated lands on steeper slopes and shallower soils. These lands may be cropped using a bush fallowing system. Overall, this farming system is extensive with changes occurring as population expands the cultivated area into shrubland and woodland.

6.3.6 Shifting Cultivation Systems of the Majangir

The Majangir people practice a sophisticated system of weed mulching and forest fallowing. They live mainly (72 percent) in Godere wereda, below the Kefa Highlands in the high forest on the escarpment and foothills. The use of the mulch to suppress weed growth extends the period of cultivation by some two to four years. Thus, the Majangir appear to have partially solved the problem of weed infestation, which is probably the cause of final abandonment of shifting cultivated fields elsewhere.

The Majangir subsistence system is based on the shifting cultivation of maize and sorghum, hunting, fishing and bee keeping. No livestock other than chickens are kept because the high tsetse challenge. There is little gathering of forest products and wild plants other than mushrooms, fresh greens (the weed *Bidens pilosa*), a wild savannah yam and wild coffee (traditionally only leaves and twigs, not berries). Coffee berries are now collected for sale.

The staple crops are maize and sorghum, with some taro and yam (several species) and pumpkin. Crops cultivated for relish include sesame, beans, peas, pumpkin and taro leaves. Spices are grown to flavour only coffee (a leaf infusion). Some recently introduced crops include sweet potato, sweet cassava, enset and sugar cane but none is important.

New and old fields are planted to maize and under-planted with pumpkin. The initial growth is so fast that the maize plants suppress any weed growth. In June and July yams and tobacco are planted in odd corners of the two fields and taro in depressions and gullies. The felled trees in the new field provide fuelwood for the whole year. Sorghum is planted on 3 year old fields or old fields not cultivated for 2 to 3 years. Sorghum is broadcast in the middle of the rains in July and the vegetation is then cut over the seed as mulch to suppress weeds.

The sesame fields are smaller and on land which has been cultivated for 5 years or more. Again seed is broadcast, the vegetation is cut as mulch until germination then swept up and cleared from the field. As sesame is resistant to pests and diseases it can be cultivated some distance away from the old and new fields.

The riverside field is made on flats adjoining perennial streams and is planted to maize or sorghum near or after the end of the rains and which then matures on the residual moisture. Either the fields are broadcast and mulched (during the rains) or fired and planted (after the rains).

Fallows last a minimum of 10 years although generally they are 10 to 15 years and often longer. The Majangir shifting cultivation system operates in a situation where the main constraining factor is labour and not land. The husbandry operations are designed to minimise weed growth with the minimum of labour. With a total area under crops of between 5 to 10 hectares hand weeding would be impossible given the extended relay cropping activities as well as the other non-crop subsistence activities (bee keeping etc). Fields are abandoned because the increasing incidence of weeds cannot be suppressed by the husbandry techniques (burning and mulching) alone. Although there is probably some decline in soil fertility the main agronomic constraint is increasing weed growth with time.

Hunting is carried out in the forest and on the savannah plains below and beyond the forest. Hunting in the forest can be done individually and the techniques include traps, snares, springs, deadfalls and spring-activated rifle. In the plains small groups burn grass and firearms are used. Most animals are used for food although monkeys and baboons are killed as crop pests. Fishing techniques include rod and line, basket traps, spears and poison. Bee keeping is extremely important and an individual family may own between 50 and 100 hives. The Majangir recognise about 40 species of trees and other plants as suitable sources of nectar. Much of the honey is used to generate cash for the purchase of items in local market.

6.3.7 The Cereal Cultivation Systems of the Anuwak, Opo and Komo Peoples

The Anuwak, Opo and Komo peoples cultivate the banks and levees of the main rivers rather than the woodlands on the interfluves. Two crops of maize and beans and one crop of sorghum are obtained. The average cropped area of each maize crop is 1-2 ha with 1 ha of long season sorghum. The first maize and bean crops are grown on the wetter soils where there is residual moisture. The second crop is grown during the rain season on the high and better-drained levee soils with the sorghum and bean crops.

Maize yields are between 600 and 1000 kgs per ha; sorghum yields 900-1100 kgs per ha, and beans 800 - 900kgs per ha.

Because of the high tsetse challenge in the woodlands and lowland forests no livestock except chickens are kept. Fishing is an important source of food. Hunting on the plains and forest edge is carried out in the dry season, like the Majangir, using fire to flush the animals.

6.3.8 Agro-Pastoral Systems of Extensive Livestock Production of the Nuer

The Nuer agro-pastoralists inhabit the wide treeless grassy and seasonally flooded plains of Jikawo, Akobo and Itang weredas. Because of the lack of shade there is no tsetse challenge in these areas. They practice an oscillating form of movement of their herds related to the rise and fall of the flooding of the main rivers.

In the rainy season from June to November the rivers overflow their banks and flood wide expanses of the plains. During this time the Nuer live in their permanent villages on the highest land ("*Lare*") and graze the livestock on these upland plains. In November they move down towards the main rivers and from December to May live in their main dry season camps ("*Kurthuony*"). From the main dry season camp temporary camps ("*Makerr*") are established some distance away as the herds are moved around to take advantage of the pastures along the rivers. As the rivers rise in May-June the herds are moved back to the permanent villages on the uplands.

The Nuer cultivate fields of sorghum and maize around their permanent villages on the uplands during the rainy season.

6.3.9 Land use systems of the refugee camps

The Bonga refugee camp was previously a Resettlement Camp for northern Ethiopians established in 1984. Following the change in Government in 1991 it was abandoned by the settlers and taken over by the Regional Government for Sudanese Refugees. The Camps at Phugnido and Dima was purpose built. However the presence of Sudanese refugees goes back three decades. Given the permanence of the Camps and their inhabitants a land use system has developed in and around the two camps.

At the Bonga Camp there is extensive cultivation of sorghum and beans both inside and outside the Camp on the deeper soils of the footslopes to the escarpment. There is little or no cultivation at the Phugnido and Dima Camps. However, at all camps there is extensive collection of fuelwood and timber for house construction. At the Bonga Camp wood is collected and cut down not only for own consumption in the Camp, but also for sale in Gambela town. The impacts of these activities are discussed in more detail below.

6.3.10 Land use systems Integration

Only in the Sheka enset system and Nuer agro-pastoral land use systems are there clear linkages among the different components: crops, livestock, tree and bio-fuel production. They are weak or even absent in the remaining systems where livestock are either absent (e.g. Coffee cultivation, Majangir shifting, and Anuwak and Refugee cereal systems).

Recently, a greater synthesis of life styles and activities has evolved between the traditional sedentary cultivators and the slash and burn agriculturists. Analysis of meetings and interviews showed that the following general trends on the social and in commercial and agro-economic development across the basin have been observed and discerned:

Observations reported on the general social trends:

- A greater homogenization of peoples as a result of cash crop cultivation and trade incentives,
- A greater synthesization of activities amongst sedentary agriculturists and shifting subsistence cultivators and,
- Ownership of cattle, either for plowing and manuring, or subsistence, as the main marker or differential of wealth between rich and poor.

Discerned general trends in commercial and agro-economic development across the basin:

- A move by small farmers in the highlands to expand and consolidate agricultural holdings to improve food security,

- A desire to diversify cash sources by growing more cash crops (citrus, banana, papaya, mango, coffee, pepper and spices),
- A desire to acquire more livestock such as cattle, sheep, goats, or chicken (even amongst the sedentary agriculturists in the lowlands) to ensure food security and develop a further cash sources.

6.4 Social Infrastructure: Education and Health

6.4.1. Health

(i) Common Diseases:

Malaria, respiratory tract infections and intestinal parasites are reported to be among the top three leading causes of outpatient visits in the basin. The well known vector-borne diseases prevalent in the basins are Trypanosomiasis, Onchocerciasis, Yellow Fever, Schistosomiasis and Malaria. Diseases that are caused by pathogens transmitted in human excreta are also among the most common diseases. The transmission of these diseases is mainly due to poor hygienic conditions and lack of safe drinking water, which is a case in most of the basin.

(ii) Health services:

In general, the provision of health services is nationally very low with the exception of very few urban centres which are in a better position than the rest of the country. The health infrastructure in the Baro-Akobo basin is similar to that of the rest of the country, with population coverage rates of 87% for Gambela, 60% for Illubabor, 66% for Kefa and 60% for Wollega (MOH, 1992).

Community Health Clinic or health post is staffed by one community health agent (CHA) and one trained traditional birth attendant (TBA) to render basic health services. These services include promotion of community participation, control of communicable diseases, provision of maternal and child health (MCH) services, and provision of curative services for minor illnesses. Each health post is expected to serve a minimum of 1,000 people.

Health stations are the lowest level health services operated directly by the Ministry of health (MOH/BOH). Each health station is often staffed by one or two health assistants (the larger ones by a nurse) and is anticipated to serve, at least, 10,000 populations within a 10 – 12 km radius. In the mid 1990's at the time of the Baro-Akobo master plan study, the numbers of health stations in the basin were 143 in Oromiya, 32 in Beneshangul, 8 in Southern Nation Nationalities and People’s Region (SNNPR) and 25 in Gambela.

Health centres are staffed by a physician, nurses, sanitarians, laboratory technicians and health assistants. Each health centre is expected to provide services for at least 100,000 populations. The numbers of health centres in the Sub-basin in the mid 1990's were 7 in Oromiya, 3 each in Beneshangul and SNNPR and 4 in Gambela.

Hospitals are expected to serve as referral centres and their numbers in the basin in the mid 1990's were 4 in Oromiya and 1 in each of the other three regions with a total of 660 beds. In the basin, it is possible that patients would travel more than 120 km to reach a hospital and about 30 km to reach a health centre or clinic.

(iii) Nutritional status:

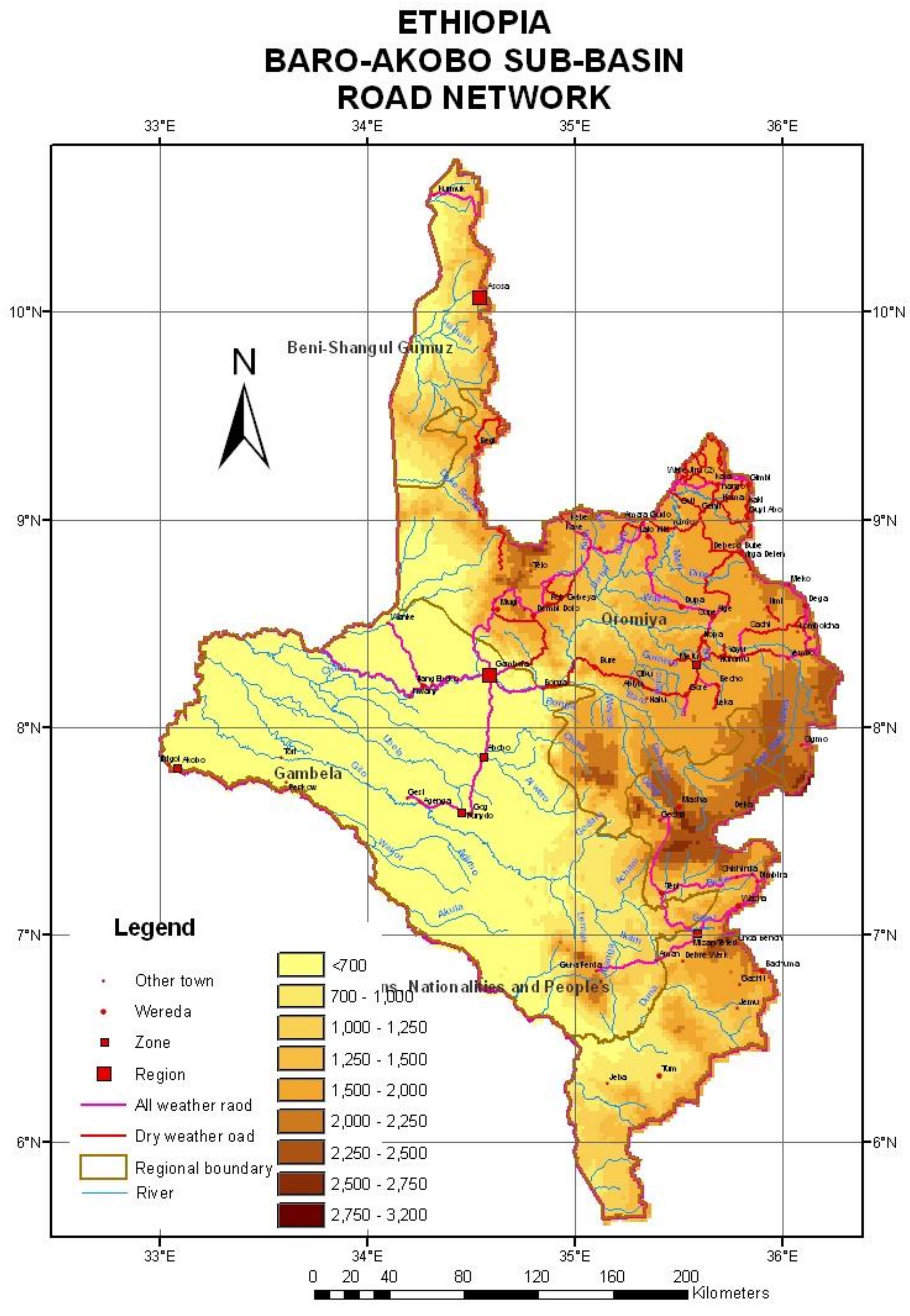
Malnutrition is a common and widespread problem in Ethiopia. The situation in the Baro-Akobo basin is not different from that of the national status. However, specific nutritional deficiencies like anemia, which is prevalent in the area either as direct iron deficiency or as indirect parasitic or other diseases, are reported in Illubabor and Gambela. Such specific deficiencies need to be attended by direct intervention on the root cause and by providing supplements. Yet, improving the general nutritional status of the populations in the basin is feasible only through improving the standard of living of the people and strengthening nutrition within the maternal and child health (MCH) program of the health institutions.

6.5 Transport Infrastructure and Markets

6.5.1 Transport

(i) Roads:

According to the Baro-Akobo master plan study, the basin is traversed by a network of all-weather roads of some 1,058 km, though the road density is low compared to many African countries. The roads Addis – Gambela, Addis – Asosa, Jimma – Mizan Teferi, and Gore – Tepi are well maintained all-weather roads. The Gambela – Dembidolo road is also all-weather road, but in need of maintenance. Numerous smaller roads or dry-weather road links, accessible only



Map 45. Ethiopia – Baro-Akobo Sub-basin: Road Network.

In general, the western part of the basin is the least served by roads. Further improvements to roads in the basin are expected to take place consistent with the priorities of the Road Sector Development Plan of the Ethiopian Road Authority.

In terms of accessibility to all-weather roads some 52 percent of the area of the Sub-basin is more than 15 kms. This compares with 45 percent for the Abay Sub-basin and 39 percent for the Tekeze Sub-basin. The main areas are the still forested plateau and escarpment, and the south-western lowlands. (Map 46).

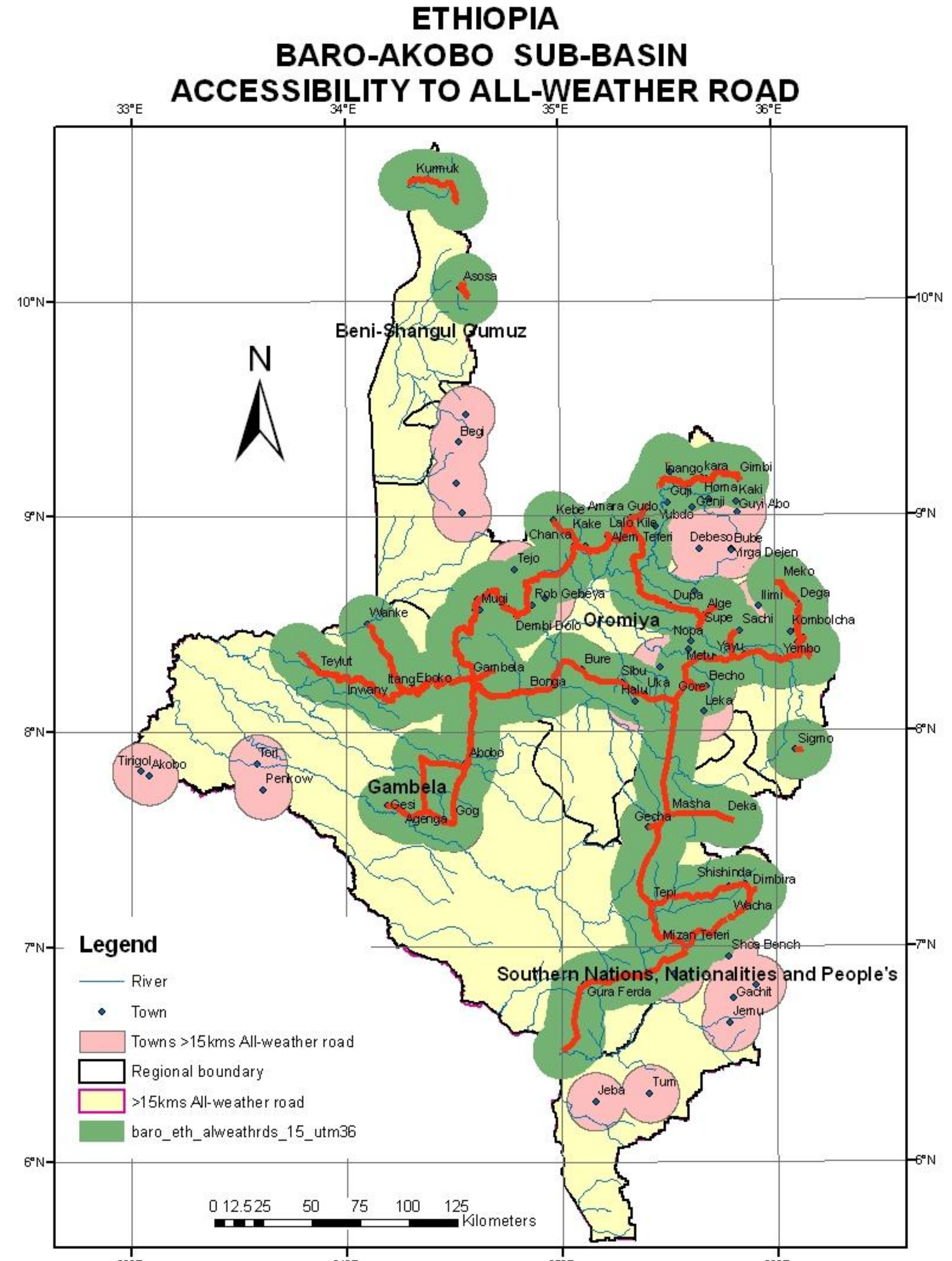
(ii) Air transport:

There are six operational airports in the Baro-Akobo basin connected to Addis Ababa by schedule air services. Gambela is the largest and the only airport with paved runway and navigation aids. It handles about 5,000 passengers (arrivals and departures) per year, while the other five handle 15,000 between them.

6.5.2 Markets

Some studies indicate that most markets in the basin are attended by both women and men. In terms of the divisions of labour and marketing responsibilities, men are generally only responsible for sale of livestock and some produce, while women are the main managers of the domestic economy. But amongst the Oromo, all crop sales are said to be managed by men while women sell butter.

The majority of traders and importers who come to Gambela, Mizan Teferi and Tepi to buy produce and sell consumers goods are from the highlands, sometimes from outside of the basin.



Map 46. Ethiopia – Baro-Akobo Sub-basin: Accessibility to All-weather Roads.

7. PROBLEM ANALYSIS OF NATURAL RESOURCE DEGRADATION

7.1 A Framework for Analysis

The land and water use systems in the three sub basins are highly varied and reflect not only the natural resource base, but also the complex social, cultural and economic characteristics of the land users and the economic, institutional and policy environment in which they operate. Land use systems have their own dynamics responding to endogenous and exogenous factors that have impacts on user livelihoods and the properties of natural resources and environmental services.

The analysis that follows attempts to establish causal linkages between land use systems and trends in these properties and services. In the Transboundary Analysis of the four Sub-basins the analysis will seek to view the Eastern Nile Basin as a hydraulic system, to identify and where possible quantify the upstream and down stream impacts of current resource use and management systems. This analysis is at the national level – in a "with borders" situation.

The International Food Policy Research Institute (IFPRI) has over the past decade developed an appropriate framework for analyzing the dynamics of change of the complex web of factors[30] (fig. 12). Pressure or "shift" variables (e.g. changes in population/migration, markets and market prices, land tenure institutions) will induce changes in baseline conditions such as natural resource endowments of households and communities, household assets, market integration and local institutions (e.g. property rights).

These shifts can in turn induce responses at the community and household level. Of particular importance and of relevance to the present analysis are the community and household decisions with regard to investments (or non investments) in agriculture, soil conservation, and small-scale irrigation. Other responses could include changes in natural resource management systems (e.g. livestock exclusion zones, rangeland management systems). These responses in turn can have positive or negative impacts on agricultural productivity, the condition of natural resources (soil fertility, forage production) and on human welfare (health, livelihoods). At each of these stages negative or positive feed back mechanisms may operate. The public policy environment (e.g. agricultural research programmes, resettlement policies, land access policies) and interventions (e.g. in infrastructural development) can influence this temporal process at various levels.

[30] Scherr, S.J. et al (1996) "Policies for Sustainable Development in Fragile lands: Methodological Overview". IFPRI, Washington DC.

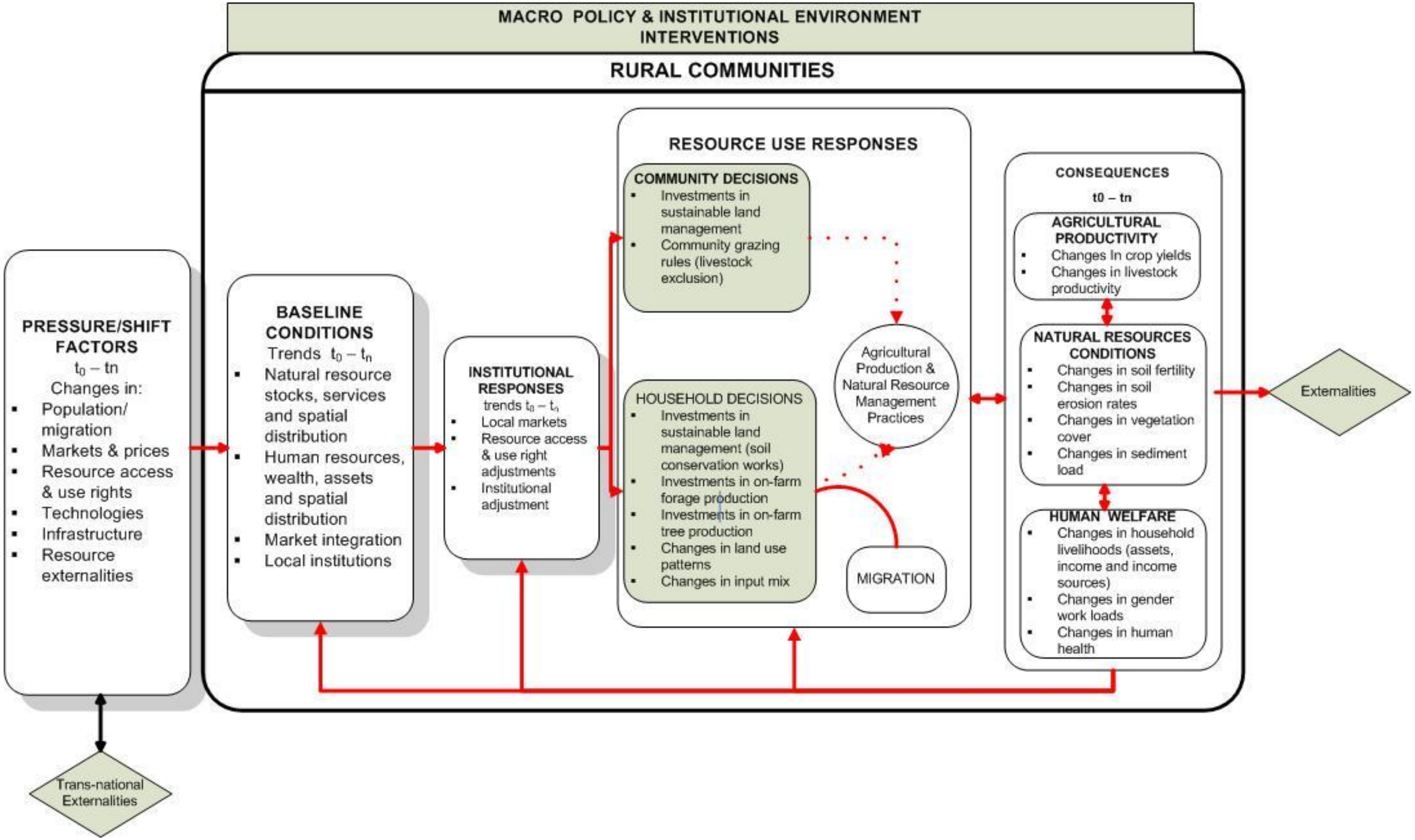


Figure 12. A Framework for Analysis of Natural Resource Degradation Problems.

7.2 Pressure-Shift Factors: The Underlying Causes of Land Degradation and Investment in Sustainable Land Management Technologies

Mahmud Yesuf and J.Pender (2005)[31] have undertaken a comprehensive review of research undertaken into identifying the determinants of the adoption or non-adoption of land management technologies in the Ethiopian highlands. This report and a number of IFPRI/ILRI reports on research undertaken between 2000 and 2004 provide a comprehensive picture of many of the underlying causes of land degradation in Ethiopia. Other useful reviews include the NTEAP Study[32], Alemayehu Tafesse (2005)[33], and Herweg (1999)[34].

7.2.1 Poverty and land Degradation

The poverty line in Ethiopia is set using a basket of food items sufficient to provide 2200kcals per adult per day. Together with a non-food component this represents Ebirr1,070 in 1995/96 prices. The proportion defined as poor in 1999/2000 was 45 percent in rural areas and 37 percent in urban areas. Per capita consumption expenditure of rural people in 1999/2000 was Ebirr 995 compared with 1,453Ebirr for urban people[35]. However, income distribution is more evenly distributed than in other Sub-Saharan countries. The egalitarian land holding system may have contributed to this in rural Ethiopia. Between 1995/96 and 1999/2000 rural poverty declined by 4.2 percent, although it increased in urban areas (by 11.1 percent).

The dependency ratio is very important in determining poverty status in rural areas. Studies indicate that if the dependency ratio increases by one unit, a household's probability of falling below the poverty line increases by 31 percent. Households with more children under 15 years and those with people older than 65 years are particularly vulnerable to falling into poverty. This underscores the importance of adult labour in the welfare of rural households. Female headed rural households face a 9 percent higher probability of being poor than male-

[31] Mahmud Yesuf & J. Pender (2005) "Determinants and Impacts of land Management Technologies in the Ethiopian Highlands: A Literature review", EEPEE/IFPRI, Addis Ababa.

[32] NTEAP (2005) "A Study on Mitigating Soil Erosion within the Nile Basin Parts of Ethiopia".

[33] Alemayehu Tafesse ("005) "Ethiopia Experience in Watershed management and lessons Learnt", paper presented to Regional Workshop on Eastern Nile Integrated Watershed management project, Barhir Dar, Dec 5-6th, 2005.

[34] K.Herweg & E.Lundi (1998) "The Performance of selected soil and water conservation measures – case studies from Ethiopia and Eritrea", Catena, 36, 99-114.

[35] FDRE (2002) Ethiopia: Sustainable Development and Poverty Reduction programme., MOFED, Addis Ababa.

headed households although other factors such as age and education play an important role and need to be taken into consideration when targeting. Households cultivating exportable crops (chat, coffee) have a much lower probability of being poor. Living near towns and better access to markets has a poverty reducing effect. Farm assets such as oxen are important poverty reducing factors: an extra ox reduces poverty probability by 7 percent. Households involved with off-farm activities are 11 percent more likely to be poor. This is because such activities are seen as a coping mechanism for poor people rather than a way of accumulating wealth.

Reardon and Vosti's (1995) typology of poverty is linked to natural resources. They use a household asset approach in terms of:

- natural resource assets (soils, water, vegetation)
- human resource assets (education, health, nutrition, household labour, skills)
- on-farm resources (farm land, livestock, trees, equipment)
- off-farm resources (non-farm employment, remittances)
- community owned resources (grazing land, dams, roads)
- social and political capital (family ties, networks)

They use a measure of "conservation-investment poverty", the cut-off point is situation and site specific being a function of labour and input costs and the type of conservation investment needed.

In Ethiopia, decisions to adopt sustainable land management technologies depend on households' asset endowments. Labour availability has been found to be a positive determinant of chemical fertilizer adoption, trees and terrace construction. However, simply using family size to measure labour availability was found to be misleading. The results of studies into the effect of farm size on land management technologies have been mixed. Both positive, negative and no relationships have been found between farm size and fertilizer adoption. However, with those technologies that take up space (terraces, bunds, trees) a positive relationships were found between farm size and adoption.

Livestock assets have been found to be positively related to adoption of fertilizer, planting of perennial crops, use of manure and contour ploughing. Gender (a human capital variable) does affect adoption of land management technologies. Male headed households use more labour and oxen draught power and apply manure, reflecting a cultural constraint on women ploughing in Ethiopia. The results for fertilizer adoption were mixed, with female headed households in northern Ethiopia likely to use more fertilizer and the reverse in southern Ethiopia. Positive relationships were found between education and adoption of soil conservation measures although the results for fertilizer adoption were mixed.

Related to poverty and household assets are the concepts of profitability of the improved land management technology, the farmers' perceptions of risk and farmers' private discount rates. Private discount rates are a measure of a person's time preference or time horizon. The shorter the time horizon the higher is the discount rate. Short time horizons are the result of a number of factors, tenure insecurity, poverty, and high risk environment. Many farmers have high private discount rates – as high as 70 percent even in the high potential farming area around Debre Zeit near Addis Ababa[36]. A number of studies have found that adoption of soil and water conservation technologies is negatively related to high discount rates. However, where a technology is risk reducing (e.g. terraces that conserve soil moisture) adoption is much more likely.

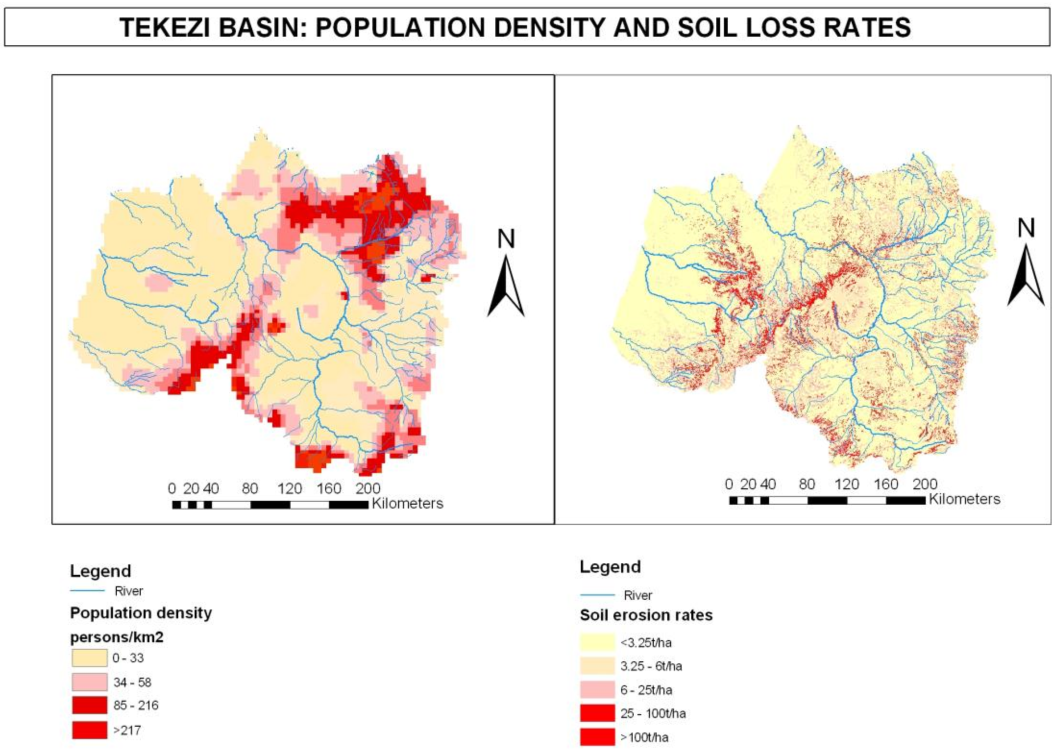
7.2.2 Population Pressure and Land Degradation

Currently there are two basic hypotheses regarding the relationship between population growth and land degradation. The "neo-Malthusian" hypothesis predicts that agricultural production is unable to keep pace with population growth leading to falling agricultural production per capita, and increasing negative impacts on natural resources including land, water, forests and biodiversity. More recently, a more optimistic perspective has developed following from the work by Ester Boserup[37] and others. This perspective emphasizes the responses of households and communities to population pressures that include a reduction in fallow periods, intensified use of labour and land, development of labour-intensive technologies and institutional changes. However, more recent evidence suggests that more specific conditions seem to be needed to get a Boserupian scenario to operate. These have been identified in the Machakos study as secure tenure, efficient markets, cash crops, supporting social organization and proven SWC measures. The evidence accrued so far in Ethiopia is mixed.

[36] Holden, S.T. et al (1998) "poverty, Credit and Time Preference: of Relevance for Environmental Policy?", Environ. and Development econ., Vol. 3, 105-130.

[37] Boserup, E (1965) "The Conditions of Agricultural Growth". Aldine Publishing, New York.

Grepperud (1996)[38] tested the population pressure hypothesis for Ethiopia using econometric analysis, and found that when population and livestock pressures exceeded a specific threshold rapid degradation of land takes place. The threshold was the population and livestock carrying capacity of the land. Pender et al (2001) found in Amhara region of Ethiopia that high population densities were related to the decline in fallowing and manuring. They also found the high population densities were related to increasing land degradation and worsening household welfare conditions. In Tigray high population density was related to more intense use of resources (more fertilizer, manure and intercropping) at the household level but increased land degradation at the community level.
A comparison between population density and soil loss rates for the Tekezi basin is shown in Map 47



Map 47 Ethiopia – Tekezi Basin: A comparison between the pattern of population density with soil loss rates.

Whilst there is some similarity in pattern along the southwestern, southern and southeastern edges of the basin, elsewhere the patterns are not directly coincident. For example, the areas of Eastern Zone in Tigray that have very high population densities are located on basalt derived soils that are less erodible

[38] Greperud, S (1996) "Population Pressure and land Degradation: The Case of Ethiopia", J. of Envir. Economics and Management, 30, 18-33.

than those derived from basement complex rocks and sandstones. This suggests that the relationship between population density and erosion is not a simple one.

7.2.3 Poor Access to markets, roads and off-farm employment opportunities and Land Degradation

Better access to markets and roads mean lower transport costs for agricultural inputs and outputs and thus lower input costs and higher market prices. Thus better access is likely to lead to increased adoption of improved land management technologies, and poor access to lower adoption rates. However, better access may lead to better opportunities for off-farm employment. Here the potential impact on adopting or not adopting improved land management technologies is ambiguous as off-farm employment may reduce labour inputs but increase availability of financial capital for on-farm investment.

Howe and Garba (200%)[39] found that reliance on traditional forms of transport pose considerable barriers to the development of an exchange economy and locks the farmers into subsistence form of livelihood. Pack animals offer a considerable advantage over human transport, with a cost reduction of approximately 50 percent. However, the average costs of mule transport of EBirr 16.7ton/km compare very unfavorably of EBirr 0.6-0.9 ton/km for local truck costs. With such high costs of transport for low value food crops such as maize ort sorghum makes a net return unlikely.

The evidence from Ethiopia of better access to markets and adoption of soil and water conservation technologies is mixed. In Tigray and eastern Amhara households with poor access were more likely to adopt labour intensive SWC structures than those with good access. Declining fallows and increasing use of manure closer to towns suggested increasing intensification of agriculture where access was better.

The use of fertilizer was everywhere positively associated with increased accessibility.

The relationship between off-farm employment and the adoption of SWC structures appears to be very context specific. In many areas adoption of fertilizer and SWC adoption was negatively associated with off-farm employment. However in the high potential area of Amhara region the relationship was positive.

[39] Howe, J & R. Garba (2005) "Transport Constraints and the Role of Mules and Donkeys in Kaficho Zone in Ethiopia" quoted in World Bank "Transport Costs in Ethiopia: An Impediment to Exports?", CEM, Ethiopia.

7.2.4 Issues of Land Tenure

Issues of land tenure here include insecurity of tenure, ability to use land as collateral and the transferability of property rights and the impacts these have on land investment or factor (land, labour or capital) allocation. This is a complex subject in Ethiopia.

The Federal Rural Land Administration proclamation (No. 89/1997) defines in broad terms individual land use and disposal rights. It delegates responsibility for land administration to the Regions. The four large Regions of Tigray, Amhara, Oromiya and SNNP have also enacted Proclamations for the Administration and Use of Rural land. Currently a land registration programme is underway in these regions. However, land redistribution has not been ruled out in both federal and regional proclamations. A US-AID Study[40] indicated that reports from kebelle administrations that redistribution is possible even with Land Registration Certificates.

Land tenure issues and their impacts on land management and technology investment in Ethiopia have been well studied over the past decade, and Mahmud Joseph and Pender (2005) provide a very comprehensive summary of the empirical evidence that is now available. Much of the evidence relating to impacts of tenure issues on land management and potential investment in improved land management is also of relevance to the situation in Sudan even if the context is somewhat different.

Tenure insecurity in Ethiopia emanates from a number of causes. A major source was periodic land redistribution to reallocation land to land-poor households. In northern Ethiopia the indications are that in areas where redistribution has occurred investment in terraces was lower, but that the use of fertilizer and tree planting was higher. This suggests that redistribution may favour short term investments in land management but hinder long term investments. The investment in tree planting (a short to medium term investment) may be due to a desire to increase tenure security or merely because trees are normally planted around the homestead.

In southern Ethiopia tenure insecurity derived not from redistribution but from the expected sharing of land among family members. In one area investment in coffee planting was reduced with increased tenure insecurity, but another study found that farmer’s resource poverty had a greater impact. A number of studies in northern Ethiopia also found evidence that resource poverty had a much greater effect on farmer’s decisions to adopt or maintain soil conservation structures.

[40] ARD for US-AID (2004) "Ethiopia land Policy and Administration Assessment", US-AID, Addis Ababa.

It is also possible that lack of rights to transfer or mortgage land may reduce farmer's incentives to invest in land improvement. A number of studies found that a perceived right to mortgage or to transfer use rights of land were positively associated with greater investments in constructing terraces and in tree planting. The evidence from studies on comparing land investments on owner-land and leased-land (mainly sharecropped) was mixed. Some studies found lower land investment on leased-land whilst other found no difference. However, on leased land the use of labour, improved seeds and fertilizer was lower as was production.

In summary the effects of tenure insecurity on land investments in Ethiopia appear to be mixed depending on whether the investments themselves affect security. Insecurity appears to hinder larger investments (e.g. terraces) than smaller and periodic investments (e.g. fertilizer, manuring). Redistribution is not the only source of insecurity, obligations to share land with younger family members is also an important source.

7.2.5 Impact of Agricultural Extension and Credit programmes on adoption of Land Management Technologies

The agricultural extension programme has strongly promoted fertilizer and improved seeds supported by credit. Studies indicate that greater access to credit increases farmers' likelihood of using fertilizer. However, risk is the crucial factor in the low rainfall areas in determining whether farmers will take credit for fertilizer even where it is readily available. The source can also determine the uptake of credit and specific use of the credit. This is probably a reflection of the technical advice that comes with the credit.

One study shows that credit uptake increased the adoption of fertilizer but reduced investments in soil and water conservation, contributing to increased soil erosion. The increase in fertilizer price since 2002 with the removal of the subsidy led farmers to increase the cultivation of crops requiring low fertilizer applications and reduce investment in soil conservation where the intervention was yield decreasing (e.g. soil bunds taking up cropland).

Studies indicate that the impact of extension on the uptake of improved land management is probably more positive in the high potential areas.

7.2.6 Impact of Public projects

Public projects such as food for work have been in operation for nearly three decades. Their potential impact on private land management is subject to much debate. Advocates assert that these programmes promote improved land management by relieving financial constraints and there are additional benefits in terms of acquired skills through "learning by doing". Critics argue that they adversely affect improved land management through competition for labour.

The empirical evidence is mixed. Both evidence for adverse effects of food for work and no effects on the adoption of improved land management have been found. One finding of interest is that food for work was associated with less use of labour, oxen and manuring but increased use of seed, suggesting that seeds are substituting for labour-intensive inputs. Another study indicated that food for work could promote SWC investments if they are applied within agriculture, but not if applied outside agriculture (e.g. road construction).

7.2.7 Economic Impacts of Land Management Technologies

Empirical studies on productivity and economic impacts of land management practices are few but consistent. Most studies show that short run returns from physical SWC structures are positive in moisture stressed areas but negative in higher rainfall areas. Returns from fertilizer use show the opposite trend: with higher returns in high rainfall areas and lower in moisture stressed areas.

In moisture stressed areas internal rates of return to stone terraces varied between 20 and 50 percent. Again in moisture stressed areas other land management practices demonstrated increased productivity: contour ploughing (25% higher productivity), reduced tillage (57% higher productivity), and manure and compost (15% higher productivity). The impact of chemical fertilizer was insignificant and showed a high variability in productivity response indicating a higher risk.

In the higher rainfall areas returns to conservation structures were low with internal rates of return of less than 10%. The exception was grass strips which produced a positive net present value even with discount rate of 50% and loss of 10% of land. Even higher rates of return were obtained if forage grass was planted on the strips. However, their lack of adoption in the area studied indicated that factors such as the practice of uncontrolled grazing in the dry season, poor extension services and tenure insecurity were also responsible.

Benefits to physical structures were low where soils were deep (more than 1meter) or very shallow where yields were already very low. This finding suggests targeting areas with rapidly degrading but still productive soils.

7.2.8 Institutional and Policy Issues

(i) Institutional Issues

The main issue which affects the sub-basins is that they are divided between two or more regional governments so management of the Sub-basin requires coordination between different regional governments. Several resource management issues specifically require inter-regional coordination due to hydrological flows, land use impacts, wildlife movements and the transboundary nature of forests. The institutional issues not only involve coordination but also getting the regions to give equal, or appropriate, attention to the issues of the sub-basin. For example, in the Baro-Akobo Sub-basin only one of these regions is fully within the basin and for two of the others their land in the sub-basin is rather remote from the regional headquarters and sometimes is given limited attention compared to other issues closer to the centre of power.

The other major institutional issue is the need for coordination between sectoral agencies, as they have competing interests about how best to use the resource base. For instance during the Derg government there were major conflicts between the agencies responsible for agriculture, forestry and coffee with each seeing a different model of how to use forest land in this area, with conflicting policies pursued and different advice given to farmers.

At present there is no coordination of regional governments' actions, while sectoral coordination within regions is limited to annual financial planning.

(ii) Policies and Prioritization

National policies are reasonably well developed in Ethiopia and regional interpretations of these have been developed in the last five to ten years. While Master Plans exist for all Sub-basins they have a rather narrow focus and are not formally recognized or used.

In fact it has been argued that over the last 20 years Ethiopia has seen a policy focus on the degraded parts of the country – seeking to achieve food security in these areas, while other areas if they are food secure have been assumed to be relatively well-off and without problems. The result has been what one organization has called “fading prosperity” in the coffee producing parts of the Baro-Akobo Sub-basin and what another has seen as the neglect of progressive desertification (EUE, 2001; NAP for CCD, 2002). This is certainly the case in Western Wellega in terms of land degradation and across much of the upper Baro-Akobo Sub-basin in terms of forest loss. There has been limited attention given to this area by the Federal Government and no recognition of this area as one of the last resource rich frontiers in the country.

Technical policies are designed and implemented in isolation and without a coherent framework. In many areas these lack sensitivity, having been designed with national priorities in mind or adjusted only to the main characteristics of a region with little attention to the specific conditions in the parts of the sub-basin which are in the region. Examples of such policies include:

- emphasis on regional or national revenue generation and food security needs which leads to investment policies and wetland drainage demands which are not in line with the needs of the local communities,

- environmentally inappropriate policies such as population concentration and the emphasis *teff* cultivation on fragile soils and research on maize cultivation in wetlands,

- lack of recognition of the links between sound agricultural land management in the high rainfall areas and forest, between forest and hydrology / hydro power development, and between wetland drainage and spring loss with its health implications,

- over-prescriptive training of DA's and their inability to analyze and adapt to different farming systems, and

- refugee settlement measures and local resource impacts.

Decentralization should have helped improve policies so that they are sensitive to regional variations but this is adaptability is still generally quite limited.

(iii) Policy practice and the ability of the state

While the government federally has specific policies to support the sustainable use of the country's resource base, practice on the ground is far from achieving this. The reasons relate to inappropriate policies, conflicting policies, poor training of Development Agents, lack of staff and resources, and an inability to liaise with the local population and build support. One example is the inability of the state to control land use is designated in designated regional priority forests and regional parks. This has led to these areas being regarded as "open access" resources. This has been partly caused in most cases by the absence of clearly demarcated and gazetted boundaries, but is also due to the inability of the state to enforce legislation.

7.3 Abay River Basin

7.3.1 Overview of the Watershed Management Problems and Potentials

The Abay Sub-basin within Ethiopia covers more than half the area and nearly three-quarters of the population in the Eastern Nile Basin. Its waters provide 57 percent of the Main Nile flow into Lake Nubia/Nasser and some 72 percent of its sediment load.

The highland plateaus have been deeply dissected by the Abay and tributaries providing severe constraints to road communications and access to markets. Agriculture expansion onto steep slopes and the consequent loss of vegetative have accelerated geological rates of soil erosion. Steep slopes and lack of vegetative cove result in relatively high rates of sediment delivery to the main rivers. Millennia of cultivation coupled with breaches in soil nutrient cycling caused by residue and dung use as fuel, grain removal and soil erosion have led to low levels of crop and pasture productivity.

Detrimental government policies in the past have left a legacy of tenure insecurity and poverty with severe constraints on farmers' willingness and ability to invest in sustainable land management. Past large-scale programmes of soil conservation and afforestation were top-down and alienated the rural population. High rainfall in the western Highlands can cause problems with physical soil conservation structures of poor drainage and of structure breaches and severe erosion.

However, the central and western parts of the Highlands in the Sub-basin have a relatively secure rainfall and have long provided crop surpluses to other parts of the Sub-basin and Ethiopia. The western Lowlands, for long sparsely populated because of the prevalence human and livestock diseases, provides the potential for agricultural expansion. The potential for soil moisture conservation is higher in the eastern Highlands given the lower and more variable rainfall. Although of lower natural resource potential they have the potential for small stock rearing, deciduous fruits, construction timber and cut flowers for both the domestic and export market. The realization of this potential will crucially depend on improved road access.

7.3.2 Assessment of the Extent Soil Degradation

(i) Sheet and Rill Erosion

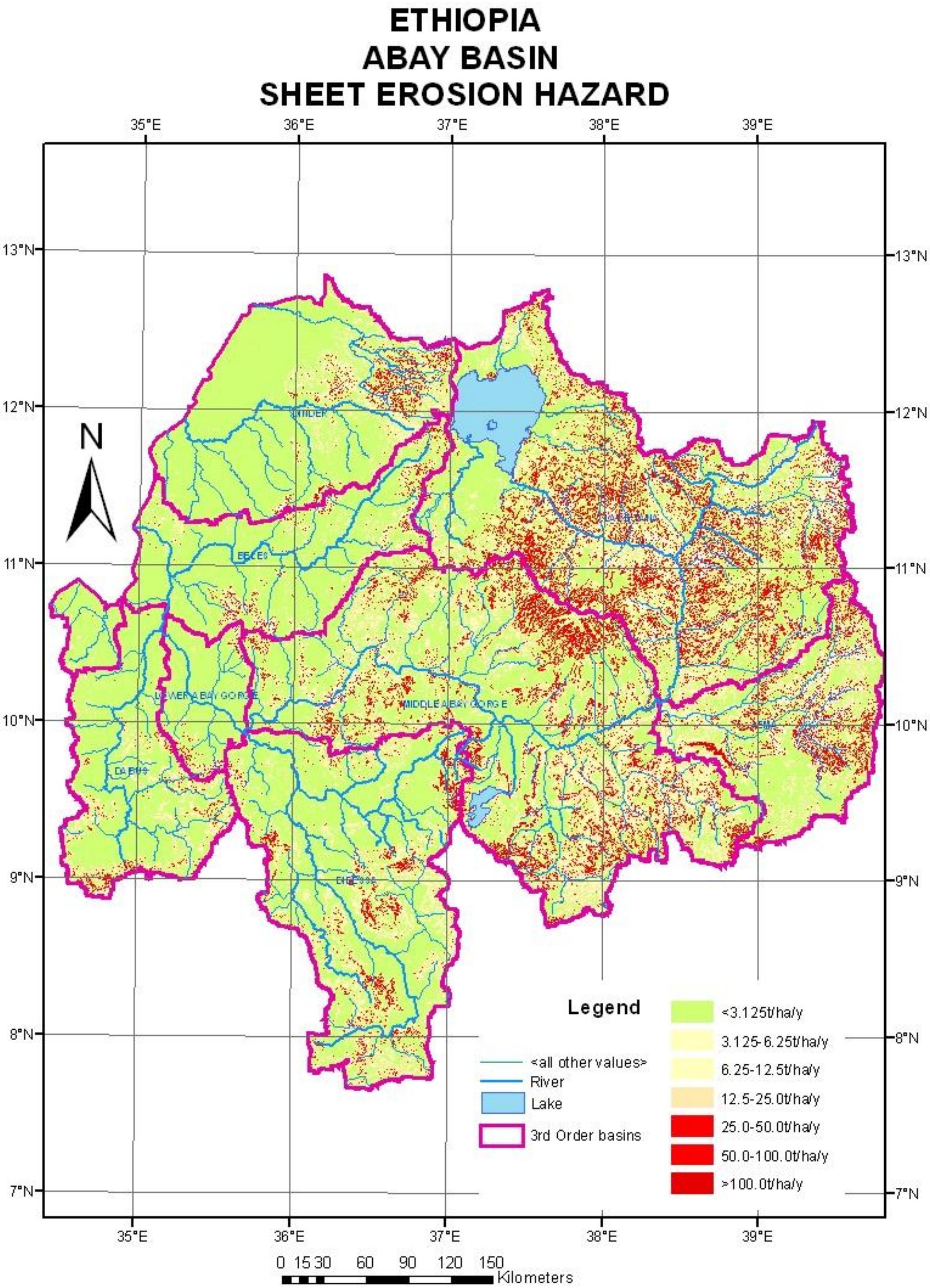
The extent of the sheet erosion hazard in the Abay Basin using the USLE as a basis is shown in Map 48 This analysis used a digital terrain model (DTM) using the digitized contours obtained from the Ethiopian mapping Agency 1:250,000 topographic sheets to obtain the slope percentage and slope length. The rainfall erosivity was derived from work undertaken by the Soil Conservation Research Project (SCRP) to derive erosivity values for Ethiopian conditions. Soil erosivity was also derived from values obtained by the SCRP for Ethiopian conditions. The soil map was obtained by using the FAO/LUPRD SOTER (Soil terrain) 1:1 million map, and then using the DTM to identify the soils by land facet at a scale of 1:250,000. Land cover values were also those obtained by the SCRP. Land cover values were those from the WBISPP 1:250,000 land cover mapping using 2000 Landsat TM images. A detailed explanation of the methodology is provided in Annex 1.

Four main areas of high sheet erosion are found in the Abay basin. The steep slopes around Mount Choke in East and West Gojam stand out as a significant area with a high sheet erosion hazard. This is an area with high rainfall causing problems in developing physical soil conservation structures because of the problems of providing effective water disposal structures.

The second widespread area of high erosion hazards occurs north and east of the Abay River in the Lake Tana Basin. This area includes the steep cultivated slopes around Mounts Guna (South Gonder) and Molle (South Wello). A third more restricted area is found in the upper Jema sub-basin in South Wello on the high hills north and west of Debre Birhan. A fourth area is found south of the Abay and encompasses the upper and middle steep and cultivated slopes of the Middle Abay Gorge Sub-basin in East Wellega. Two subsidiary areas with a high erosion hazard can be seen in the Upper Didessa Valley and along the escarpment hills to the west of Lake Tana in the upper Dinder and Beles valleys.

Similar patterns can be observed using the wereda statistics of the percent area of "moderate to severe" erosion hazard (i.e. potential soil loss rates exceeding 50tons/ha). These are shown in Map 49

The main areas of Mount Choke, Lake Tana Basin, South Wello and East Wellega standout. The east of the Basin is moisture deficit area with high evapotranspiration rates, particularly in those areas at lower altitudes in the "rain shadow" of the gorges. Many of these areas indicate a relatively low erosion hazard but will benefit significantly from soil-water conservation measures.



Map 48 Ethiopia – Abay Basin: Sheet Erosion Hazard

The total soil eroded within the landscape in the Abay Basin is estimated to be 302.8 million tons per annum and that from cultivated land[41] is estimated to be 101.8 million tons per annum. Thus about 66 percent of soil being eroded is from non-cultivated land, i.e. mainly from communal grazing and settlement areas.

The area of cropland subject to "unsustainable" (i.e. loss exceeds soil formation or 12.5 tons/ha/yr) are 968,900 ha, 104,000 ha and 956,900 ha in the Amhara, BSG and Oromiya areas of the Basin respectively. Thus some 2.03 million ha of cultivated land have unsustainable soil loss rates.

Of the total 302.8 million tons of soil eroded a proportion is re-deposited within the landscape, the remainder reaching streams and rivers. At the Basin level the estimated SDR indicates that approximately 55 percent of sediment remains in the landscape and does not reach the stream system, a higher proportion than the Tekezi Basin. This estimate is much lower than the 90 percent estimated by the Ethiopian Highlands Reclamation Study (EHRS) but closer to the estimate by Hurni (1985)[42] of 70 percent.

(ii) Gulley Erosion

Although some work has been undertaken on gulley formation and extension[43] [44], there is no information on the distribution and density of gullies. Barber (1984)[45] considers that much sediment from gullies is deposited on lower slopes without entering the drainage system. Stocking (1996)[46] working Zimbabwe estimated sediment from gullies contributed approximately 18 percent of suspended sediment loads. Loss of cropland from gully erosion was considered to be insignificant.

[41] "Cultivated land" as identified on the 1:250,000 landsat images. This may include areas of grassland, settlement, field boundaries etc. that are too small to discriminate separately. Invariably "cultivated" land is greater in area than land under crops as defined e.g. by the Central Statistical Office (CSA).

[42] Hurni, H (1985) "Erosion, Productivity and Conservation Systems in Ethiopia". Paper for IV Int. Conf. on Soil Conserv. , Venezzuela.

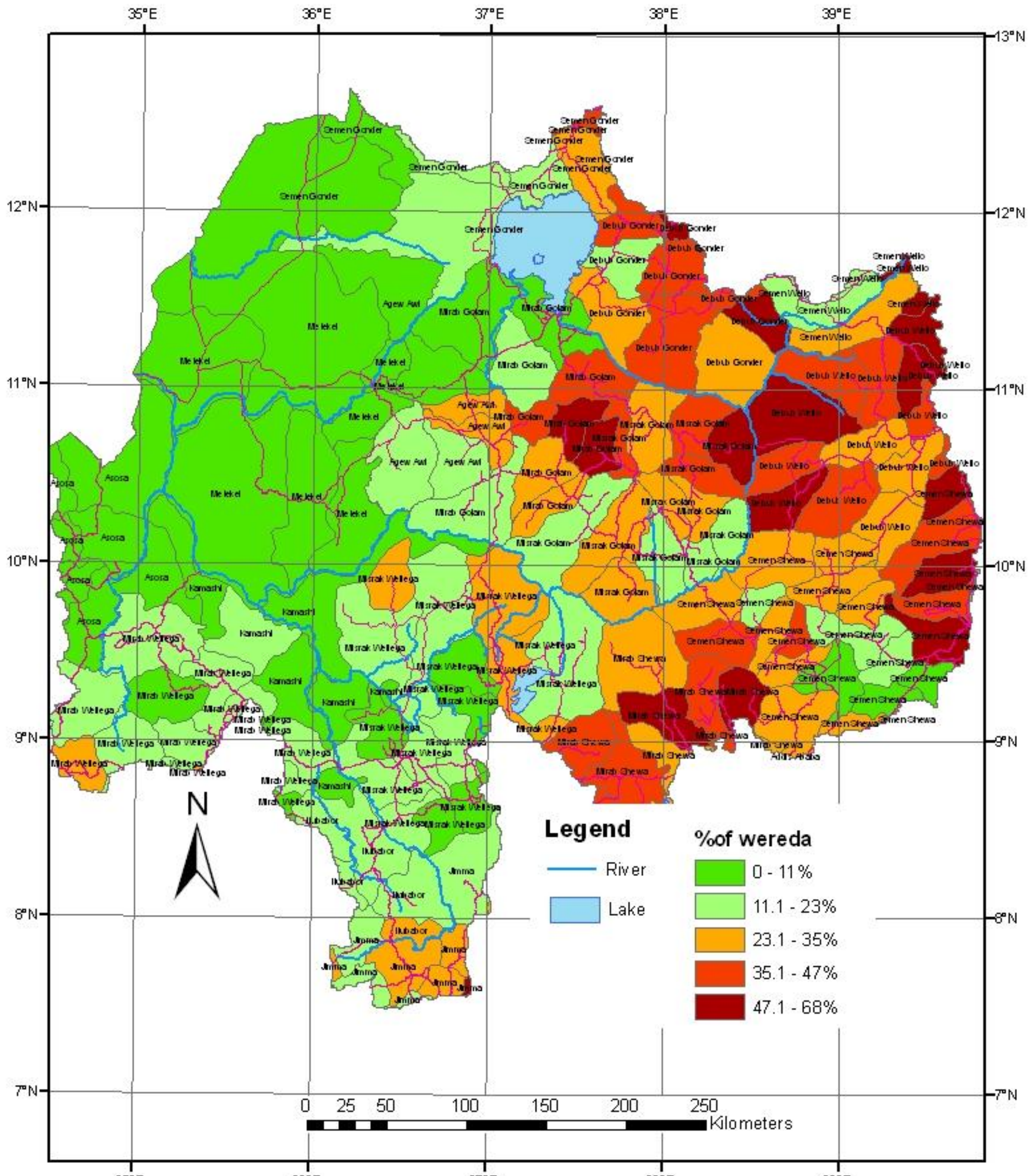
[43] Billii & F.Dramis (2003) "Geomorphological investigation of gully erosion in the Rift Valley and the northern Highlands of Ethiopia", Catena Vol. 50, 2-4, pp. 353-368.

[44] Shibru Daba et al (2003) Assessment of gully erosion in eastern Ethiopia using photogrammetric techniques", Catena Vol. 50, 2-4, pp. 273-291.

[45] Barber, R (1984) “An assessment of the dominant soil degradation processes in the Ethiopian Highlands: Their impacts and hazards", EHRS WP 23.

[46] Stocking, M (1996), ”Soil Erosion: Breaking New Ground", in Eds. M.Leach & R. Mearns "The Lie of the land", IAI, London.

ETHIOPIA
ABAY SUB-BASIN
% AREA WITH
MODERATE TO SEVERE EROSION HAZARD
BY WEREDA



Map 49 Ethiopia – Abay Basin: % Area with Moderate to Severe Erosion Hazard by Wereda.

Very recently research by the Universities of Makelle, Ethiopia and KU Leuven, Belgium in Tigray[47] have provided information of gulley erosion rates, sediment yields and sediment delivery ratios in northern Ethiopia. They report that gullies were initiated by a variety of changes in environmental conditions: removal of vegetation between fields, Eucalyptus planting in valley bottoms and new road construction. Gullies followed a sigmoidal evolution in volume, with a rapid increase until the mid 1990's when the rate of growth declined to almost nothing. This has been due to the considerable development of soil conservation structures and communal area closures that have occurred since 2000.

During the period of most rapid gully growth, soil erosion rates were between 13 – 27t/ha/yr. Currently, the rates have slowed to 1.1t/ha/yr. The average rate of total years of gully evolution was 6.2t/ha/yr and they recommend this figure for sediment budgeting where conservation measures have not been implemented. The figure of 1.1t/ha/yr is approximately 10 percent of the weighted average soil erosion rate of 9.7t/ha/yr in the area. Approximately 50 percent of the sediment reached the drainage system, the remainder being deposited within the landscape.

Thus, where soil conservation measures have been introduced and gullies are relatively stable they contribute approximately 5 percent to sediment load. Where there are no conservation measures the average rate is 32 percent. In the present report it is assumed that sediment from gullies contributes an additional 20 percent to sediment loads in streams and rivers.

(iii) Mass Movement of Soil

Mass movement processes include slow acting soil creep as well as more rapid and dramatic processes of landslides, earth flows and mudflows. They are likely to occur in the higher rainfall areas, on steep slopes and in soils with high infiltration rates and high moisture holding capacities. Localized mass movements can be observed on cultivated and non-cultivated steep slopes where the main road crosses the Abay gorge. However, there is no information on the extent of mass movements of soil within the Basin. Barber (1984) considers that it is unlikely that they are important in the Ethiopian Highlands, in extent or river sediment load contributions.

(iv) Sedimentation

Infrequent, unsystematic and incomplete suspended sediment data for the El Deim gauging station just across the border in Sudan is available. This has been

[47] Nyssen, J et al (2005) "Assessment of gully erosion rates through interviews and measurements: a case study from northern Ethiopia", accepted for publication in Earth Surf. Process. Landforms 30, (2005).

analyzed by Group 1 of the NBCBN/River Morphology Research Cluster[48]. They estimated that the long-term mean suspended sediment at El Diem to be 123M tons. They estimated bedload to be 15 percent giving a total mean annual sediment inflow of 140M tons. This figure gives an annual sediment yield for the Abay basin of 700t/km2/yr, and a sediment delivery ratio of 45 percent. This figure is similar to SDR's quoted by Walling (1983)[49] for central and eastern USA. The estimate is lower than that for the Tekezi Sub-basin (between 800 t/km2/yr and 65 percent respectively).

The Tekezi Medium Hydro Study (1998)[50] quotes a much higher figure of 273M tons per annum as the mean annual suspended sediment load for Roseire. However, the sediment monitoring programme of the Sudan Hydraulic Research Institute recorded a figure of 135.6M tons for 2000 for the same station. Thus, the annual mean of 140M tons is more consistent with the NBNBN study.

The Ethiopian MWR has a number of intermittent sediment records for tributaries of the Abay. Nearly all watersheds are less than 1,000km2 in area. They have been analyzed and tabulated by three sources: (i) The Abay Basin Master Plan Study, (ii) the Tekezi Medium Hydro Study, and (iii) a study undertaken by Rodeco for MWR (2002). There are a number of discrepancies between the data sets and some stations are included one data set and not the other, and vice versa. Figure 13 is a scatter diagram of sediment yield against basin area using the Abay Master Plan data.

There is no clear relationship between sediment yield and watershed area indicating that a number of other factors have a much stronger influence. In the Study undertaken in Tekezi Basin these were found to be variations in lithology, landuse, gully density and connectivity[51]and given the similar conditions in the Abay Basin the same factor are also likely to be responsible. The sediment yield estimates are generally lower than those recorded for small dam catchments in the Tekezi basin.

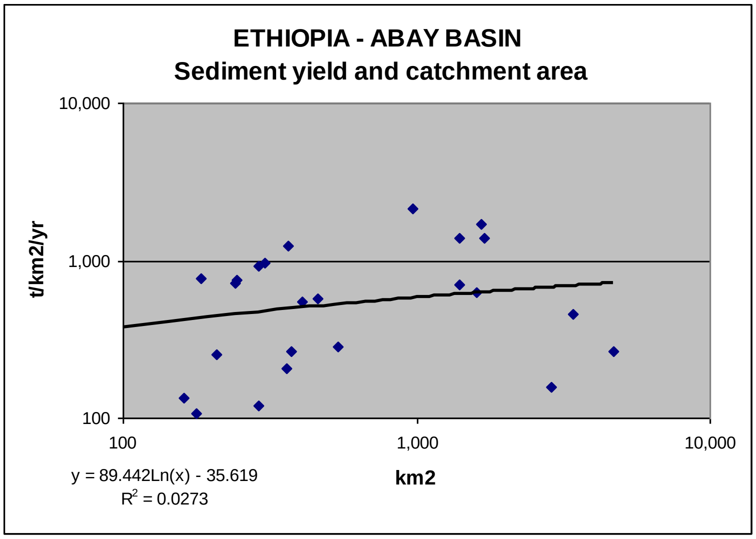
[48] Ahmed Musa Siyam et al (2005) "Assessment of the Current State of the Nile Basin Reservoir Sedimentation Problems", UNESCO-

[49] Walling,D.E. (1983) “The Sediment Delivery Problem", J. of Hydrology vol. 68, pp. 209-237.

[50] MWR (1998) “Tekezi Medium Hydro Study”, Addis Ababa.

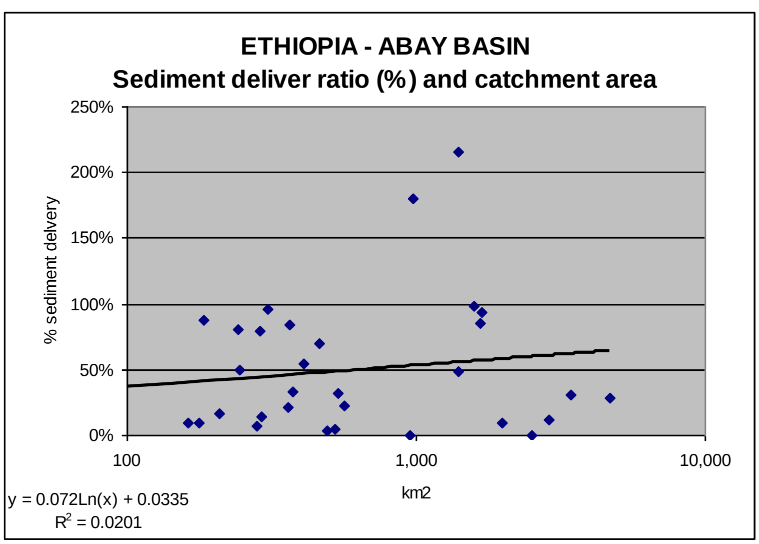
[51] Nigussie Haregeweyene et al (2005) op. cite.

Figure 13. Ethiopia – Abay Basin: Sediment yield (t/km2/yr) and catchment area for medium catchments (100 - 5000km2).



In order to estimate the sediment delivery ratio the gauging stations were located by wereda and the mean soil erosion rate of the wereda used to generate an estimate of the total erosion within the catchment. The scatter plot of these estimates is shown in figure 14. Two catchments show SDR's of >100 percent. In these cases the amount of soil erosion within the catchment could be under-estimated. Again there is no clear relationship between basin size and SDR and there is a slight but not statistically significant positive trend line in contrast to the generally published figures. The mean SDR is 49 percent but with a coefficient of variation of 100 percent.

Figure 14. Ethiopia – Abay Basin: Sediment delivery ratio and catchment area for medium catchments (100 – 5000km2)



There is no significant difference between the sediment yields of small and large catchments, with the mean of the small catchments close to that of the large catchments. This would indicate that there is little or no storage of sediment within the Abay river system, a factor normally attributed to declining sediment yields with increasing catchment areas. This is to be expected given the steep gradients in both tributary and main rivers. Given the relatively high sediment delivery ratios and very similar sediment yields it would appear that the Abay River system is also relatively efficient in delivering and removing eroded sediment from the landscape.

From the data on suspended sediment discharge at three key stations on the main Abay River, it appears that most of it comes from the tributaries located in the south and west parts of the basin. The average suspended sediment at Bahir Dar station, where Abay leaves Lake Tana, is about 2.2 million tons per year, or about 143 t/km^2/yr; the average suspended sediment at Kessie station (on the bridge between Addis Ababa and Debre-Markos) is 49.4 million tons per year, or 751 t/km^2/yr, while the average suspended sediment measured at the El Diem station of the Sudanese border is 140 million tons per year, or 700t/km^2/yr (Table 56).

Table 56. Suspended sediment discharge for selected hydrometric station within the Abay basin

Station	Length of record	Catchment area (km^2)	Sediment load ('000 tons/yr)	Soil loss in (t/km^2/yr)	Annual av. discharge (m^3/s)
Gilgel Abay, near Merawi	1980-1992	1,664	2,821.0	1,695.3	58.17
Gumara, near Bahir Dar	1980-1992	1,394	1,937.1	1,390	27.18
Megech at Azezo	1980-1992	462	263.0	569	7.5
Abay at Kessie	1982-1992	65,784	49,404.0	751	450.5
Muger, near Chancho	1980-1992	489	38.2	78	9.26
Abay at Bahir Dar	1980-1992	15,321	2,191.0	143	111.32
Guder at Guder	1980-1992	524	47.2	90	12.63
Birr, near Jiga	1980-1992	975	2,075.4	2,129	17.86
Dura, near Metekel	1980-1992	539	386.5	717	
Angar, near Nekemte	1980-1985	4,674	701.9	150	62.79
Dabana, near Abasina	1980-1984	2,881	452.9	157	57.35
Angar, near Gutin	1982-1983, 1986-1992	1,975	176.3	89	
Beles, near Metekel	1983-1992	3,431	1,563.3	456	51.38
Abay at Sudan border	1980-1991	172,254	140,000.0	700	1555.73

Source: Abay Basin Master Plan Study.

(v) Soil Nutrient Losses

Three sources of accelerated soil nutrient loss are examined:

- Losses from the burning of dung and crop residues

- Losses from the removal of crop grain
- Losses from soil removed due to soil erosion.

The WBISPP (2003) estimated that within the Abay Basin some 1,751,600 tons of dung collected from crop fields (about 40% of total dung produced) and some 3,207,046 tons of crop residues were burnt as household fuel. This resulted in a loss of some 44,060 tons of N and 9,250 tons of P.

An estimated 515,626 tons of grain is removed from cropland annually. This would account for an additional 10,292 tons of N and 2,058 tons of P being removed.

Another source of soil nutrient losses at the field level is soil erosion. Hashim et al (2000) estimate nutrient loss as:

*Nut Loss = Soil loss * Nutrient concentration of topsoil * Enrichment ratio*

where the enrichment ratio refers to the ratio of the additional minerals and organic matter in eroded soil compared with the original soil. Barber (1983)[52] estimated an enrichment ratio of 2 for eroded N and organic matter. As only about 2 percent of the total N and P is available in any one year replenishment costs should be based on this proportion. Using Barber's estimated annual nutrient losses from different soil erosion rates losses of available N would be approximately 7,058 tons and 1,233 tons of available P on 7.4 million ha of cultivated land losing 101.8 million tons of soil annually.

The estimated annual losses of soil nutrients to cultivated land are summarized in table 57.

Table 57. Ethiopia – Abay Basin: Estimated losses of N and P soil nutrients from three sources.

Source of loss	tons N	tons P
Dung/residues as fuel	44,060	9,250
Grain removed	97,780	19,556
Soil erosion	7,058	1,233
TOTAL	**148,898**	**30,039**

Against these N losses are annual increments of N from rain, dust, non-symbiotic fixation and symbiotic fixation. These are estimated to be 15 kgs per ha for the cultivated land in Ethiopia, or 111,260 tons per annum in the Abay Basin. There is thus a net annual loss of available N from cultivated land of approximately 37,640 tons or 5.1 kgs/ha of available N. The rate of loss of nutrients is nearly 2.5 times the rate of loss occurring in the Tekezi basin, confirming the work of

[52] Barber, R (1984) op.cite

other workers (e.g. Desta et al, 1999, Word Bank, 2004)[53] [54] that soil nutrient breaches and decline in soil nutrient status is major problem in the higher rainfall areas. It is noticeable that in contrast to the Tekezi Basin where the greatest losses are from burning dung and residues, losses from grain removal make the largest contribution to total losses in the Abay Basin.

7.3.3 Assessment of the Extent Deforestation and Degradation of Vegetation Cover in the Abay Basin

(i) Definition of terms

Removal of woody vegetation for fuel consumption has often been blamed for "deforestation" leading (eventually) to "desertification". More recently the blame for deforestation has been laid at the door of agricultural and settlement expansion. "**Deforestation"** is here defined (following Reitbergen, 1993) as:

> *The permanent conversion of "forest" to non forest land cover and land use.*

For this purpose "Forest" in the context of "Deforestation" includes high forest, woodland and shrubland. It is land with woody biomass cover where the crown cover exceeds 20 percent. Selective timber felling, and browsing by cattle, coffee cultivation or harvesting BLT under the trees do not fall within the definition of deforestation. Similarly, clearing for cultivation followed by bush fallowing, where fallow periods are of sufficient length to allow full regrowth of secondary forest, woodland or shrubland, should be not included.

Wood cleared for agriculture involves a complete change in land cover from shrubland, woodland or forest to "non forest land" and an almost complete removal of wood in the area cleared. However, wood removed for fuel does not involve a complete and instant change in land cover. Shrubland, woodland or forest may remain as those land cover types for a number of years. Instead, there is a gradual erosion of wood stocks and "**degradation**" of land cover rather than "deforestation". Dense woodland gradually becomes open woodland, which may then gradual become open shrubland. This may in turn become "grassland" with scattered trees.

[53] Desta et al (2001) Land degradation in the highlands of the Amhara region and strategies for sustainable land management. ILRI Livestock Policy Analysis programme, Working Paper 32, Addis Ababa.
[54] World Bank (2004) Four Ethiopias: A Regional Characterisation Assessing Ethiopia's Growth Potential and Development Obstacles. Draft background report to Country Economic memorandum, Addis Ababa.

The conclusion is therefore that **the two processes are different and cannot be directly compared**. Clearing woody biomass for agriculture is a sudden and complete process. The "degradation" of woody biomass stocks caused by wood removal for fuelwood and charcoal is gradual and partial.

(ii) Deforestation

In the northern Highlands in the Abay Basin there is little or no potential for expansion of agriculture except in very local situations. However, south of the Abay River in Oromiya Region there is some potential for agricultural expansion and this taking place into areas covered by shrubland, woodland and forest. In the western lowlands, mainly encompassing Beneshangul-Gumuz Region there remains considerable areas for agricultural expansion. Hitherto settlement and expansion of agriculture in these areas have been constrained by the presence of human diseases (particularly malaria) and cattle diseases (particularly trypanosomiasis).

In the 1980's a large scale resettlement scheme was implemented at Pawi in the Beles Valley. A smaller scheme had been established in the Anger Valley (a tributary of the Didessa) some years earlier. In addition, small-scale "integrated" resettlement had been implemented in a number of areas in both highland and lowland areas. The large scale schemes were criticized for their lack of planning, poor site selection and lack of social infrastructure. Although in Pawi considerable investment in infrastructure was implemented as part of a large Italian funded Tana-Beles project. Following the fall of the Derg many settlers returned to their home areas, although in Pawi and Anger, as well as most of the integrated schemes a substantial number remained.

In the late 1970's a large-scale mechanized farm of 96,000 ha was cleared and developed in the lower Didessa and Anger Valleys. It experienced continued declining yields and following the fall of the Derg it was abandoned. Such was the efficiency of the clearing of the original woodland that even after 10 years it remains grassland with no woody vegetation.

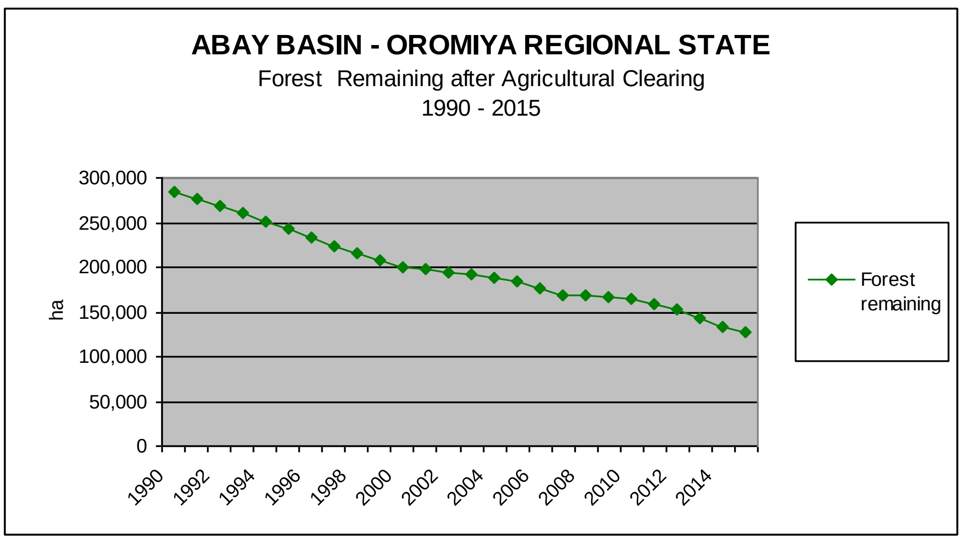
Since 1991 a new voluntary resettlement programme is being implemented in Oromiya region and to a much lesser extent in Amhara region. The main areas for resettlement are in the Didessa and Anger valleys. The Pawi scheme has also continued to receive settlers. In BSG Region some 128,000 ha have been allocated for medium-large scale agricultural investment.

There has been no monitoring of landcover changes in response to the new resettlement and agricultural investment programmes. The WBISPP attempted to forecast future landcover changes resulting from natural population increase in Oromiya and BSG Regions, using 1990 and 2000 as the base years respectively[55]. Because of the ease of clearing, the landcover change model assumed that potentially arable land with shrubland would be cleared first, followed by woodland and then forest.

"Forest" here follows the definition of Friis (1992)[56] who defined "Forest" as "*a relatively continuous cover of trees, which are evergreen or semi-deciduous, only being leafless for a short period, and then not simultaneously for all species. The canopy should preferably have more than one story.*" Woodlands are "a continuous stand of trees with a crown density of between 20 - 80%. Shrublands are defined as "a continuous stand of shrubs with a crown density of between 20 -100 %. There may be scattered individual trees with a crown cover of less than 20% or scattered clumps (i.e. less than 0.5 hectare) of trees (as modifiers)."

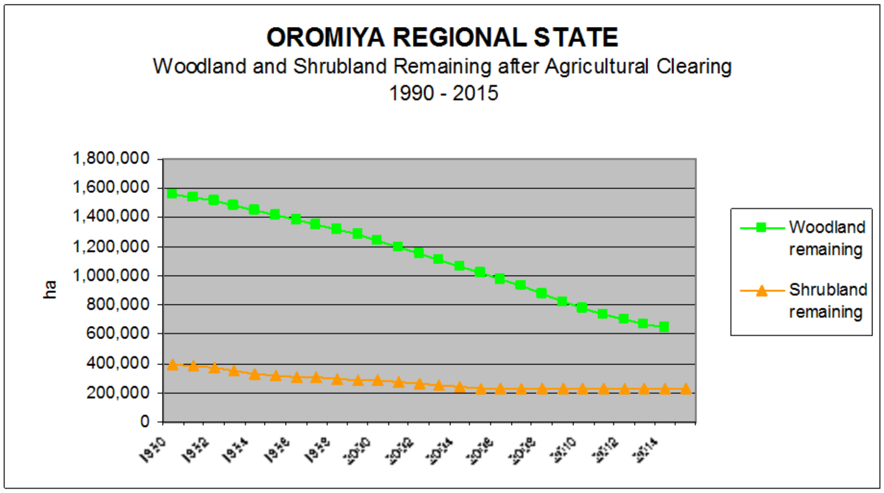
The analysis was conducted at the wereda level using current population growth rates and crop, grazing and settlement land requirements of the existing farming systems. The results for Oromiya region which is main highland, and BSDG Region which is mainly lowland are shown in figures 15 (a) and (b).

Figure 15 (a) and (b) Ethiopia - Abay Basin – Oromiya region: Shrubland, Woodland and Forest Remaining after Agricultural Expansion from Natural population growth: 1990 – 2015



[55] Oromiya landcover was mapped using 1989 landsat imagery and BSG using 2000 imagery.

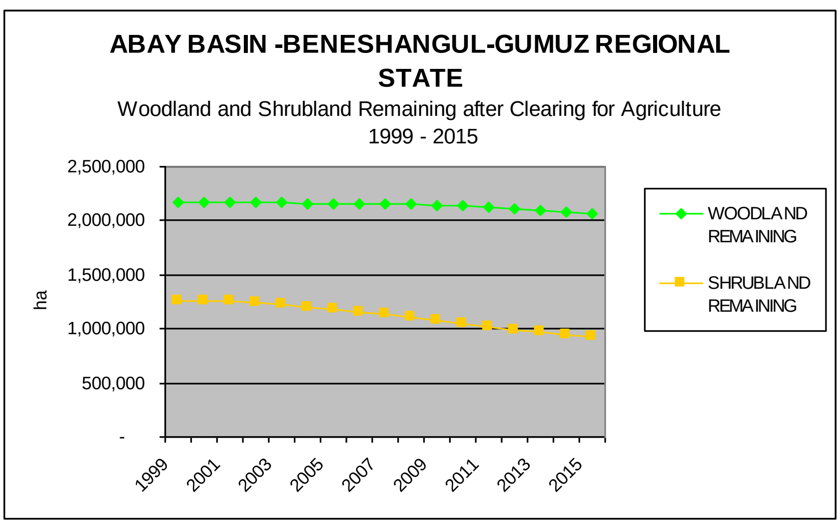
[56] Friis, I (1992) "Forests and Forest Trees of Northeast Tropical Africa", HMSO, London.



By 2015 some 56 percent of forests, 61 percent of woodlands and 43 percent of shrublands will have been cleared for agriculture and settlement as a result of natural population increase. No account is taken of resettlement and migration, or of expansion of large-medium scale commercial agriculture.

In BSG given its low population densities the rates of clearing are much lower. The woodland and shrubland remaining after agricultural expansion between 2000 and 2015 are shown in figure 16.

Figure 16. Abay basin – Beneshangul-Gumuz Region: Woodland and Shrubland remaining after agricultural expansion: 2000 – 2015.



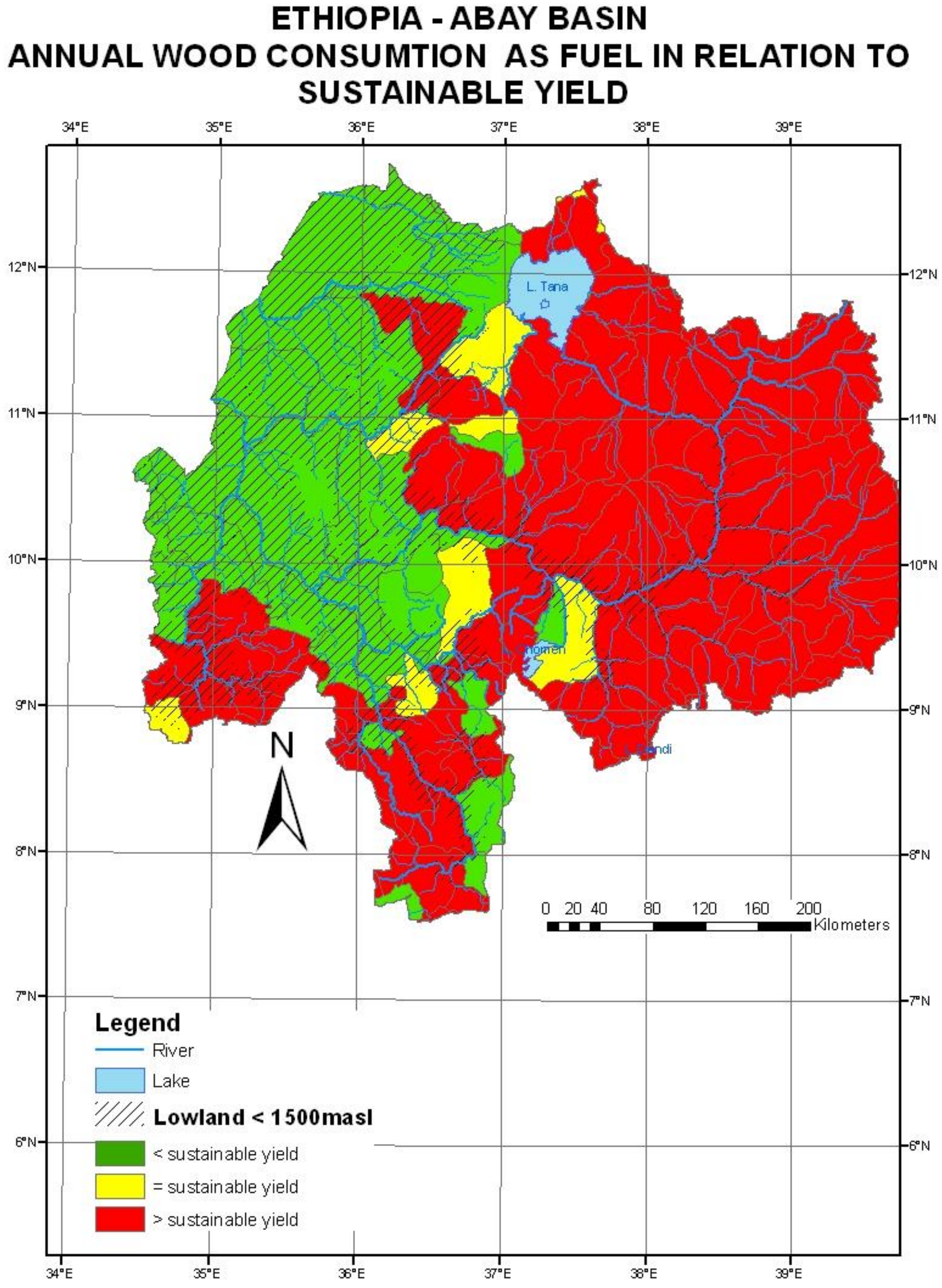
In BSG some 5 percent of *Acacia-Commifera* woodland and 27 percent of shrubland are estimated to be cleared for agricultural expansion due to natural population increase. Again no account is taken of expansion of agriculture for irrigation (e.g. the Beles scheme), resettlement for rainfed agriculture or large-medium scale commercial agriculture.

(iii) Degradation of Woody Biomass

Removal of wood in excess of the sustainable yield (after accounting for removal of dead wood and fallen branches, leaves and twigs) leads to declining stocks, which in turn leads to declining yields and so to progressive degradation of woody biomass. The proportion of sustainable annual woody biomass yield consumed as fuelwood by wereda is shown on Map 50. Note that this does not include wood removal for new house construction and current house maintenance.

It can be seen that the pattern of weredas consuming in excess of sustainable yield mirrors that of the weredas with high proportions of their area experiencing moderate to severe soil erosion (see Map 49).

Most weredas consuming more wood than the sustainable yield are located in the highlands a clear reflection of the low population densities in the lowlands. The map shows the current rates of consumption and supply. In practice there is substantial development of on-farm trees in many areas of the higher rainfall areas of the highlands. However, in the drier areas of the eastern highlands development of on-farm tree production has been slower, partly because of the more difficult tree planting environment and partly because of the lack of markets for construction poles.



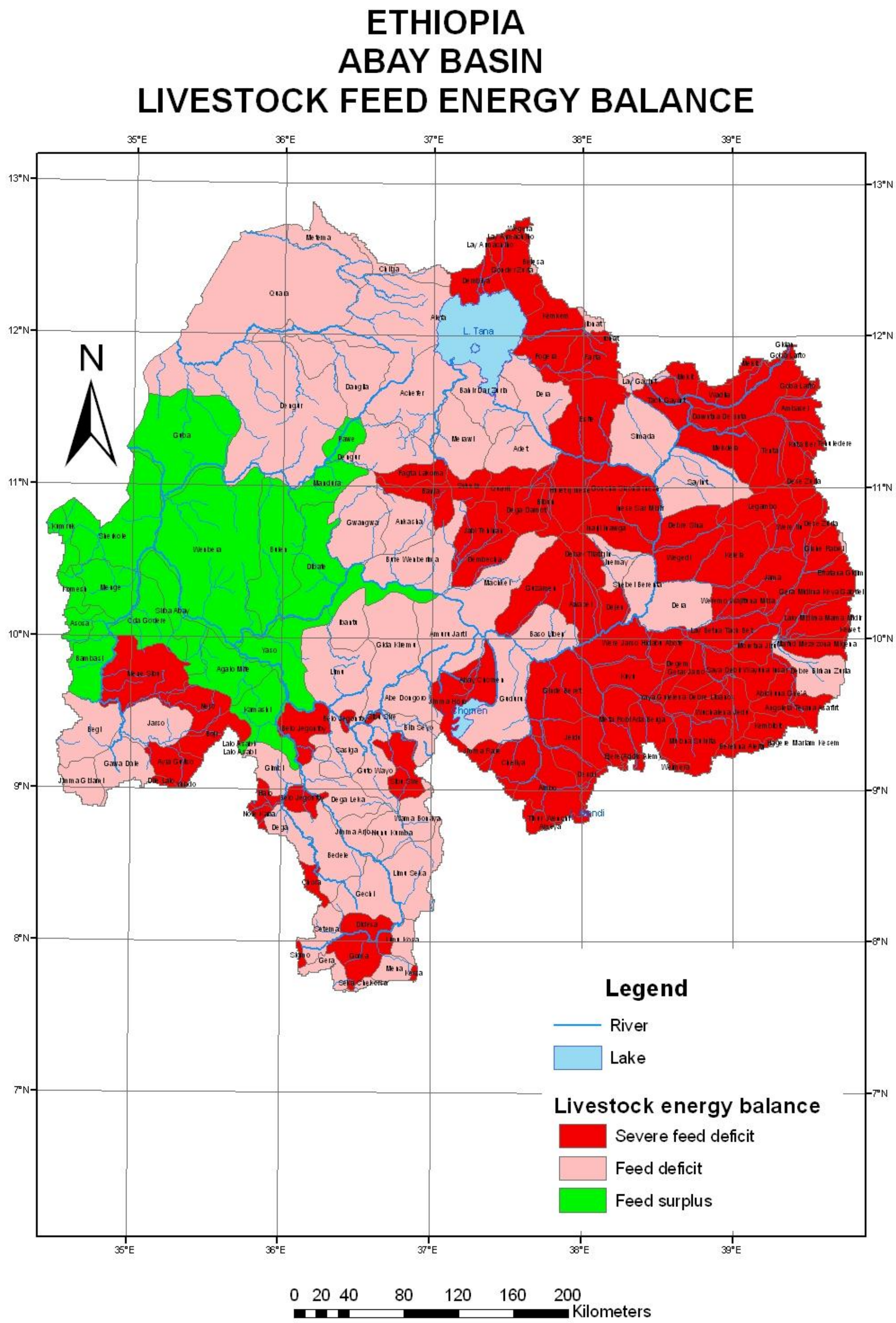
Map 50. Ethiopia – Abay Basin: Annual woody biomass consumption as fuel in relation to annual sustainable yield.

(iv) Degradation of Herbaceous Biomass

An indicator of overgrazing can be determined by examining the livestock feed energy balance at the wereda level. Energy requirements of all livestock are computed using energy requirements for maintenance, draught power and lactation, and balanced against estimates of energy supply from natural pastures and crop residues[57]. The results for the Abay Basin are shown in Map 51.

The main areas of livestock feed deficits are the upper slopes of Mount Choke in East and West Gojam, the eastern weredas in North Shewa and South Wello, with more isolated areas in East and West Wellega. These areas are largely coincident with the areas of high soil erosion hazard.

[57] WBISPP (2003) Separate Reports on Natural Grazing Lands and Livestock Feed Resources for Tigray, Amhara, BSG, Oromiya, SPNN and Gambela regional States.



Map 51. Ethiopia – Abay Basin: Livestock Feed Energy Balance by Wereda.

7.3.3 Assessment of the Extent and Degradation of Wetlands in the Abay Basin

The WBISPP landcover map covering the Abay Basin estimates the area of permanent swamp as 49,943 ha and of seasonal swamp 59,250 ha. Much of these wetlands are located in the highlands. The most extensive are found around the shores of Lake Tana, around the shore of Finchaa reservoir and in the headwaters of the Dabus River. However, across the highlands are hundreds of small poorly drained valley bottoms.

A survey and inventory of wetlands in the Amahra Region[58] found that many of these wetlands were under threat due to land degradation and sedimentation, and the lack of bylaws and community rules regarding their use. Many are used for dry season grazing, hay production, thatching grass and grass mats (*cheffe*).

In the area between Gimbe and Nejo within the Dabus and Abay sub-basins many wetlands are used for cultivation. Because of severe degradation on the upland granite soils the wetlands have become vital elements in sustaining peoples' livelihoods. However, in some areas there have been reports of over-draining of these wetlands leading to the destruction of their delicate hydrography and loss of value for cultivation[59].

7.3.4 Assessment of the Extent Reforestation and Increases of Vegetation Cover in the Abay Basin

(i) Assessment

Whilst there is evidence of the removal and degradation of natural vegetation cover, there is considerable evidence that there has been an increase in on-farm tree planting and plantations, almost entirely of *Eucalyptus* species. Farm surveys of the numbers of trees owned and planted by farmers in Amhara and Tigray Regions have revealed that considerable planting of trees (mainly Eucalyptus) has taken place since 1991[60].

Prior to 1991 there was very little on-farm tree planting. The reasons were firstly, that between 1975 and 1991 cutting of on-farm trees was prohibited, and secondly that between 1975 and 1989 there were frequent re-distributions of farmers plots. The net result was a strong feeling of insecurity of tree and land tenure that strongly discouraged farmers investing in tree planting. Following the change of Government in 1991 the prohibition on tree cutting was withdrawn and redistribution of holdings was much reduced and since 2000 had stopped. As a

[58] Enyew Adgo et al (2005)
[59] Wood, A (2000) "The Role and Importance of Wetlands in Ethiopia", EWRP Policy briefing Note 1, Ethiopian Wetlands Research programme, Addis Ababa.
[60] WBISPP/MoARD (2001-2004) op. cite.

consequence perceptions of tree tenure security became stronger. This was coupled with a very large increase in the demand for construction poles following the surge in economic growth and the increase in building construction from 1992 onwards.

Farm surveys in the Amhara Region have shown that there has been a massive increase in the planting of on-farm trees (mainly Eucalyptus spp.) between 1993 and 2000, and that this continues. In Tigray tree planting did not commence until about 1997 and the cumulative totals of trees planted on-farm by 2000 was very much smaller than those in Amhara Region. In the Woina Dega land use system 40 percent of trees were less than 3 years old and thus not ready for harvesting.

Unfortunately, the surveys carried out in Oromiya Region were undertaken too early (1993-4) to pick-up these trends. However, a survey of Pole Merchants in Addis Ababa in 2004 indicated that poles are being transported from considerable distances in Oromiya Region. Further, visual evidence of the age of on-farm Eucalyptus trees in the Highland Cereal Land Use Systems in many parts of Oromiya Region indicates that considerable on-farm tree planting has occurred since 1993 in these Regions also. Thus it is likely that on-farm rates of tree planting since 1993 in the Highland Cereal Systems in Oromiya and SNNP Regions have been similar to those in Amhara Region.

Generally, the rate of on-farm tree planting has been highest in areas where rainfall is adequate and also where road access to pole markets is good. Thus in Amhara Region on-farm tree planting has been most intense in East and West Gojam and least in Wag Hamre and North Wello. Away from the main roads demand for poles in local markets is quickly satisfied. Where transport and marketing of poles and linkages with urban pole traders is well organized then on-farm trees planting can be very intense. Interviews with farmers in West Gojam indicated that individual farmers face considerable constraints in getting their poles marketed - particularly if they are off the main road - because of the problems in meeting up with pole merchants.

At a more local level detailed Bewket (2003) has studied changes in woody biomass in the Chemoga Watershed in Gojam[61]. This study found that stocks of woody biomass had increased over the past four decades, and these constituted mainly homestead woodlots of Eucalyptus.

[61] Bewket, W (2003) "Household level tree planting and its implications for environmental management in the north-western highlands of Ethiopia: a case study in the Chemoga watershed, Blue Nile Basin" Land Degradation & Development 14: 377-388.

(ii) Impact on Water Yield

In another study of the Chemoga Watershed, Bewket and Sterk (2005)[62] examined the changes in stream flow patterns with reference to the dynamics of land cover. The results showed that between 1960 and 1999 annual stream flow decreased at a rate of 1.7 mm/yr whereas annual rainfall decreased only at a rate 0.29 mm/yr. The decrease in stream flow was more pronounced in the dry season to which a statistically significant decline of 0.6 mm/yr was observed, whilst rainfall showed no discernible trend. Wet season rainfall and flows showed no trend. Analysis of extremely low flows confirmed that low flows declined with time.

Using aerial photographs land cover changes were examined between 1957 and 1982, and 1982 and 1998. Over the past four decades the major change in land cover was the increase in cultivated land from 60.4 to 66.6 percent. Closed canopy forest cover increased 2.4 to 3.6 percent. This was attributed to plantation (mainly Eucalyptus) activities during the Derg, and planting of trees by households since 1991 (again mainly Eucalyptus). Woodland and shrublands declined during the first period (1957 – 82) and increased over the second period (1982-1998). The increase in the second period was attributed to hillside closures. The significant change was in the amount of Eucalyptus that had been planted during the second period.

The changes in stream flow were ascribed to increase in cropland, increase in Eucalyptus planting and overgrazing. Another cause was the increased abstraction of water due to the increase in population during the study period. The increase in Eucalyptus has led to an increase in evapotranspiration over the previous land cover. Local people confirmed that Eucalyptus dried out the land, but that the economic returns were substantial. Decreased dry season flows indicate a decline in groundwater resources.

7.3.5 Trends in Soil and Vegetation Degradation

(i) Soil Degradation

In the absence of any widespread, consistent and long term monitoring it is difficult to estimate medium or long term trends of erosion or sedimentation. Any evidence must therefore be circumstantial.

Within existing settled areas there has been some expansion of cultivation although this has been mostly at the expense of uncultivated patches of land

[62] Bewket, W & G. Sterk (2005) "Dynamics in land cover and its effects on stream flow in the Chemoga Watershed, Blue Nile Basin, Ethiopia", Hydrological processes 19: 445-458.

between fields and on the more marginal land. Voluntary migration of people from north to south of the Abay has seen agricultural expansion into the Lower Didessa and Anger valleys. Although soils are derived from Basement Complex rocks and thus highly erodible slopes are relatively gentle. The second main area of agricultural expansion has been on and down the western escarpment towards the western lowlands in the Dinder, Beles and Dara valleys. These are areas of steep slopes and high rainfall and are very susceptible to soil erosion. The third area of agricultural expansion over the past two decades has been into the upper parts of the Abay Gorge. Although rainfall amounts are lower than the western escarpment slopes are steep and susceptible to soil erosion.

On balance and given the reluctance of farmers to invest in physical conservation structures in the high rainfall areas of the western Highlands, it is likely that soil erosion could increase in the upper Main Abay valley and on the western escarpment in the Dinder, Beles and Dara valleys.

In the absence of preventative measures, declining soil fertility and organic matter content are likely to increase soil erodibility. However, there have been some increases in the adoption of soil and water conservation and soil improvement measures over the past ten years. Map 52 indicates the percentage of farmers who have adopted terracing. Adoption has been particularly successful in Tigray, where the positive impacts on soil-water conservation are more successful than in the wetter areas in Amahra Region. Overall, it appears that 30 percent of cropland in the Tekezi Basin has now been terraced. Not shown on the map are the adoption rates of soil bunds and grass strips, which have been more widely adopted in Amhara Region.

An un-quantified area of cropland is also receiving improved tillage and soil amelioration measures (composting, contour ploughing, etc). However, one of the main causes of soil nutrient depletion: burning of dung and residues and grain removal from fields without replenishment continue. The WBISPP Woody Biomass Strategic Plan for Tigray reported that between 1984 and 2000 consumption of resides and dung has increased by about 3 percent per annum.

The Strategic Plan for Amhara Region reported a decline in residue and dung use for fuel as result of the very large increase in on-farm tree planting since 1991. Substantial on-farm tree planting in Tigray was only beginning in about 2000 and had not had any significant impact on reducing dung and residue use as fuel. In the absence of substantial external inputs of soil nutrients (chemical fertilizer and/or manure) nutrient decline is likely to continue.

7.3.6 Conservation of Biodiversity: Alatish Regional Park

The Amhara regional Government has proposed to develop the Alatish Regional Park in Quara wereda of North Gonder Zone, almost opposite the Dinder national Park in the Sudan. The area represents the Sudan-Guinea Biome. The park has been gazetted as a Regional Park and demarcated. However, the Park lacks national legislation and international recognition[63].

The Park covers an area of 2,666 km2 to the north of the Dinder River, which forms its southern boundary, and to the south of the Gelegu River that forms its northern boundary. The Alatish and other ephemeral streams drain the central area. Its altitude ranges from 500 to 900 masl. The main vegetation is woodland, shrubland and lowland bamboo thicket. Studies so far have revealed that the Park contains 48 mammal species and 180 bird species. It contains such endangered species as *Loxodonta africana, Panthera pardus* and *Panthera leo*.

The area is intact with no permanent settlement, although Fellata pastoralists enter the Park in the dry season with over 10,000 head of livestock. The northern and eastern sides have a 2 kms buffer zone, but the southern boundary has no buffer zone as it border Beneshangul-Gumuz regional State.

The Gumuz people have settled to the south of the Park and practice poaching and fishing along the Dinder River. Settlement is increasing and agriculture expanding along the northern boundary and numbers are being swelled by migrants from other parts of Amhara region. People enter the Park area to collect honey, gums and resins.

There is an urgent need to collaborate with the Beneshangul-Gumuz Regional government and with the Government of Sudan to secure the area. The Ethiopian Wildlife Conservation Organization has strongly recommended that the Alatish Park been proclaimed a National park and that in the future it should form part of a Transboundary Park with the Dinder National Park. There is also an urgent need to develop a park management plan in participation with local communities.

[63] Cherie Enawgaw et al (2006) "Report on the Assessment of Alatish Park in Amhara regionbal State", EWCO, Addis Ababa, May 2006.

7.4 Tekezi River Basin

7.4.1 Overview of the Watershed Management Problems and Potentials

The Tekeze Sub-basin within Ethiopia covers a quarter of the area and a fifth of the population in the Eastern Nile Basin. Its waters provide 14 percent of the Main Nile flow into Lake Nubia/Nasser and some 25 percent of its sediment load.

As in the Abay Sub-basin the highland plateaus have been deeply dissected by the Tekeze and tributaries again providing severe constraints to road communications and access to markets. Agriculture expansion onto steep slopes and the consequent loss of vegetative cover have accelerated geological rates of soil erosion. Steep slopes and lack of vegetative cove result in relatively high rates of sediment delivery to the main rivers. Millennia of cultivation coupled with breaches in soil nutrient cycling caused by residue and dung use as fuel, grain removal and soil erosion have led to low levels of crop and pasture productivity. Agricultural productivity in the Tekeze Sub-basin is further constrained by low and variable rainfall.

Detrimental government policies in the past have left a legacy of tenure insecurity and poverty with severe constraints on farmers' willingness and ability to invest in sustainable land management. Past large-scale programmes of soil conservation and afforestation were top-down and alienated the rural population.

Nevertheless, physical soil and water conservation structures have been very successful in increasing soil moisture retention and their adoption by farmers has been very substantial. Small dams and water-harvesting for small-scale irrigation have demonstrated their potential for increasing crop production, but have also demonstrated the need for an integrated watershed management approach to such water development.

As in the Abay Sub-basin the western Lowlands have the potential for agricultural expansion, although rainfall amounts are lower than those in the Abay Sub-basin.

7.4.2 Assessment of the Extent Soil Degradation

(i) Sheet and Rill Erosion

The extent of the sheet erosion hazard using the USLE as a basis and described in section 6.2 and Annex 1, is shown in Map 52.

Within the Tekezi Sub-basin the main area of high soil erosion hazard follows the western side of the spur of highland that trends northwestwards from the Simien Massif. This continues over the watershed into the main Tekezi Sub-basin. Within the main Tekezi Sub-basin there are three main areas of high erosion hazard. The first lies to the southwest and west of the river and follows the ridge of steep land along two ridges from the Simien Massif trending to the southeast and the northeast. A second area is found on the eastern rim of the basin in the high basaltic mountains from Korem to Adi Gudem. A third area is found in the lower Werii valley whilst a fourth area is located on the high basaltic mountains to the west of Adigrat.

Map 52. **Ethiopia - Tekezi Basin: Sheet Erosion Hazard**

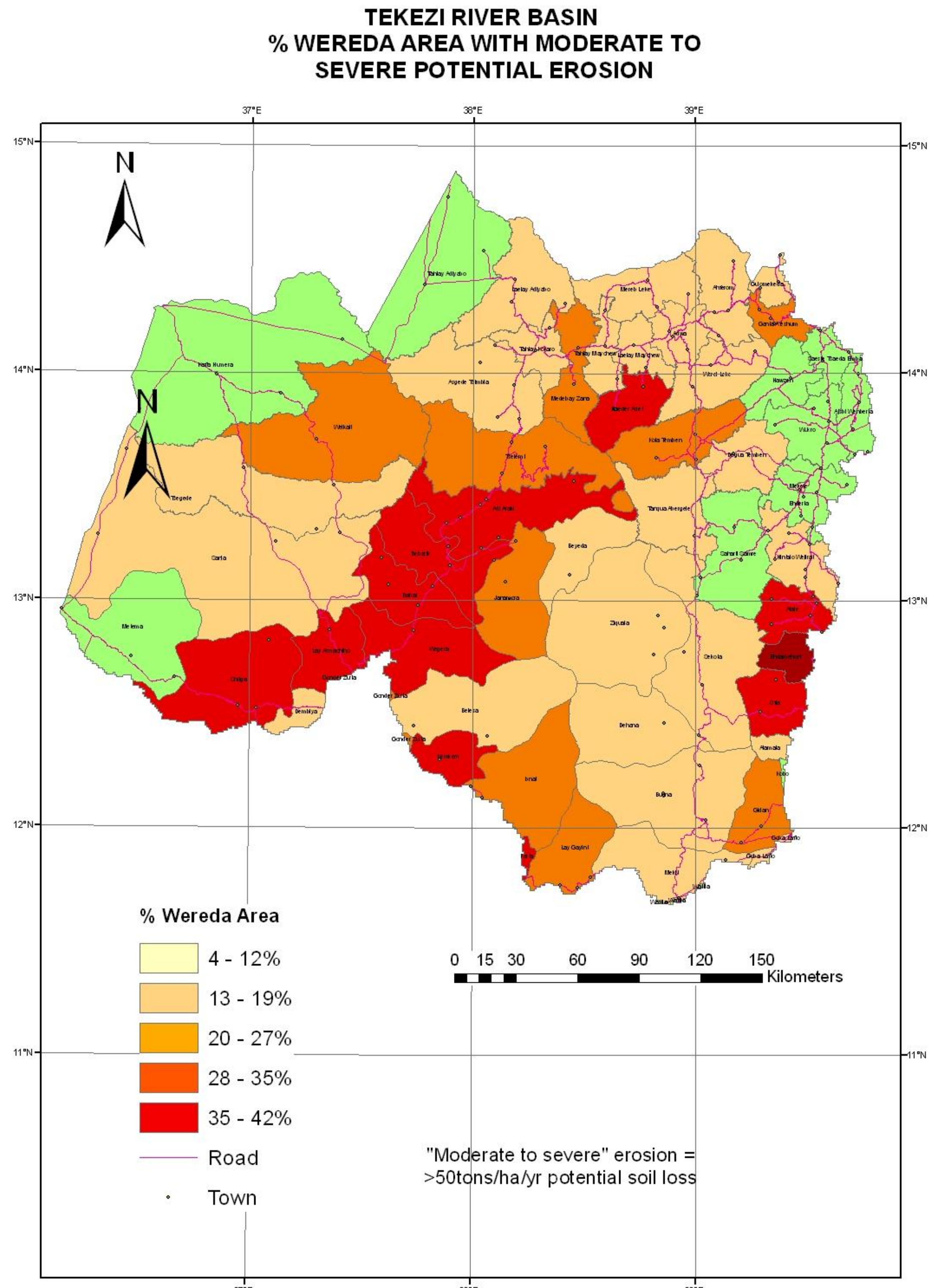
The sheet erosion hazard map is translated into wereda statistics using the percent area of "moderate to severe" erosion hazard (i.e. potential soil loss rates exceeding 50tons/ha). These are shown in Map 53.

The broad pattern of moderate to severe soil erosion hazard indicated above is clearly reflected in the wereda map. However, it is important to note that much of the Tekezi Basin is in a moisture deficit area with high evapotranspiration rates (see map), particularly in those areas at lower altitudes near to the main river. Many of these areas indicate a relatively low erosion hazard but will benefit significantly from soil-water conservation measures.

The total soil eroded within the landscape in the Tekezi Basin is estimated to be 100.5 million tons per annum and that from cultivated land is estimated to be 27.2 million tons per annum. Thus over 70 percent of soil being eroded is from non-cultivated land, i.e. mainly from communal grazing and settlement areas.

The area of cropland subject to "unsustainable" (i.e. loss exceeds soil formation or 12.5 tons/ha/yr) is 275,400 ha and 374,000 ha in the Tigray and Amhara areas of the Tekezi Basin respectively, a total of 649,400 ha.

Of the total 100.5 million tons of soil eroded a proportion is re-deposited within the landscape, the remainder reaching streams and rivers. The ratio of the amount of sediment reaching streams to the total eroded soil is known as the sediment delivery ratio (SDR). This is considered below in the section on sedimentation. At the Basin level the estimated SDR indicates that approximately 40 percent of sediment remains in the landscape and does not reach the stream system. This is much lower than the 90 percent estimated by the Ethiopian Highlands Reclamation Study (EHRS) and the 70 percent estimated by Hurni 1984).



Map 53. Ethiopia – Tekezi Sub-basin: Moderate to Severe Soil Erosion Hazard by Wereda.

(ii) Gulley Erosion

Although some work has been undertaken on gulley formation and extension[64] [65], there is no information on the distribution and density of gullies. Barber (1984)[66] considers that much sediment from gullies is deposited on lower slopes without entering the drainage system. Stocking (1996)[67] working Zimbabwe estimated sediment from gullies contributed approximately 18 percent of suspended sediment loads. Loss of cropland from gully erosion was considered to be insignificant.

Very recently research by the Universities of Makelle, Ethiopia and KU Leuven, Belgium in Tigray[68] have provided information of gulley erosion rates, sediment yields and sediment delivery ratios in northern Ethiopia. They report that gullies were initiated by a variety of changes in environmental conditions: removal of vegetation between fields, Eucalyptus planting in valley bottoms and new road construction. Gullies followed a sigmoidal evolution in volume, with a rapid increase until the mid 1990's when the rate of growth declined to almost nothing. This has been due to the considerable development of soil conservation structures and communal area closures that have occurred since 2000.

During the period of most rapid gully growth, soil erosion rates were between 13 – 27t/ha/yr. Currently, the rates have slowed to 1.1t/ha/yr. The average rate of total years of gully evolution was 6.2t/ha/yr and they recommend this figure for sediment budgeting where conservation measures have not been implemented. The figure of 1.1t/ha/yr is approximately 10 percent of the weighted average soil erosion rate of 9.7t/ha/yr in the area. Approximately 50 percent of the sediment reached the drainage system, the remainder being deposited within the landscape.

Thus, where soil conservation measures have been introduced and gullies are relatively stable they contribute approximately 5 percent to sediment load. Where there are no conservation measures the average rate is 32 percent. In the present report it is assumed that sediment from gullies contributes an additional 20 percent to sediment loads in streams and rivers.

[64] Billii & F.Dramis (2003) "Geomorphological investigation of gully erosion in the Rift Valley and the northern Highlands of Ethiopia", Catena Vol. 50, 2-4, pp. 353-368.
[65] Shibru Daba et al (2003) Assessment of gully erosion in eastern Ethiopia using photogrammetric techniques", Catena Vol. 50, 2-4, pp. 273-291.
[66] Barber, R (1984) "An assessment of the dominant soil degradation processes in the Ethiopian Highlands: Their impacts and hazards", EHRS WP 23.
[67] Stocking, M (1996), "Soil Erosion: Breaking New Ground", in Eds. M.Leach & R. Mearns "The Lie of the land", IAI, London.
[68] Nyssen, J et al (2005) "Assessment of gully erosion rates through interviews and measurements: a case study from northern Ethiopia", accepted for publication in Earth Surf. Process. Landforms 30, (2005).

(iii) Mass Movement of Soil

Mass movement processes include slow acting soil creep as well as more rapid and dramatic processes of landslides, earth flows and mudflows. They are likely to occur in higher rainfall areas, on steep slopes and in soils with high infiltration rates and high moisture holding capacities. Localized mass movements can be observed on cultivated steep slopes in the inner Tekezi gorge. However, there is no information on the extent of mass movements of soil within the Tekezi basin. Barber (1984) considers that it is unlikely that they are important in the Ethiopian Highlands, in extent or river sediment load contributions.

(iv) Sedimentation

The average sediment yield, total sediment and estimated sediment delivery ratios for two points along the Tekezi-Atbara River are shown in table 58. Kashm el Gibe is 180 kms below the border with Sudan whilst Embamade is close to the junction of the Tekezi and its tributary the Werii. Some sediment from the eroded *Kerib* land will be contributing to the sediment load in the Atbara within the Sudan, which could account for the slight rise in the sediment yield.

Table 58. Sediment yield, total sediment load and sediment delivery rations for two locations along the Tekezi/Atbara River.

River (/source)	Location	Area (km2)	Sediment yield (t/km2/yr)	Total sediment (million t/yr)	Total erosion (million t/yr) (incl. gulley sediment)	Sed. delivery ratio
Atbara 1/	Kashm el Girba	80,000	900	79.20	120.5	66%
Tekezi 1/	Embamade	25,063	798	36.40	60.7	58%

1/ Tekezi Medium Hydro-Project, 2001

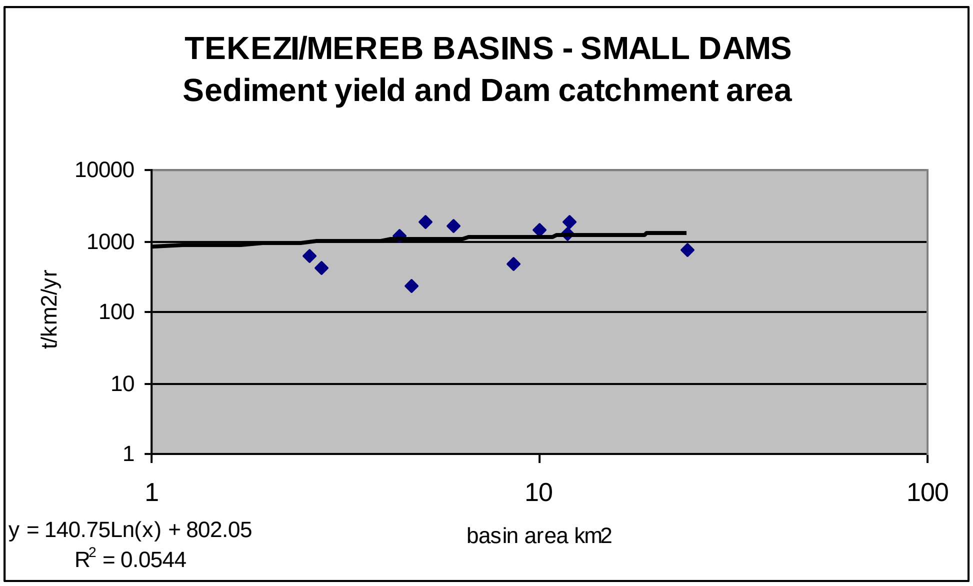
The figures in table 54 indicate sediment yields of between 798 and 900t/km2/yr and sediment delivery ratio over the whole basin of between 58 and 66 percent. These estimates are close to those quoted by Walling (1982) for Texas, USA, well below the nearly 100 percent quoted for China and well above those for the central and eastern USA. They are certainly well above the rate assumed by the EHRS (of 10 percent) and by Barber (1984) of 2 to 3 percent.

Sediment yields generally decrease with increasing catchment area (Walling,1982). Considerable research has been undertaken by Makelle University and KU Leuven (Belgium) on sedimentation in small dams in Tigray[69] [70]. They surveyed 54 recently built small dams in Tigray. and found that 70

[69] Nigussie Haregeweyne et al (2005) "Specific sediment yield in Tigray – Northern Ethiopia: Assessment and semi-quantified modelling", Geomorphology, 69, 315-331.
[70] Nigussie Haregeweyne et al (in press) "Reservoirs in Tigray: Characteristics and sediment deposition problems", Land degradation and Development (in press).

percent had significant siltation problems (in addition to problems of seepage and insufficient water supply). The estimated sediment yield varied from 237 to 1,817t/km2/yr with a mean of 909t/km2/yr (+/- 500t/km2/yr). The variation in sediment yield was attributed to differences in lithology, gully networks and human action. Research into small dam sedimentation in the Mereb-Gash basin[71] in Eritrea (in catchments between 6 and 12 km2 in area gave sediment yields of between 1624 and 1816t/km/yr. The scatter plot of the sediment yield to basin area results are shown in figure 17. This indicates a slight increase in sediment yield with increasing basin size but this is not statistically significant.

Figure 17. Tekezi and Mereb basins – Small Dam catchments: Relationship between sediment yield (t/km2/yr) and Catchment Area (km2)



There is no significant difference between the sediment yields of small and large catchments, with the mean of the small catchments close to that of the large catchments. This would appear to indicate there is little or no storage of sediment within the Tekezi river system, a factor normally attributed to declining sediment yields with increasing catchment areas. However, this is to be expected given the steep gradients in both tributary and main rivers. Given the relatively high sediment delivery ratios and very similar sediment yields it would appear that the Tekezi River system is relatively efficient in delivering and removing eroded sediment from the landscape.

The inference of this is that interventions to reduce in-field erosion are likely to have a relatively immediate impact on sediment loading in the river system.

[71] R. Colombo & P.Safatti (2005) "Hydrological analysis of two sub-catchments of the Mereb River (Eritrea)", Water Report No. 16.

(v) Soil Nutrient Losses

(a) Burning of Dung and Crop Residues

The WBISPP (2003) estimated that within the Tekezi Basin some 809,400 tons of dung collected from crop fields (about 40% of total dung produced) and some 902,370 tons of crop residues were burnt as household fuel. This resulted in a loss of some 17,460 tons of available N and 3,990 tons of available P.

(b) Nutrient Losses through Removal of Grain

An estimated 738,560 tons of grain is removed from cropland annually. This would account for an additional 14,770 tons of available N and 2,950 tons of available P being removed.

(c) Nutrient Losses from Soil Erosion

Another source of soil nutrient losses at the field level is soil erosion. Hashim et al (2000) estimate nutrient loss as:

*Nutrient Loss = Soil loss * Nutrient concentration of topsoil * Enrichment ratio*

where the enrichment ratio refers to the ratio of the additional minerals and organic matter in eroded soil compared with the original soil. Barber (1983) estimated enrichment ratios of 2 for N and organic matter. As only about 2 percent of the total N and 0.16 percent of P is available in any one year, replenishment costs should be based on this proportion. Using Barber's estimated annual nutrient losses from different soil erosion rates, and a sediment delivery to streams ratio of 59 percent, losses of available N would be approximately 1,886 tons with 810 tons of available P on 2.6 million ha of cultivated land from 27.2 million tons of soil that is eroded.

Against these N losses are annual increments of N from rainfall and asymbiotic and symbiotic fixation. For Ethiopia these are estimated to be 15kgs per ha per annum[72]. From external sources there is an annual increment of 39,320 tons of N. Storvogel and Smaling (1990)[73] estimate that some 30 percent is lost through leaching and gaseous exchange (approximately 10,920 tons/yr). Thus, it would appear that there is a net loss of N of about 6,600 tons or 2.54kgs/ha from burning dung and residues, grain removal and soil erosion.

[72] Sanchez, P (1976) Properties and Management of Soils in the tropics (data for highland Madagascar)

[73]

However it is important to note, as Barber comments, "the prediction of soil nutrient losses is a very dubious and precarious exercise based on very limited amount of "hard" data and involving many estimates".

7.4.3 Assessment of the Extent Deforestation and Degradation of Vegetation Cover

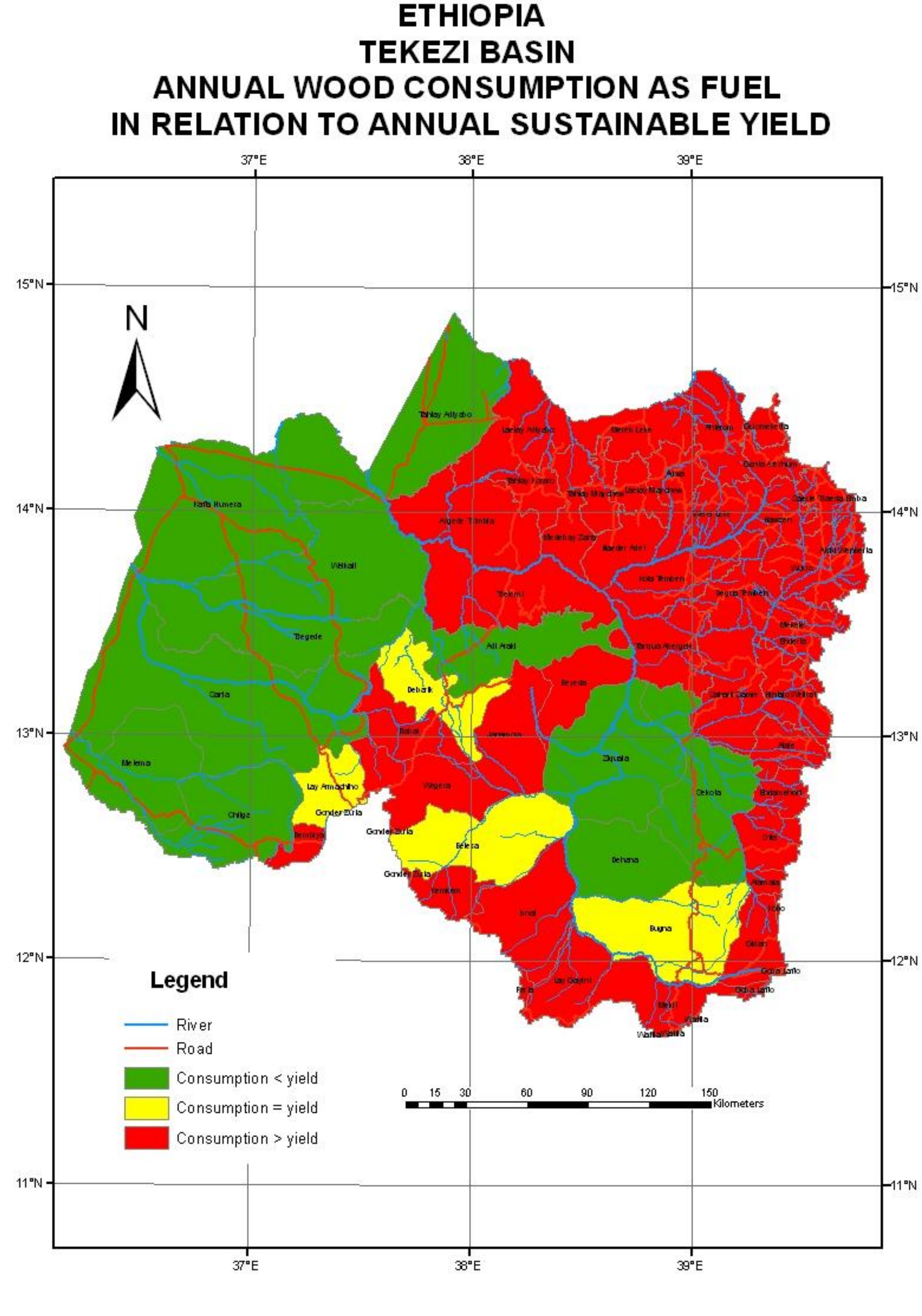
(i) Deforestation

Following the cessation of the civil war and return of large numbers of refugees from Sudan there was some expansion of agriculture in the Tigray region of the Tekezi basin. However, over the past five years little expansion of agriculture, and thus complete clearing of woody vegetation has taken place in the highlands as agricultural expansion has reached the limits of cultivable land. Two areas of continued although limited agricultural expansion are the lower altitudes in the main Tekezi valley and in the western Lowlands.

(ii) Degradation of Woody Biomass

Degradation of woody biomass is caused in the main by the removal of wood for household fuel. Removal of wood in excess of the sustainable yield (after accounting for removal of dead wood and fallen branches, leaves and twigs) leads to declining stocks, which in turn leads to declining yields and so to permanent degradation of woody biomass. The proportion of sustainable annual woody biomass yield consumed as fuelwood by wereda is shown on Map 54. Note that this does not include wood removal for new house construction and current house maintenance.

It can be seen that the pattern of weredas consuming in excess of sustainable yield mirrors that of the weredas with high proportions of their area experiencing moderate to severe soil erosion (see Map 52).



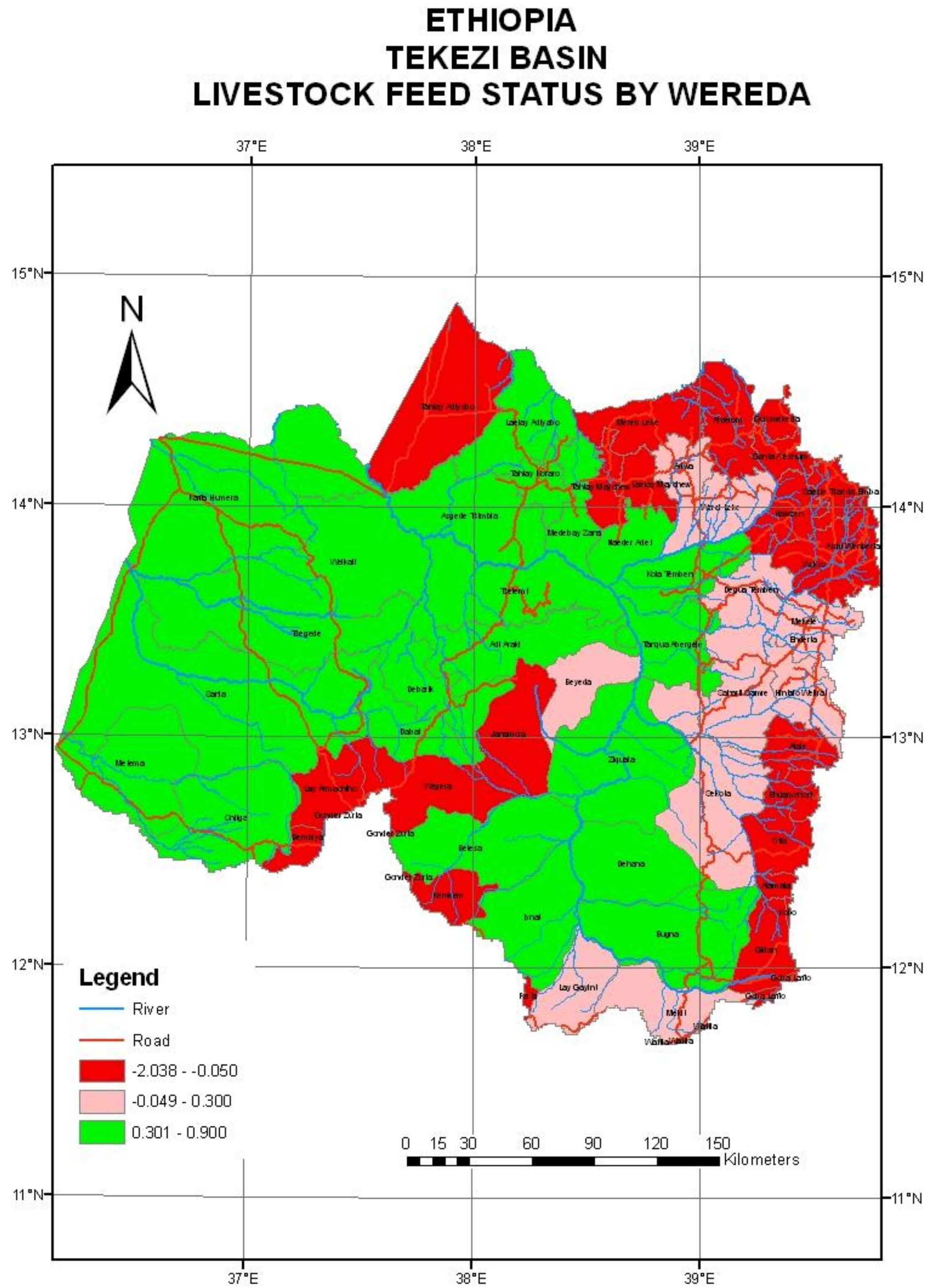
Map 54. Ethiopia – Tekezi basin: Annual woody consumption as fuel in relation to annual sustainable yield.

(v) Degradation of Herbaceous Biomass

Degradation of herbaceous biomass is caused mainly by overgrazing of livestock. An indicator of overgrazing can be determined by examining the livestock feed energy balance at the wereda level. Energy requirements of all livestock are computed using energy requirements for maintenance, draught power and lactation, and balanced against estimates of energy supply from natural pastures and crop residues[74]. The results for the Tekezi Basin are shown in Map 55.

The weredas along the eastern and northeastern part of the basin, as well as the weredas trending northeastwards from the Simien Massif stand out as livestock feed deficit areas and thus likely to be severely overgrazed. Again the pattern generally mirrors that of weredas with high proportions of their area experience moderate to severe soil erosion (see Map 53).

[74] WBISPP (2003) Separate Reports on Natural Grazing Lands and Livestock Feed Resources for Tigray, Amhara, BSG, Oromiya, SPNN and Gambela regional States.



Map 55. Ethiopia – Tekezi Basin: Livestock Feed Energy Balance by Wereda

7.4.4 Trends in Soil and Vegetation Degradation

(i) Soil Degradation

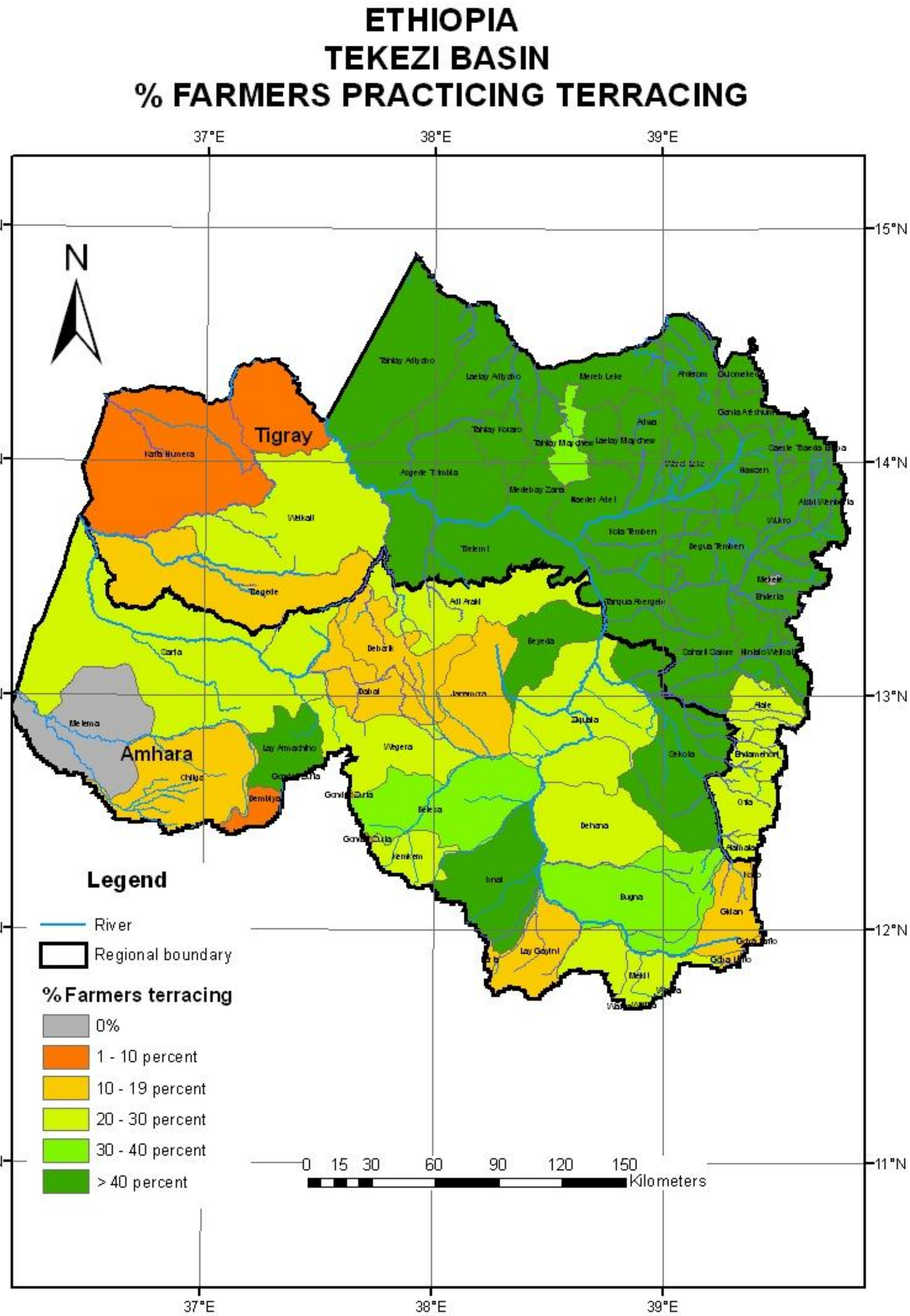
In the absence of any widespread, consistent and long term monitoring it is difficult to estimate medium or long term trends of erosion or sedimentation. Any evidence must therefore be circumstantial.

As indicated above, it is likely that there has been little expansion of cropland in the highlands of the Tekezi Basin after the return of refugees between 1991 and 1995. Most expansion has occurred in the inner parts of the middle Tekezi valley and in the western lowlands. Generally slopes here are shallow although the soils derived from the Basement Complex rocks are very erodible.

In the absence of preventative measures, declining soil fertility and organic matter content are likely to increase soil erodibility. However, there have been impressive increases in the adoption of soil and water conservation and soil improvement measures over the past ten years. Map 56 indicates the percentage of farmers who have adopted terracing. Adoption has been particularly successful in Tigray, where the positive impacts on soil-water conservation are more successful than in the wetter areas in Amahra Region. Overall, it appears that 30 percent of cropland in the Tekezi Basin has now been terraced. Not shown on the map are the adoption rates of soil bunds and grass strips, which have been more widely adopted in Amhara Region.

An un-quantified area of cropland is also receiving improved tillage and soil amelioration measures (composting, contour ploughing, etc). However, one of the main causes of soil nutrient depletion: burning of dung and residues and grain removal from fields without replenishment continue. The WBISPP Woody Biomass Strategic Plan for Tigray reported that between 1984 and 2000 consumption of resides and dung has increased by about 3 percent per annum.

The Strategic Plan for Amhara Region reported a decline in residue and dung use for fuel as result of the very large increase in on-farm tree planting since 1991. Substantial on-farm tree planting in Tigray was only beginning in about 2000 and had not had any significant impact on reducing dung and residue use as fuel. In the absence of substantial external inputs of soil nutrients (chemical fertilizer and/or manure) nutrient decline is likely to continue.



Map 56. Ethiopia- Tekezi Basin: % of farmers Practicing Terracing by Wereda.

Although not quantifiable, there has been a substantial area of free grazing land subject to livestock exclusion or controlled grazing. In Tigray, all Farmers Associations surveyed by IFPRI/ILRI[75] had controlled or managed grazing schemes. This is particularly important as some 70 percent of soil erosion occurs on grazing land.

Thus, circumstantial evidence suggests physical soil degradation processes in the Tekezi Basin are likely to be slowly reducing, although soil nutrient depletion is continuing.

(ii) Vegetation Degradation

Deforestation is likely to continue and may accelerate in the western Lowlands with resettlement and the expansion of medium scale semi-mechanized farming, although in the absence of monitoring it is not clear at what rate. Stocks of woody biomass in the highlands are now starting to increase with continued closure of grazing lands, expansion of community and on-farm tree planting.

As community and on-farm tree plantings mature the rate of wood extraction from shrublands and woodlands should decline. Together with grazing area closures vegetative degradation should also decline in the highlands. With increasing population pressure bush fallow periods in the shifting cultivation systems are likely to decline leading to degradation of the existing shrubland and woodland.

7.5 Baro-Akobo River Basin

7.5.1 Overview of the Watershed Management Problems and Potentials

The Baro-Akobo sub-basin is one part of Ethiopia which is still relatively well endowed with natural resources as has been outlined in the previous section. In many ways it is as yet an only partially exploited resource frontier, with good land in many places, plentiful and reliable rainfall - especially in the upper basin, a major cash crop resource in the form of coffee, major biodiversity and genetic resources in the form of wild forest coffee, forests, wetland resources and some wildlife, and plentiful water for irrigation and hydro-power development. Overall population pressure is not severe, especially in the lower sub-basin, and communications are improving with new roads bringing about 48% of the sub-basin within 15 kilometres of an all-weather road.

[75] Berhanu Gebremedhin, J. Pender and Girmay Tesfay (2002). "Nature and determinants of collective action for woodlot management in Northern Ethiopia. " ILRI Socio-economics and Policy Working Paper No. 40, ILRI, Addis Ababa.

However, there are some major constraints to development. These include malaria in the lower sub-basin, trypanosomiasis in the woodland parts of the lower sub-basin, the remoteness of the sub-basin - especially the lower sub-basin, from major urban centres, markets and ports, as well as limited communications in the lower sub-basin. There is also low population density in many parts of the lower sub-basin and low levels of literacy amongst the population. Further constraints are the ethnic tensions which exist within some areas, especially in the Gambela salient and adjoining areas, which have not been fully addressed by the Ethiopian decentralization process.

As well as these specific constraints to development, there are a number of problems appearing which relate to development in the sub-basin and to watershed and natural resource management in particular. These include deforestation, land degradation, wetland loss and wildlife loss. In some part of the upper sub-basin fragile environments, such as in Western Wellega and Beni-Shangul, are being degraded by inappropriate farming systems. Overall there is growing evidence that the resource base of the sub-basin, and the highland area especially, is declining.

The causes of this resource degradation are predominantly due to population growth, problems with farming system development, the loss of land to investors and settlers and the fluctuating presence of refugees in specific locations. However, these proximate causes are usually the result of other underlying drivers which include government policies, poverty and the competition for resources.

This section will explore these issues through the analysis of a number of key land use and development problems in the basin and their drivers (3.2), an assessment of the plans for sub-basin development which were developed in the mid 1990s (3.3), and a review of alternative approaches to addressing the development problems and their underlying causes in this area (3.4).

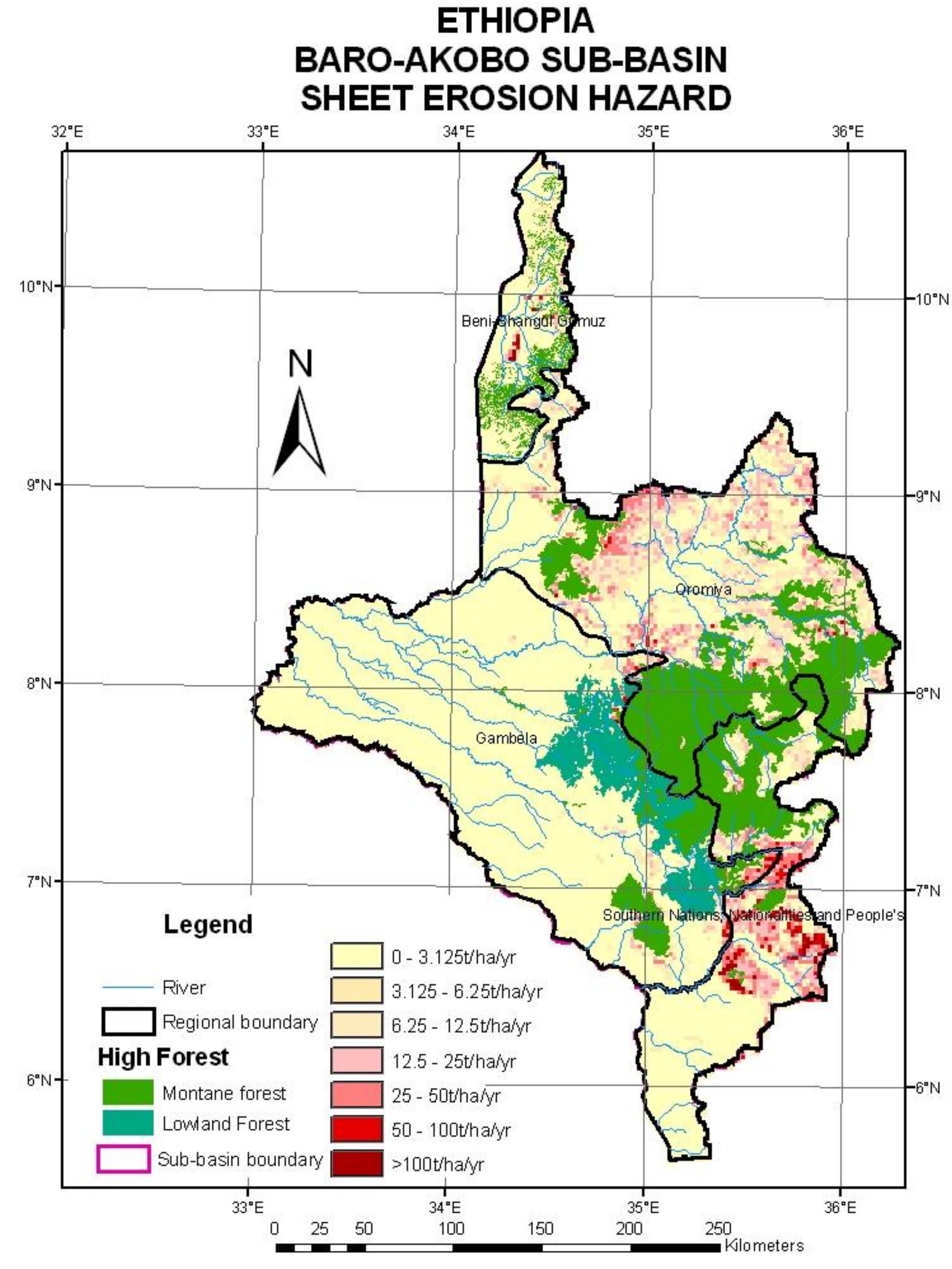
7.5.2 Assessment of the Extent Soil Degradation

(i) Sheet and Rill Erosion

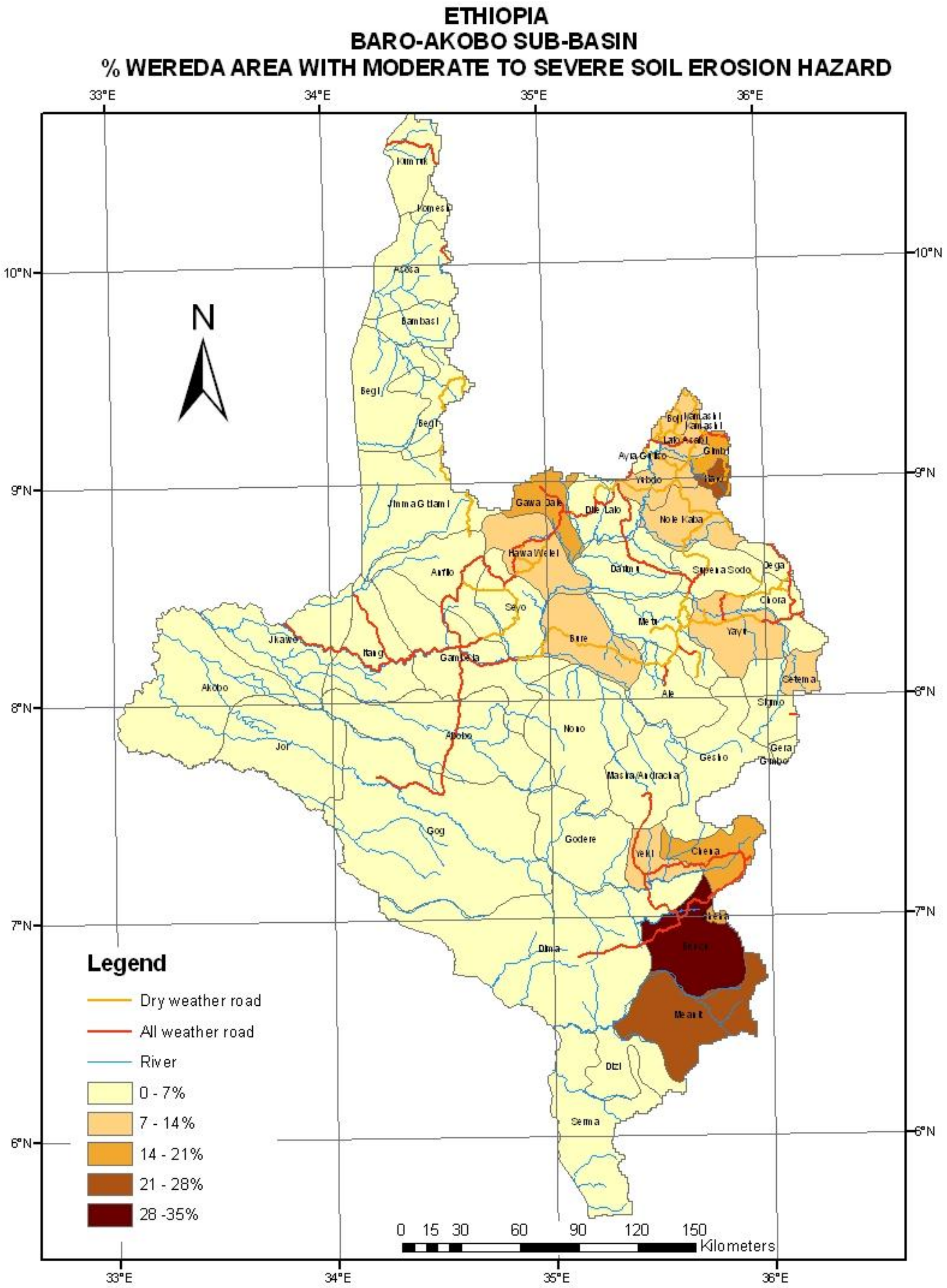
The extent of the sheet erosion hazard using the USLE as a basis and described in section 7.2 and Annex 1, is shown in Map 57. Within the Baro-Akobo Sub-basin there are two main areas of high erosion hazard: in the northeast in the Upper Baro Catchment, and in the southeast in the catchments of the Upper Gilo and Duna.

The sheet erosion hazard map is translated into wereda statistics using the percent of wereda area of "moderate" to "severe" erosion hazard (i.e. potential soil loss rates exceeding 50tons/ha). These are shown in Map 58.

The broad pattern of moderate to severe erosion hazard indicated above is clearly reflected in the wereda map. The total soil eroded in the Sub-basin is estimated to be 43.7 million tons per annum and that from cultivated land 21.5 million tons per annum. This is a much higher proportion than in either the Tekeze or Abay Sub-basins, a reflection of the much higher vegetative cover in the communal lands of this high rainfall area.



Map 57. Ethiopia – Baro-Akobo Sub-basin: Sheet and rill erosion hazard



Map 58. Ethiopia – Baro-Akobo Sub-Basin: Percent of Wereda Area with Moderate to Severe Sheet Erosion Hazard.

(ii) Gulley Erosion

The Highlands of the Sub-basin are relatively free of gulley erosion given the good vegetative cover in this high rainfall environment. Locally some gully erosion can be observed, almost invariably due to the poor location of a road culvert, and along cattle tracks between villages and water sources.

(iii) Mass Movement of Soil

There are no visible signs of mass movements of soil, except where road construction has destabilized hillsides.

(iv) Sedimentation

Sediment transport data have been collected at eleven gauging stations in the Baro-Akobo basin. The oldest records started in 1988 on the Keto River near Chanka, followed by the records on other six stations started in 1988. All records on these stations stopped in 1990. However, indicative annual sediment load has been estimated for six stations (see Table 56a) using the limited amount of data available.

The Baro 1 and 2 Dam Feasibility Study has examined additional data taken by MWR upto 1996 and additional data collected by the Study. Data is available for 7 additional stations. The data for these stations are shown in Table 56b. Sediment yields vary from 35 to 324t/km^2/yr with an average of 125t/km^2/yr. These rates are considerably lower than those of the Tekeze and Abay Sub-basins, reflecting the greater ground cover in this forested high rainfall regions.

Table 60a. Average Annual Sediment Yield (Master Plan)

River	Drainage Area (km²)	Mean Annual Flow (m³/s)	Annual Sediment Load (t/yr/km²)
Keto	1,006	17.60	324
Gumero	106	2.05	35
Ouwa	288	5.80	284
Sor	1,620	53.60	124
Gecheh	79	1.90	63
Begwaha	125	3.30	85

Source: B-A Master Plan Study

Table 60b. Average Annual Sediment Yield (Master Plan)

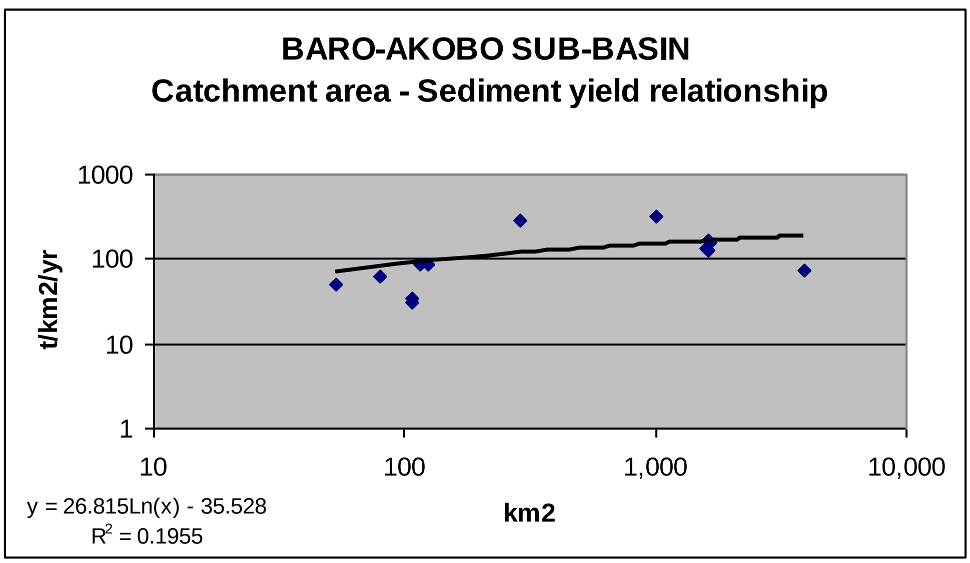
River	Drainage Area (km²)	Mean Annual Flow (m³/s)	Annual Sediment Load (t/yr/km²)
Sor nr. Metu	1,622	50.1	169.0
Geba nr. Chora	1,582	49.3	137.0
Geba nr. Suppi	3,894	54.8	75.2
Uka at Uka	53	1.3	49.5
Gummero nr Gore	106	1.9	31.6
Baro nr. Masha	1,653	56.8	155.0
Genji nr. Gecha	115	4.6	87.8

Baro1-2 Feasibility Study (2006)

			Annual Sediment Load (t/yr/km²)
Mean			**124.6**

Figure 18 shows the scatter plot of tables 60a and 60b. As with the Tekeze and Abay Sub-basins annual sediment yields had a slight tendency to increase with catchment area, although the relationship is not significant.

Figure 18. Ethiopia – Baro-Akobo Sub-basin: Catchment area and sediment yield relationships.



There is no significant difference between the sediment yields of small and large catchments. This would appear to indicate there is little or no storage of sediment within the Baro-Akobo river system within the Highlands, a factor normally attributed to declining sediment yields with increasing catchment areas. However, in this case, this is to be expected given the steep gradients in both tributary and main rivers. Given the relatively high sediment delivery ratios and very similar sediment yields it would appear that within the Highlands the river system is relatively efficient in delivering and removing eroded sediment from the landscape. The inference of this is that interventions to reduce in-field erosion are likely to have a relatively immediate impact on sediment loading in the river system.

With an estimated annual mean suspended sediment load at Gambela of 9.48 million tons and an estimated 43.7 million tons of soil eroded, this gives an estimated sediment delivery ratio (SDR) for the whole Sub-basin of only 22 percent, considerable less than the Tekeze (about 60 percent) and the Abay (about 49 percent).

(v) Soil Nutrient Losses

The WBISPP (2003) estimated that within the Baro-Akobo Basin some 342,213 tons of dung collected from crop fields (about 40% of total dung produced) and some 218,832 tons of crop residues were burnt as household fuel. This resulted in a loss of some 1,064 tons of N and 108 tons of P.

An estimated 514,616 tons of grain is removed from cropland annually. This would account for an additional 14,770 tons of N and 2,950 tons of P being removed.

Another source of soil nutrient losses at the field level is soil erosion. Hashim et al (2000) estimate nutrient loss as:

*Nut Loss = Soil loss * Nutrient concentration of topsoil * Enrichment ratio*

where the enrichment ratio refers to the ratio of the additional minerals and organic matter in eroded soil compared with the original soil. Barber (1983) estimated enrichment ratios of 2 for N and organic matter. As only about 2 percent of the total N and P is available in any one year replenishment costs should be based on this proportion. Using Barber's estimated annual nutrient losses from different soil erosion rates, losses of available N would be approximately 1,886 tons with 329 tons of available P on 1.6 million ha of cultivated land and 43.7 million tons of annual soil loss.

The estimated total annual losses of soil nutrients to cultivated land are summarized in table 61.

Table 61. Ethiopia – Baro-Akobo Basin: Estimated losses of N and P soil nutrients from three sources.

Source of loss	tons N	tons P
Dung/residues as fuel	17,460	508
Grain removed	14,770	2,950
Soil erosion	1,886	329
TOTAL	**34,116**	**3,387**

Against these N losses are annual increments of N from rainfall and asymbiotic and symbiotic fixation. For Ethiopia these are estimated to be 15kgs per ha per annum[76]. From external sources there is an annual increment of 24,195 tons of N. Although some of this would be lost through leaching, it would appear that there is a net gain of N of about 6,475 tons. This is in contrast to the net losses incurred in the Tekeze and the Abay Sub-basins. However it is important to note, as Barber comments, "the prediction of soil nutrient losses is a very dubious and precarious exercise based on very limited amount of "hard" data and involving many estimates".

7.5.3 Assessment of the Extent Deforestation and Degradation of Vegetation Cover in the Highlands

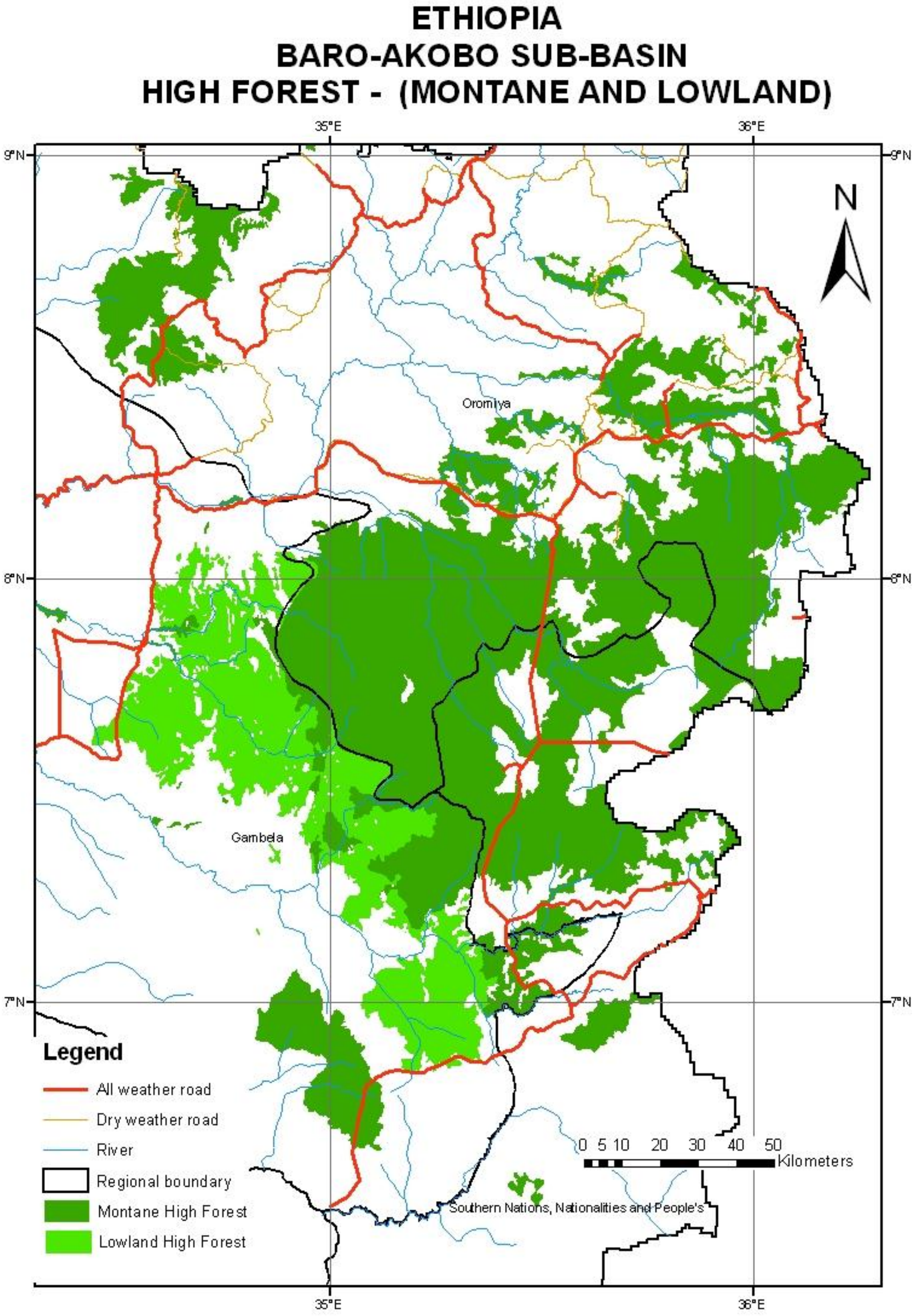
(i) Trends and Impacts

The dominant environmental change in the Baro-Akobo sub-basin is the loss of forest cover which is most marked in the southern and eastern part of the upper sub-basin where the main areas of forest remain. The clearance of forest in this area has been reported throughout Ethiopian recorded history, as there has been expansion of denser settlement from north and east since middle ages. However, it should also be recognized that in some areas there was recovery of the forest in the late 19th century following the conquest and incorporation of this area into the Ethiopian state due to a major collapse in the population. Hence, much of the forest in the upper-basin is secondary (Chaffey, 1979)[77].

The most recent analysis of forest clearance in the south-west highlands, both within the sub-basin and to the east, was made by Reusing (1999) using data from the WBISPP. He identified extensive thinning of the forest and the break-up of the major block of forest in the south-west due to clearance in particular salients, especially along newly constructed roads. His figures show that between 1971 and 1997 approximately 60% of the high forest showed signs of

[76] Sanchez, P (1976) Properties and Management of Soils in the tropics (data for highland Madagascar)
[77] Chaffey (1979) op. cite.

some negative human impact, with 17% having such severe impact that there was complete deforestation. In this period he identified a loss of approximately 4940 sq km out of a total monitored are of 18,000 sq km (Reusing, 1999, pp.29-32).



Map 59. Baro-Akobo Sub-basin: Montane and Lowland High Forest Areas.

The forecast amount of forest, woodland and shrubland cleared between 1990 and 2015 within the Baro-Akobo Sub-basin are as follows:

Forest:	642,445 ha (33% of 1990 area)
Woodland:	724,367 ha (23% of 1990)
Shrubland	126,448 ha (155 of 1990 area)

The reason for the lower area of shrubland cleared is because much shrubland occurs on slopes greater than 30 percent and is not used for cultivation.

Figure 19. Ethiopia- Baro-Akobo Sub-basin: Projected remaining Forest, Woodland and Shrubland after Clearing for Small-scale Agriculture and Settlement.

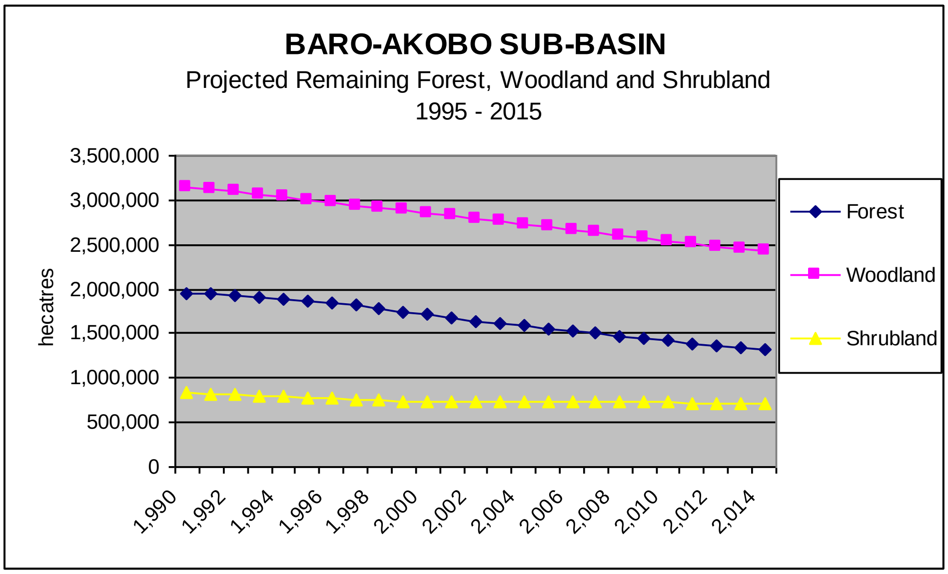
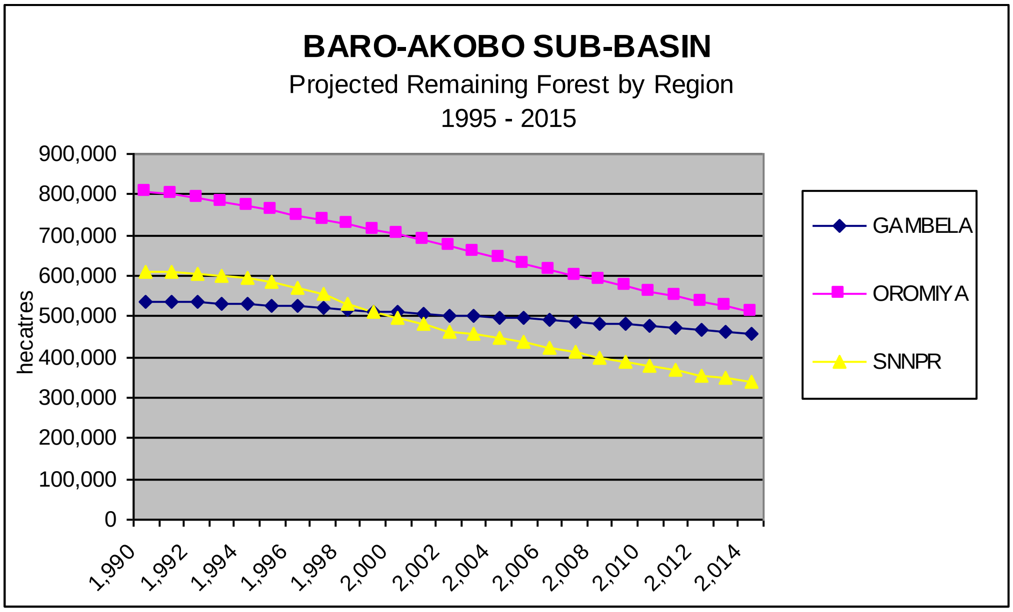
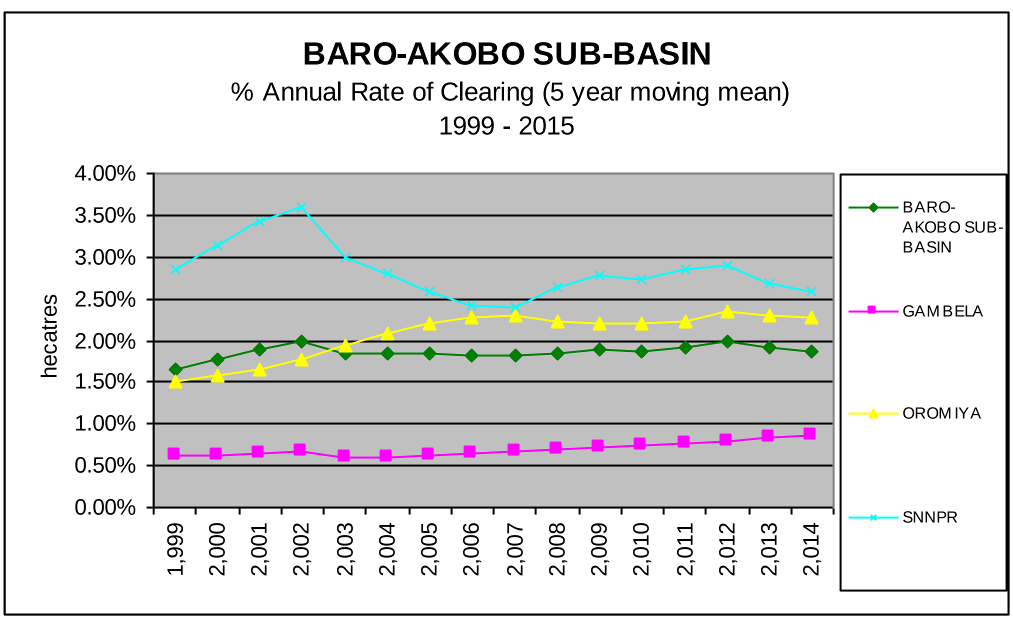


Figure 20. Ethiopia- Baro-Akobo Sub-basin: Projected remaining High Forest after Clearing for Small-scale Agriculture and Settlement by Region.



The average rate of clearing of High Forest across the Sub-basin is approximately 1.8 percent but figure 19 indicates there are Regional variations, with the highest rate of clearing in SNNP region and the lowest in Gambela.

Figure 21. Baro-Akobo Sub-basin: Annual % Rate of Clearing of High Forest by Region (5 year moving mean)



The conversion of forest land to crop land and then grazing land has implications for hydrology. Although there is much debate at present about the role of forest land in affecting the volume of flow, due to evapotranspiration by trees, there are clear implications of forest loss upon the moderation of stream flow, especially the storage of water from the rainy season into the dry season. Hence, linked to the loss of forest are trends towards higher floods and lower dry season flows. There is some evidence of this already occurring in the sub-basin, with the Sor hydro-power plant (near Metu) becoming more seasonal in its power generation and the Baro River at Gambela having more frequent high floods which are affecting long-established villages and low flows which allow the river to be forded in the dry season. Further, as forest in the upper sub-basin is replaced by farm land sediment loads are reported to be increasing with their implications for dam development in the upper sub-basin and for river bed levels and channel overflow in the lower sub-basin.

Finally it should be mentioned that there is significant thinning of the forest for coffee production in many areas. This involves clearance of the natural under-storey and its replacement with often wild, but sometimes improved varieties of coffee, and the occasional thinning of the canopy. This has impacts upon the biodiversity, but probably little impact on the hydrological impacts of land use.

(ii) Drivers of Change

(a) Farming system dynamics:

The main cause of forest loss is agricultural clearance. This is driven by two main factors, the decline in yields on cultivated land with the subsequent abandonment of that land from cultivation, and rural population growth. Through much of the northern part of the highland portion of the sub-basin there are growing areas of farm land which are no longer in cultivation, and while some of them are fallowed and likely to be brought back into cultivation within a few years, others are degraded to varying degrees and likely to remain out of cultivation for a decade or more, and then may still have limited value as farm land. This phenomenon is especially marked in the cereal cultivation areas in Western Wellega and Illubabor Zones.

This process of farm land abandonment is in some ways similar to that found in the highlands of Ethiopia being linked to soil fertility loss due to erosion, soil compaction and the prevention of forest fallow regrowth due to the uncontrolled grazing of livestock (IUCN, 1985). In addition, in the areas close to the forest there is a severe shortage of grazing land and this leads to heavy grazing of fallowed land with particular severe occurrence of the impacts just mentioned.

In the highlands of the Baro-Akobo sub-basin, the potential for soil erosion is the highest in Ethiopia due to the long and heavy rainfall season and the dissected terrain. In addition, various studies report the impact of this and cultivation upon the loss of organic matter in the upper horizons of the soil (Solomon Abate, 1999). The problem of soil degradation and loss is especially marked in some areas where there are fragile soils derived from granite. For instance in Western Wellega from Ghimbi to Nejo, cultivation on these soils has led very severe degradation of the interfluves and the almost complete abandonment of these areas from cultivation with heavy reliance now placed on wetland cultivation (see below). Erosion risks also increase where agricultural expansion extends beyond the plateau areas, onto the slopes of the interfluves and into the incised valleys. Erosion problems have been increased also by the introduction of *teff* cultivation with its particular needs for seed bed preparation long before sowing towards the end of the rains and the use of drainage channels to prevent waterlogging.

Use of soil and water conservation measures varies across the upper sub-basin. Indigenous methods are practiced in the forest fringe areas where bunds of weeds are used to stop the build-up of sheet erosion, but this is also as a way of disposing of the heavy weed growth which often cannot be burned. Further in newly cleared areas a numbers of trees are left within the farmland. Permanent crop cultivation, of enset and coffee, in general helps soil conservation, as does the limited periods of cultivation associated with shifting field cultivation. It should also be noted that in the *enset* dominated areas of the upper sub-basin the problem of land abandonment is less extensive as this permanent crop provides less opportunities for erosion and land degradation. *Enset* and roots crops used to be dominant over a much larger area of the upper sub-basin in the past, and are better suited to the high rainfall, providing good ground cover and stability to the soil in the case of the semi-permanent *enset*.

Where the problems seem to occur is with the movement toward more extensive and permanent cereal cultivation. For instance, as the forest frontier progresses and fuelwood supplies become less readily available, trees in fields tend to be removed. This also makes ploughing easier. Prolonged cultivation also leads to less vigorous weed growth and less use of weed / trash bunds which, with larger contiguous areas becoming cleared, lead to increased runoff and erosion. Also once land is abandoned from cultivation and becomes subject to grazing, this leads to compaction and to increased runoff from this land which often flows onto cultivated land lower down the interfluves and onto higher slope gradients. All of this increases erosion and soil loss.

One of the possible problems with soil erosion and land degradation in the upper sub-basin is that they are currently not as obvious as in the northern highlands of Ethiopia. This is due to the soil depth of up to 2m in the centre and south of the upper basin on the basalt, rather than granitic, parent material. However, it is the loss of organic matter and fertility in upper layers of the top soil which is critical in leading to initial decline in crop yields after 5-10 years which leads to abandonment of land from cultivation for short or long term fallowing.

Hence, it can be argued that in the areas of permanent cereal cultivation there is often insufficient attention given to soil and water conservation. Recent field experiments by an NGO (The Ethio Wetlands and Natural Resources Association) in the Metu area, where short-fallow cultivation has been practiced for some 30 years, have shown that use of a combination of physical and biological soil and water conservation measures can have a major impact on crop yields, increasing them from 39% to 57%.

In general it seems that the Boserupian model of agricultural intensification applies here with land intensification, through manuring investments in land management, not being economically attractive while there is forest land to clear whose high yields and limited pest and weed problems provide an attractive opportunity with better returns to labour.

(b) Population Growth and Resettlement:

A related driver of forest clearance is population growth which is in the order of 2.8% in the rural areas of the upper sub-basin. This growth is mostly due to natural increase, but there has been a long history, when permitted, of spontaneous migration of people in search of land or economic opportunities associated with the coffee economy, as well as planned resettlement from famine affected areas. Resettlement is on-going at present to a limited scale, but was much more extensive in the period after the 1984 famine. At that time the population of some areas, such as highland Illubabor (half of which is within the sub-basin), increased by almost 10%, with existing communities required to find land for settlers under the “integrated” resettlement programme. There was also major resettlement into the lower sub-basin through the establishment of mechanized settlement schemes, to the south of Gambella, for several tens of thousands of famine victims, although this has been deserted by almost all of the settlers. Resettlement is again on the government’s agenda but because of the emphasis upon voluntary resettlement, and the requirement that people can only be moved within their (ethnically-based) regions, the numbers coming to the upper Baro-Akobo basin are less. In the Gurafarda area west of Mizan Teferi in SNNPRA there has been the resettlement of a few thousand people and a similar number are involved in an area to the west of Bedele in Illubabor Zone of Oromiya Regional State.

It should be noted that the impact of settlers from outside the sub-basin is not just in terms of their number but also their land management practices which are often poorly suited to the forest fringe and high rainfall environment. They are unfamiliar with enset and tubers which are suited to the high rainfall environment, and have no experience of controlling soil erosion under such high rainfall conditions. Hence in a number of places there has been major environmental degradation of the land they first clear, encouraging further forest clearance.

(c) Forest Land Alienation to State Farms and Investors:

There is a long history of forest land in the upper sub-basin being given to people from outside the area for agricultural development. In the late 19th century and for the first seven decades of the 20th century this was through the land grants legislation of the Imperial regime which rewarded political loyalty among the mostly northern elite with forest and farm land in the south. There was also some development of private commercial farms and estates toward the end of this period, especially coffee estates around Tepi and one parastatal tea plantation near Gore.

The process of forest land allocation for parastatal estate farming accelerated during the Derg government (1974-1991) as the road infrastructure in this area was improved. This saw the establishment of the 8,000 ha coffee estate at Bebeka, to the west of Mizan Teferi and the established of another state farm for coffee near Tepi covering around 5,000 ha. In the lower basin the state farm at Abobo was also established partly in woodland.

Since the change of government in 1991, and the introduction of the free market, forest land has been allocated to investors on long leases for estate agriculture. This has mostly been done in SNNPRS where a rather favourable attitude to investors exists, compared to that in Oromiya where more stringent EIA procedures have been applied. The new estates are mostly in Sheka Zone, near Masha, along the road from Tepi to Gore, but also west of Mizan Teferi. The major new estates are the East African Tea Plantation in the Baro valley north of Masha, and Sheik Al Ahmoudi's coffee plantation at Gumadro, south-west of Masha, while further forest clearance is expected for a new rubber plantation in the Gurafarda area.

Table 62. Estates developed in High Forest in the Upper Baro-Akobo Sub-Basin.

Location	Investor	Date Est'd	Crop	Area
Gumaro	State/CDC	1960s	Tea	2,300 ha
Bebeka	State	1980s	Coffee	8,000 ha
Tepi	State	1980s	Coffee	6,250 ha
Nr. Masha	East African	1990s	Tea	4,000 ha
Nr. Masha	Midroc	1990s	Coffee	1-2000 ha
Gurafarda	Korean investors	upcoming	Rubber	n.a.

In all cases the estates have been established in areas of high forest and experience shows that when options exist for using secondary / thinned forest within the allocated area, investors prefer the high forest. This has led to a range of social impacts which are ignored by the state and the investors. These relate to the fact that the forest which is removed has been used for generations by local communities for a variety of gathering purposes, including the collection of wild coffee, spices – such as *korerima* (Ethiopian cardamom), other NTFPs for domestic use and for the hanging of beehives, using the traditional *kobo* system of heritable rights to trees. This neglect of traditional rights has led to a number of conflicts in this area the most important and largest of which was the march on Tepi and associated killings in 2002 of farmers complaining about the loss of land to the Bebeka estate and to labourers brought there to work on the estate who are also farming. More recently guards on one estate have been murdered and their bodies hung from trees, presumably as a warning against further alienation of forest land from local communities who use these areas.

(d) Coffee Prices and Forest Loss:

A further irregular driver of forest clearance is the periodic fall in coffee prices and the subsequent decision by farmers to convert coffee forest, already thinned in terms of tree density, into farmland. The most recent experience of this was in the early years of the 21st century. The impact of low coffee prices is exacerbated by the impact of a long and complex trading chain which means that the village price for coffee is often only some 30% to 45% of the international price. Conversely, forest thinning for coffee increases during times when the coffee prices are strong relative to other crops.

(e) Sawmills and Forest Access:

A major threat to the forests during the days of the Derg government was the felling of trees for lumber. While one or two sawmills remain in the Tepi and Metu-Yayu areas, there is little legal logging going on today, although small-scale pit sawing remains. The major aspect of large-scale logging has been the way in which it opens up areas of forest for spontaneous agricultural settlement. This settlement was held in check to some extent under the Derg by the Peasant Associations but once their power began to decline around the time of the change of government there was major agricultural expansion by local people into these logging affected areas. A prime example is around Gesha in Kefa zone in the headwaters of the Baro River.

It should be noted that there was sensitivity over logging under the military government with some local government administrations in the Masha area reportedly refusing to allow logging in what they felt were the forests which belonged to their people. Permits issued in Addis Ababa by central government were not seen as valid.

(f) Land Tenure and Land Registration:

The issue of land tenure over the last 30 years has received little investigation in the forest-fringe areas of the upper Baro-Akobo basin. Speculation suggests that insecurity of tenure, especially under the military regime, reduced farmers' investment in their land in terms of soil and water conservation and fertility enhancement and encouraged further forest clearance where that was allowed by the Peasant Associations. However, there is also evidence that the Peasant Associations were quite effective in controlling forest clearance for some of that period.

Where land tenure related issues have had an impact upon forest clearance is during the last two years (2004-2006) since the process of land registration has been publicized – but not implemented. Land registration rights will be given to individuals on the basis of the land they are using and so the rule has led to those with access to forest areas clearing it and undertaking minimal farming so that they can claim they are using this land. This seems to involve all elements of the community, rich and poor, as well as settlers.

Of particular concern is the fact that this process is coinciding with the flowering of the bamboo in the highest part of the upper sub-basin between Gecha and Masha. As the bamboo dies once it has flowered and regenerates from seed, this coincidence of biological and socio-economic events could see a major loss of bamboo forest.

7.5.4 Environmental Change and Deforestation in the Escarpment.

There are a number of different scenarios along the escarpment zone in terms of land use and environmental change. The driving forces of this change are generally associated with increased access to this area, population growth, and farming system or livelihood dynamics. Three different situations are discussed here.

(i) Majangir

(a) Trends:

The Majangir are shifting cultivators and gatherers who live in the middle section of the escarpment zone, where the terrain is steep and still mostly forested. They are known as the honey gatherers and the collection of wild honey has traditionally been a key element of their economy, along with the cultivation of sorghum on a shifting field basis. Outside contact has begun to affect these communities over the last 30 years and this has had a number of disruptive impacts which are leading to more permanent cultivation, soil erosion in their sorghum fields, and pressures with respect to access to forest for honey gathering. The latter is leading to political tensions.

(b) Driving Forces:

Land Alienation

The key driving force behind the pressure on the Majangir way of life is the failure of the regional government, and under the previous regime the central government, to recognize the rights of these people to the land they have traditionally used. This is a long-standing problem in many parts of Ethiopia which goes back to the time of the conquest and incorporation of the southern part of the country by Menelik in the late 19^{th} century, and has been documented in recent decades with the loss of key pastoral grazing areas to irrigated farms and other agricultural developments (Bondestam, 1973, Wood, 1982). The problems with the Magangir date back to the establishment of the Bebeka Coffee Estate in the 1980s, but has been made worse in recent years with plans for the expansion of coffee estates, the establishment of farm in the forests around these estates by immigrant workers, in complete ignorance of local uses of that land.

Population Growth

The other major factor is the introduction of improved health care for the Majangir through the activities of Christian NGOs (EECMY). This is reported to have led to an increase in the Majagir population, just at the time when they are loosing territory. The low level of education and modern skill development amongst these people means that they have no alternatives to their traditional way of life and hence the growing population is increasing the pressure on the natural resource base.

(ii) Beni-Shangul Gumuz:

(a) Trends:

There is a strong desire in this new region to progress develop as rapidly as possible. This is seen to involve the development of new types of agriculture and the establishment of permanent settlements. Both of these practices are likely to increase environmental degradation, especially soil erosion. The other trend in the area is the clear cutting of natural forest and bamboo for agricultural development and furniture making respectively. Neither practice is subject to effective EIA procedures.

Agricultural expansion is now starting to expand onto marginal and steep lands leading to accelerated soil erosion and to declining and more variable crop yields. Expanding cultivation is also taking place at the expense of lands under communal use rights on which important grazing and woody biomass resources are located, leading to changes in the supply of these resources.

Overall, there is evidence of negative environmental impacts growing in this part of the sub-basin in terms of vegetation loss and catchment degradation, increased run off and increased sediment loads. That being said the areas where these developments are occurring are at present quite limited in extent and regional or trans-boundary impacts of these developments are yet to become significant.

(b) Driving Forces:

Communications and In-Migration:

A key driving force for environmental change in this region is the improving communications to other parts of the country, notably to the neighbouring highlands, and the spontaneous in-migration from theses areas. Some of this movement is intra-regional migration, but some is inter-regional migration which is strictly banned in Ethiopia at present.

Investment Policy and EIA Procedures:

Following the passing of the Investment Proclamation, the past ten years has seen a rapid expansion in the area of land brought under cultivation for medium to large-scale agriculture in this state. This type of development requires the total clearing of woody vegetation including roots to enable mechanized cultivation. Access roads constructed for commercial agriculture also allow easier access for small-scale cultivators. Although investment licenses had been issued for the development of 131,983 ha by 2003 (WBISPP) it is not clear how much land has actually been cleared for cultivation. The key issue here is the complete lack of EIA procedures both before the allocation of land to investors and the absence of any impact monitoring of the use of this land. (WB CEA study).

Concentrated Settlement Policy and Population Growth:

Government policy to consolidate the settlements of the indigenous people is creating areas with increased erosion risks due to more intensive and contiguous use of land for farming and fuelwood collection. These are similar negative environmental impacts as occurred with the villagization policy in this country under the Derg government and as were seen in Tanzania under the Ujamaa policy. Population growth, through natural increase and in-migration is the major reason for the expansion of cultivation onto steep and marginal land where the risks of soil erosion are high.

Support for Highland Farming Systems:

Another driving force is the nature of the agricultural advice from the government Development Agents. This supports highland farming practices, and especially the introduction of *teff* and associated field drains, even though the crop and practices are not appropriate for the area and encourage erosion. The D.A.s are not trained to adjust their advice to different ecological conditions and are not taught how to analyze existing farming systems to identify their strengths and adjustments to the ecological conditions.

(iii) Mizan Teferi

(a) Trends:

In the southern part of the escarpment zone, in the broken highland to lowland transition zone around Mizan Teferi, there has been a change from forest fringe shifting cultivation to permanent cultivation over the last three decades. This has occurred for the most part in areas with steep slopes, often over 20%, with major erosion hazards. There is almost complete clearance of the trees in these areas with only a few remaining around homesteads. As yet there are few measures being adopted by farmers to conserve the soil and prevent erosion and no application of lessons from “steepland” farming in other parts of the world which could help improve sustainability and reduce erosion and sediment generation.

(b) Driving Forces:

Population growth:

The primary driving force for this change in the farming system is population growth, which is predominantly due to natural increase. However, there is probably some local migration occurring with the population concentrating in the more accessible areas to facilitate access to roads and services.

Agricultural extension:

The training of Development Agents has little of relevance to the farming and erosion issues faced in this area. The accepted view in Ethiopia is that land over 30% slopes should be taken out of cultivation and closures created to rehabilitate the natural vegetation. This would create massive starvation in this area and is not an option.

7.5.5 Natural Resources, Refugees and Development in the Lowlands

(i) Trends:

(a) Forest Loss:

Analysis by the WBISPP in the high forest areas of Dima, Godere, Gog, Akobo and Gambela weredas has estimated the rates of deforestation caused by expanding population (2.23% per annum) and its need for agricultural crop land. Annual destruction of the woody biomass from the high forest areas for agricultural expansion was estimated at about 4,287 ha per annum in 1995. This will increase exponentially and it is estimated that Gambela Regional State could lose 32% of its high forest resources between 1990 and 2020. Some 68 percent of the loss will occur in Godere and Dima weredas. These weredas are also exhibiting the fastest rate of decrease of forest.

Table 63. Predicted Areas of Forest & Forest Loss in Gambela Regional State, by Zone 1990-2020

ZONE	1990	2000	2010	2020	Loss 1990-2020	Loss % of 1990	Loss % of total
Itang	536	0	0	0	536	100 %	0%
Gambela	24,443	21,990	18,937	15,132	9,311	38%	6%
Abobo	142,460	135,795	127,501	117,160	25,300	18%	15%
Gog	45,039	40,286	34,373	27,000	18,038	40%	11%
Godere	152,511	135,687	114,752	88,652	63,859	42%	39%
Dima	165,415	152,586	136,624	116,723	48,692	29%	29%
TOTAL	**364,989**	**333,757**	**295,563**	**247,944**	**117,045**	**32%**	**100%**

It should be noted that the above analysis does not take into account forest that is cleared or seriously disturbed for coffee cultivation in the limited higher altitude areas of this state, nor does the rate of population increase take into account migration to forested areas by populations from outside the wereda.

The impact of forest loss is likely to be much less serious for soil erosion than in the escarpment zone due to the lower gradients. Nonetheless, there are serious biodiversity implications of the loss of this forest and the habitat it provides for wildlife.

(b) Woodland Destruction:

The main threats to the lowland woodlands come from clearing for large scale irrigated agriculture, state farms and resettlement schemes, fuel wood collection around the large refugees camps, fuelwood collection for the towns, and the burning activities associated with hunting by the Anuak and Majangir. The impact of these fires on tree mortality of both the lowland forest and the Combretum-Terminalia woodland is not known but must be positive.

(c) Wildlife Loss and Habitat Destruction:

Over the last three decades there has been a dramatic decline in the wildlife population in the Gambela salient, including in the national park. Elephants are now no longer seen in these lowlands and many of the antelope species have been reduced to the extent that sightings are quite rare. There are no specific details available on wildlife numbers in this area.

(d) Flooding:

A reported environmental change which may be getting increasing is the worsening of floods. It was reported in the early years of the 21st century that floods in the Gambela area had been the worst in living memory and had required the abandonment of villages which had been occupied for many generations. Conversely, the low season flow in the Baro has been so little that for the first time within living memory people can now cross the river in most dry seasons. Evidence for this is limited but the flow data for Gambella do show a tendency for more months to have high flows in the late 1990s compared to the 1970s, although the data is incomplete for some part of the last 30 years.

(e) Drivers:

Refugees:

There are three Refugee Camps: at Bonga, Phugnido and Dima with a total population of 50,000 inhabitants in 2000. This population has fluctuated considerably over the last thirty years and currently the camps are declining in size following the peace agreement for southern Sudan. The Camp at Bonga (12,500 inhabitants in 2000) is located some 20 kms east of Gambela town, and the refugees are clearing woodland for their own use, to obtain fuelwood to be sold in Gambela town, and for timber for their own use (house maintenance) and again for sale in Gambela town. Phugnido (25,500 inhabitants in 2000) is located some 20 kms west of Gog and here woodland is being cleared only for use by the Camp inhabitants as fuelwood and for house maintenance. Dima Camp (12,000 inhabitants) is just outside Dima town.

Analysis of supply and consumption at Bonga Camp reveals that:

- Consumption is two times the annual sustainable yield.
- Total stock will be depleted by the year 2010

The camp at Phugnido is located close within the Gambella National Park. Fuel and construction wood collection is resulting in destruction of this valuable forest resource also widespread destruction of the wildlife habitat.

Drivers Affecting Wildlife Habitat:

There are a diverse number of causes of the destruction of wildlife habitat. These include:

- destruction of high forests from the uncontrolled expansion of small-scale agriculture
- destruction of woodland and grassland through the development of large scale rainfed and irrigated agriculture
- destruction of woodland and forests through the collection of fuel and construction wood, particularly at the Phugnido refugee camp
- destruction of forest, woodland and grassland by the lighting of fires during hunting campaigns
- lack of human and logistical resources leading to lack of effective management and control within the Gambella National Park.

Land Use Change in the Highlands:

A further factor driving some environmental changes in the lower Baro-Akobo sub-basin is land use change in the highlands. Reduced forest cover and wetland loss have reduced the storage of rainfall in the highlands. This is probably the major factor leading to the more extreme river flow in the Gambela area, with higher floods and lower dry season flow.

7.5.6 Wetland Loss in the highlands

(i) Trends

Within the plateau area of the upper sub-basin there are many small permanent and semi-permanent wetlands, mostly occupied by *Cyperus latifolius*. These are mostly found in the upper reaches of the Sor, and Gabba rivers. These account for approximately 2% of the land area but they are becoming increasingly important as land pressures in the cleared area outside the forest increase.

Traditionally the wetlands have been avoided due to the presence of diseases such as typhus fever for humans and liverfluke for cattle. However, these areas have long been used as source of domestic water, from the springs which occur along their edges, and as sources of sedges (*Cyperus latifolius*) for thatching. Limited wetland edge cultivation of maize is known to have been practiced in the area going back to the mid 19th century (McCann, 1995)[78] but this expanded during the 20th century (Wood and Dixon, 2001)[79].

Table 64. Wetland uses and beneficiaries in Illubabor.

Uses	Estimate of Households Benefiting
Social /ceremonial use of sedges	100% (including urban dwellers)
Thatching sedges	85% (most rural households)
Temporary crop guarding huts of sedges	30%
Dry season grazing	most cattle owners, c 30 % of pop.
Water for stock	most cattle owners, c 30 % of pop.
Cultivation	25%
Domestic water from springs	50% - 100% (depending on the locality)
Craft materials(palm products & sedges)	5%
Medicinal plants	100% (mostly indirectly by purchase from collectors / traditional doctors)

Source: Wood and Dixon (2002)

In some areas, where upslope erosion has been particularly severe, as in the Ghimbi to Nejo area, wetlands have become the major source of food accounting for up to 70% of the grain produced by these communities (WA / WI study). More commonly this figure is around 10 to 20%, but the timing of these harvests, as the hungry season approaches, makes the wetland food particularly valuable.

[78] McCann, J (1995) "People of the Plough: An Agricultural History of Ethiopia, 1800 - 1990", Univ. Wisconsin press.
[79] Wood, A & A. Dixon (2001) "???

Figure 22. Baro-Akobo Sub-basin: Valley-bottom Swamp Converted to Agriculture.

In addition, to the drainage based cultivation of wetlands in the northern and eastern parts of the upper Baro-Akobo sub-basin, there is also long established cultivation of *taro* (*Colocasia esculenta*) in wetlands in Bench Maji Zone around Mizan Teferi, and in Sheka Zone around Tepi. Traditionally this does not usually involve any water management as this crop is tolerant of flooding. However, water management is occurring in some places farmers because farmers have realized that yields can be increased in this manner with flooded areas extended and water availability improved before and after the rains.

Management of wetlands for sustainable cultivation, when drainage is involved, is not easy and there has been extensive and, in some areas, complete, loss of wetlands in the southwest highlands of Ethiopia. (This is especially so beyond the Baro-Akobo upper sub-basin in parts of Jimma and in Eastern Wellega zones over the last 100 years of so, a phenomenon which can be easily observed from the air.)

Research within the upper sub-basin shows that wetlands frequently end up as rough grazing land, providing mostly wet season grazing as their vegetation has become dependent on rainfall. The main causes of this loss of wetlands include over-draining, especially due to down-cutting at the wetland outlet, acidification of the soil as a result of prolonged drainage (for double cropping) and associated oxidation of organic matter, coarse sediment deposition on wetlands from uplands, and soil compaction caused by uncontrolled cattle grazing (EWRP, 1999). The general neglect of wetland management in agricultural training has meant that despite there being an increased number of Development Agents in the villages these days (now three per *kebele*) they have little advice to offer farmers to ensure the sustainable use of these areas.

Table 65. Wetland benefits and beneficiaries

Benefits	Gender of Actors	Socio-Economic Status of Actors	Overall Beneficiaries	Wider Benefits
Water	Women	All, except rich	All	Health
Reeds	Men (& women for crafts)	Often poor, also middle income	All for roofing, especially women for mat making	Shelter, supplementary income
Fish	Men	All	All of fishing communities	Those who can afford the purchase of fish
Agriculture	Men	Mid-rich, non-aged	All through sales, also for household through domestic consumption	Domestic and wider food security
	Men	Poor share-cropping	Poor households	Food for survival
Medicinal	Men	Skilled	All, especially poor	Health
Grazing	Men	Richer and middle income. Poor as herders.	Households with cattle	Facilitates wealth accumulation, as well as ploughing for food production
Palm fronds	Men	Often poor	All, especially poor women	Supplementary income
Brick making	Men	Very rich	Rich and poor daily labourers	Contributes to shelter for rich
Sand extraction	Men	Poor and middle income	All through house construction	Income generation

Source: Wood and Dixon (2002)

The benefits of wetlands vary across the community as is shown in the Table 64. The impacts of the loss of wetlands or their transformation for farming are considerable and are also distributed in different ways across the communities. Women and the poor are especially seriously affected when wetland cultivation leads to the loss of safe spring water for domestic use and the loss of plant materials for craft and domestic use. Similar losses are linked to wetland degradation, but in addition the typically richer cultivators loose out.

(ii) Driving Forces for Upland Wetland Drainage Cultivation

(a) Food Shortages:

The major driving forces for wetland cultivation are seasonal food shortages caused by grain storage problems and the small areas of uplands cultivated due to guarding problems and shortages of plough oxen. Other constraints on upland farming have included the expansion of coffee land by landlords in the past. Hence a combination of environmental and socio-economic issues, as well as technical failings are driving wetland use.

(b) Market Opportunities

More recently and also more location specific, there has been a growing demand from urban areas for green maize, *teff* and vegetables which are grown in wetlands. Urban growth has been associated with the growth of the coffee-based economy and there has been some response by farmers close to urban centres to grow crops in response to these market opportunities.

(c) Land Tenure Change:

A key driving force which led to an expansion in wetland cultivation in the late 1970s was the land reform of 1975. This led to the equal redistribution of all types of farm land, including wetlands, but excluding forest land, amongst the households of each Peasant Association. In order to keep access to each type of land farmers had to show that they were using it and so wetland cultivation increased.

(d) Resettlement:

The resettlement after the 1984 famine also led to the increased use of wetlands in some areas of Illubabor where the integrated resettlement approach was used. Local communities asked to host resettlers allocated them land which was not in use or not of prime quality, and in some cases this included wetlands. Settlers were also encouraged to cultivate wetlands for an early maize harvest as they did not have root crops which help local farmers fill the hungry season food gap.

(e) Menschen fur Menschen (MFM) Eco Programme

In the mid / late1980s, the NGO MFM developed a programme, in Illubabor, which sought to reduce the pressure for forest clearance by developing rural livelihoods in the areas outside the forest. One element in this was wetland drainage for vegetable cultivation. Although this element of the programme was closed by the late 1990s, it showed communities some of the possibilities, as well as some of the problems, that could be encountered in wetlands and provided a stimulus to further wetland drainage.

(f) Wetland Task Force:

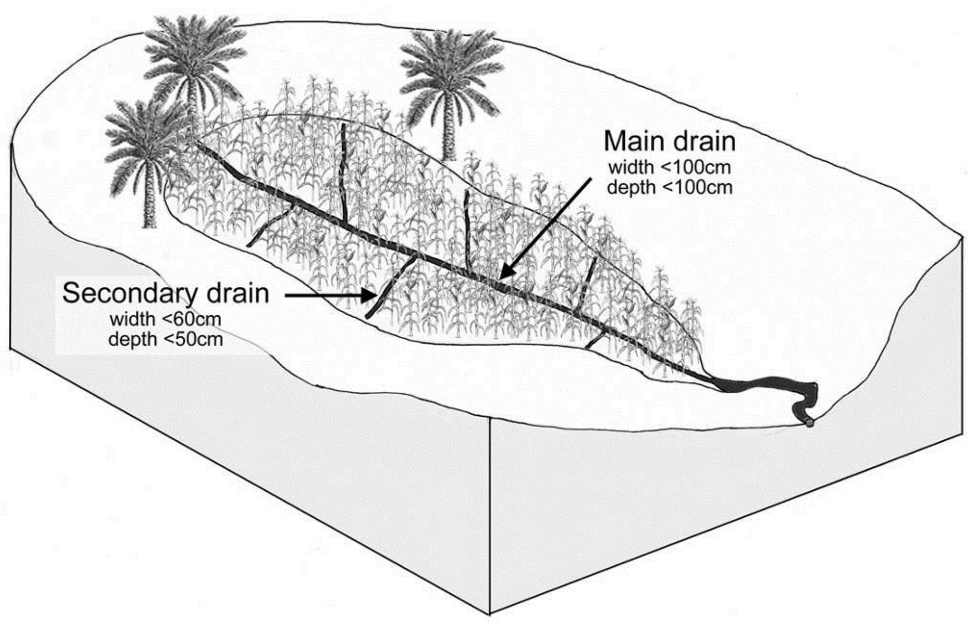
Since the present government has come to power, a key goal has been to reduce the country's dependence on foreign sources of food. Hence national food security has been a priority. This policy has linked to the approach of the previous military government which sought to encourage the use of valley bottoms across the country, mostly through micro-irrigation, but also drainage where there are swamps. Hence since the early 1990s there has been Wetland Task Forces in the south-west highlands, including parts of the upper Baro-Akobo sub-basin. In years when food shortages are severe in other parts of the country, the Task Forces set communities targets for additional wetland drainage and cultivation and regularly visit communities to ensure these are achieved. In some cases they are also requiring farmers to extend the drainage period and undertake double cropping in the wetlands.

(iii) Facilitating Factors:

(a) Technological Innovation:

In response to the need to cultivate wetlands in the early 20th century a system of dendritic drainage was developed and this spread widely in Wellega and Illubabor. This meant that instead of just the margins of swamps being drained by channels going into the central swamp, whole swamps could be drained for cultivation. In some cases this technology was followed by methods of channel blocking to reduce over-drainage, but this was not always the case.

Figure 23. Baro-Akobo Sub-basin: Valley-bottom Swamp Development



(b) New Crop Varieties:

Over the last 30 years there has been research undertaken in Ethiopia to develop short-season or early maturing varieties of crops. These have been sought to help the country overcome food insecurity caused by irregular rainfall and short growing seasons. One indirect impact of this has been to improve the success of wetland farming with short-season maize (from Kenya) maturing before the rain causes the valley bottoms to become waterlogged. Partly linked to this, but also due to the growing recognition of the importance of valley bottom wetlands for food production in Wellega, the Ethiopian Agricultural Research Organization (Bako Research Centre) has been undertaking research into wetland or *"bone"* cultivation methods in an attempt to improve yields.

7.5.7 Loss of Biodiversity: Gambela Regional Park

The Baro-Akobo Sub-basin contains only one of Ethiopia's 9 National/Regional Parks and three of the 17 Controlled Hunting Areas. The Gambella Regional Park is 5,061 km^2 in extent and is located between the Akobo and Ghilo rivers, east of the road between Gambella and Gog. The Park was proposed because of the numerous large wildlife species, particularly Nile Lechwe, White eared Kob and the Whale-headed Stork. The White Eared Kob migrates every year between the Sudd in Sudan and the Gambela Marshes. There are extensive areas of swamp habitat. Some 43 species of mammals and an IBA team recorded 230 species of birds[80]. A full list of species can be found in Hillman (1993)[81]. There are two near threatened bird species: the Shoebill (last recorded in 1961) and the Basra Reed Warbler (last recorded in 1976).

The Park is not legally gazetted. No Management plan has been prepared. There are no visitor facilities. The two vehicles and Park stores were destroyed during the government change over in 1991. The Park contains the Akobo large-scale farm and irrigation development is currently underway in the centre of the Park. There is a critical problem of illegal hunting with a large number of arms made available because of the Sudanese Civil War.

The Controlled Hunting Areas comprise:

Akobo CHA (5,049 km^2)
Jikawo CHA (3,375 km^2),
Tedo CHA (2,347 km^2)

[80] EWNHS/Bird Life International (1996) "Important Bird Areas of Ethiopia: A First Inventory", Addis Ababa.
[81] Hillman, J (1993) "A Wildlife Compendium of Ethiopia", EWCO, Addis Ababa.

7.5.8 Baro-Akobo Basin Studies and the Master Plan

(i) Background

There have been three investigations of the development potential in the Baro-Akobo sub-basin in the last three decades. The first in the later 1980s was a very detailed survey of the Gambela lowlands below 500m which involved almost eight years of study (EVDSA & Selkhozpromexport, 1990). The second, and more superficial study, was a Russian-lead study of the upper sub-basin with inputs from an Ethiopian team from EVDSA (EVDSA & ARDCO-GEOSERV, 1993). The third and most recent study, in the mid 1990s, was undertaken by a joint American and British team, TAMS/ULG (1997).

The first study particularly focused on the potential of the lowlands for state farm development, especially through irrigated agriculture (and associated resettlement of people from the drought prone highlands). The second study (currently unavailable) included discussion of the development of hydro-power in the highlands. The most recent study, which included a Master Plan for the basin, drew heavily on the two previous studies, especially for the Gambela lowlands but generated some data itself. This focuses on role of the sub-basin in contributing to the country's development priorities as specified in the mid 1990s under the ADLI policy, primarily food security.

(ii) Master Plan Proposals

One of the key objectives of the Master Plan is to increase food production in the highlands where rainfall is plentiful and health problems are minimal. Although not clearly explained in the Plan, this is to be achieved through the clearance of extensive areas of forest so that the area of cropland in the upper sub-basin can be increased from 610,000 ha to 1.4 million ha. One of the driving factors behind this was the view that the proportion of the sub-basin unable to support its population would increase from 15% to 60% in the period 1995 to 2020, with the bulk of this being in the upper sub-basin. In addition, it was seen that this area could produce food surpluses for use in other parts of the country as well as agricultural exports.

Table 66. Area in Each Population Support Capacity Mapping Unit, 1995 to 2015

Mapping Unit	Area (km²)	%
Critical (1995)	11,440.97	15.07
At capacity (1995)	85.59	0.11
At capacity within 10 years	17,535.92	23.10
At capacity within 25 years	16,240.01	21.39
No pressure	30,609.27	40.32

Total	75,911.76	99.99

Source: BARO – AKOBO Water Resources Master Plan.
GIS data from WBISPP, 1995

A second major proposal of the Master Plan is the development of six hydro electric power schemes in the upper sub-basin, using small and medium sized dams, to produce electricity both for domestic consumption and export through the developing national and international grid. The third element of the proposal is the development of three irrigation schemes in the lower sub-basin which would bring 100,000 ha of the potential 400,000 ha suitable for irrigation. Some of this irrigated land is envisaged to be under small-holder production but the majority is expected to be under commercial estates, although the balance between these production forms is seen to be subject to adjustment depending on the development priorities.

The land transformation proposals were based on the Soil Conservation Requirement Classification (SCRC) for the area, a type of land capability assessment. Taking agricultural production as the main goal this estimated that forest and woodland was the best land use for only 6,400 km² of the sub-basin, mostly for catchment protection, while a further 14,500 km² would be unsuitable for agricultural uses, due primarily to waterlogging. Of the remainder of the sub-basin, some 55,000 km², was planned to be developed for rainfed or irrigated agriculture.

Table 67. Area of SCRC Mapping Units in Baro-Akobo sub-basin

SCRC Class	Area (km²)	Recommended Land Use
I	2275	Annual crops/perennial
II e	19,259	Annual crops/perennial
III e	11,844	Annual crops/perennial
III w	9,705	Annual crops
IV e	2,619	Perennial/annual crops marginal
IV w	7,554	Non – agricultural
V w	4,823	Non – agricultural
V sh	2,084	Non – agricultural
VI s	3,351	Perennial crops/grazing
VI e	5,999	Perennial crops/grazing
VII e	2,683	Forestry
VIII ds	2,408	Catchment protection
VIII de	1,302	Catchment protection

Source: Master Plan, 1997. (SCRC: Soil Conservation Requirements Classification, FAO, 1984)

As a result of this assessment it was recommended in the Master Plan that 60% of the basin will be under annual and perennial crops, 13% under perennial crops and grazing, 5% under catchment protection, 3.6% under forestry and 19% non-agricultural land (Table 68).

Table 68. Summary of Recommended Land Uses

Recommended Land Use	Area (km²)	As % of Total
Annual crops/perennial	36,000/9,705	60.20
Perennial crops/grazing	9,350	13.32
Forestry	2,683	3.56
Catchment protection	3,710	4.86
Non-agricultural	14,465	19.06
Total	75,910	100.00

Source: Master Plan, 1997

Most of the highland sub-basin is regarded as suitable for rainfed agriculture and much of the eastern part of the lower sub-basin. Only very limited areas are regarded as suitable for forestry, these being mostly in the north-central part of the escarpment zone. There are throughout the escarpment zone areas which require catchment protection and a narrow band running east from Dembidollo across the upper sub-basin.

The proposed dams for hydropower are all in the highland portion of the basin with those for irrigation and the irrigation sites all in the lower sub-basin.

The approach of the Master Plan focuses on increasing fertilizer use in to highland agriculture to maintain crop yields, and the extensive use of inputs in the irrigation schemes in the lowlands. The idea of building on existing farming systems and practices seems to have been given little attention, except for the recognition that permanent crops such as *enset* and coffee do have a role to play in the upper sub-basin.

The expected impacts of the Master Plan's proposals upon rainfed agriculture in the highlands are shown in Table 69. This predicts a major expansion in cereal crops for on-farm use and domestic trade, as well as the development of cash crops such as oil seeds, pulses, cotton, rice and, unexpectedly, bananas.

Table 69. Impact on rainfed agricultural production of Master Plan Proposals

Crop	Without project (tons)	At full development (tons)	Incremental production (tons)
Maize	265,000	1,879,000	1,614,000
Coffee	26,000	184,000	158,000
Teff	90,000	379,000	289,000
Pulses	17,000	160,000	143,000
Oil Seeds	4,000	80,000	76,000
Cotton	6	363	357
Rice	700	19,000	18,300
Bananas	-	262,000	262,000
Sorghum	111,000	919,000	808,000

Fodder	100	25,000	24,900

Source: Master Plan, 1997.

According to the Master Plan it is possible to irrigate 330,000 ha with a series of five specific irrigation dams and diversion structures in the lowlands, and up to 400,000 ha if there is additional flow moderation higher up the system from hydro-power plants. The three schemes given priority in the Master Plan are as follows:

- Baro North (Right) Bank and Itang Dam - 54,000 ha
  - 32,000 ha small-scale farmers and 22,000 ha commercial
- Upper Alwero and Dumbong Dam - 15,000 ha
  - (8,000 ha small-scale farmers and 7,000 ha commercial
- Gilo Right Bank and Gilo 2 Dam - 47,000 ha
  - (26,000 ha small-scale farmers and 21,000 ha commercial

The plan for Hydro power production involves in the base scenario the following dams being constructed:

- Gumaro River, three small dams
- Baro River, two medium dams
- Geba A, one medium dam

In total the Master Plan calls for the following hydropower dams to be constructed which will lead to the production of some 1,075 MW.

Table 70. Hydropower Schemes proposed by the Master Plan, 1997

Hydropower Scheme	Installed Capacity
Geba A 1+2	183MW
Birbir A+B	508MW
Baro A1+2	259MW
Kashu	60 MW
Sor	65MW

The overall cost of the investment to for the base plan achieve these developments is in the order of US$ 2,542 million to US$ 5,255 million depending on the scenario followed.

Table 71. Summary of the costs of 6 Scenario (US$ millions)

Scenario	Immediate term (1996-2000)	Short term (2001-2015)	Medium term (2016-2035)	Total
I	191.25	767.20	1,583.93	2,542
II	13.47	276.32	303.04	+ 593
III	13.47	544.23	598.64	+ 1,156
IV	30.72	1778.82	338.54	+ 2,148
V	32.52	2044.73	636.14	+ 2,713
VI	32.52	2198.03	482.84	+ 2,713

Note: I = Base case, II = Base + Small hydropower and Small holder irrigation, III = Base + Small hydropower and commercial irrigation, IV = Base + Large hydro power and Small holder irrigation, V = Base + Large hydropower and Commercial irrigation, VI = Base + Maximum investment

The Master Plan's analysis of the hydrological situation suggests that the level of utilization of the water resources is only 18% (Table 72) and concludes that all the proposed irrigation, hydro-power and urban water supply schemes can go ahead. In reality much of the water use is not complete extraction as all of the hydro water and some of the irrigation water returns to the river system.

Table 72. Water Balance with implementation of Baro-Akobo Master Plan

Basin	Annual Water requirement (Mcm/Year)						
	Irrigation	hydro	Water Supply	Environ.	Total	MAR	Utilization %
Baro	742	281	85	1,023	3,131	12,784	17
Akobo Upper	0	20	2	142	164	1,774	10
Akobo Lower	0	0	2	169	171	2,118	9
Gilo	754	0	20	258	1,057	3,224	33
Alwero	215	0	18	110	343	1,375	24
Serkole	0	0	10	106	116	1,320	9
Tirmatid	0	0	3	33	36	419	8
Pibor	0	0	2	18	20	224	8
Total	**1,869**	**301**	**142**	**1,859**	**4,171**	**23,237**	**18**
%	**8**	**1.3**	**0.6**	**8**	**18**	**-**	**-**

Source: Master Plan, 1997

(iv) Watershed Management Issues

A number of watershed management issues are raised by the Master Plan proposals and these are discussed before considering other approaches to the sustainable utilization of the resource base in this region (Section 3.4).

a) Investment Costs

It is questionable whether the funds necessary for the implementation of this Master Plan can be obtained, and whether, with rising fertilizer costs, the rate of return on investment is still attractive. Another key concern with obtaining the funding for the expansion of highland agriculture is the growing international concerns about the loss of tropical forests. Recently the flooding of 5,000 ha of tropical forest in the sub-basin for a hydro power reservoir with potential electricity exports opportunities has been seen as too much for one international development agency to accept.

b) Forests

There are a number of issues raised about the degree of forest clearance proposed in the plan. In summary these are:

- Should two thirds of the forest be cleared given its biodiversity value and the absence of any protected area of this forest type in Ethiopia?

- Has the impact on river flows of removing nearly 1.2 million hectares of high forest been considered in the development of the Master Land Use Plan?

- Has the impact of removing 1.2 million ha of high forest been considered on their influence on air masses moving north east from this area and their associated rainfall?

c) Approach to Agriculture

The Master Plan emphasizes the use of fertilizer and other inputs for cereal focused agriculture in most of the upper sub-basin. A number of specific questions arise as to whether this is appropriate, including:

- Does this approach increased risks of indebtedness too much for small-scale farmers given harvest and price fluctuations?

- Will fertilizer use in this high rainfall area become ineffective due to soil acidity and leaching?

- Is it desirable to encourage the expansion of cereal cultivation, and especially teff, in the high rainfall areas, where roots crops and enset may be more environmentally suitable?

- What is the comparative advantage of this area for the national marketing and export of crop compared to other parts of the country – notably Arsi and South Shewa?

7.6 The Consequences of Soil and Vegetation Degradation

The consequences of soil and vegetation degradation can be generally categorized into environmental, economic and social. They can be located on-site and off-site and occur at various scales: field, sub-catchment, catchment, basin, region and country.

The previous sections have focused on the environmental consequences. The following analysis will focus on socio-economic impacts, both on-site and off-site and be aggregated to the Basin scale.

7.6.1 Soil Degradation:

(i) On-site Consequences

On-site consequences of soil erosion are reductions in agricultural productivity. Productivity is reduced because of nutrient and organic matter losses and reduced water holding capacity caused by reduced soil depth.

The impact of reduced water holding capacity caused by soil erosion was estimated using the method used by the National Conservation Strategy of Ethiopia (NCS)[82]. This relates declines in soil productivity to declines in the soil's water holding capacity using the soil life model of Stocking and Pain (1983)[83] as the framework. Using a model developed by FAO[84], the Water Requirements Satisfaction Index, the relationships were established between declining soil moisture capacity and crop yield, the minimum required soil depth for cultivation and the maximum depth beyond which there is no impact on crop and pasture yield. This method allows the calculation of different yield losses for different

[82] Sutcliffe, J.P. (1993) "Economic assessment of land degradation in the Ethiopia Highlands: a case study", NCS Secretariat, MoPED, TGE, Addis Ababa.
[83] Stocking, M.A. & A. Pain (1983) "Soil Life and the Minimum Soil Depth for productive Yields: Developing a New Concept", Discussion paper No. 150, Univ. of East Anglia, November 1983.
[84] FAO (1986) "Early Agro-Meteorological Crop Yield Assessment", FAO, Rome.

erosion rates. The areas of cropland under different soil erosion rates were obtained by overlaying the wereda map with the soil erosion map in the GIS. Yield reductions caused by different rates of soil loss are shown in table 73.

Table 73. Grain yield reductions due to loss of soil due to soil erosion and thus reduction in soil water holding capacity

Soil loss t/ha/yr	Soil loss mm/yr	Yield decline %
12.5	1	**0.02%**
25	2	**0.04%**
50	4	**0.08%**
100	8	**1.6%**

In the absence of remedial measures, crop losses from soil erosion accumulate until such time the soil profile is reduced to a depth where no production is possible. The total annual crop production lost due to soil for the Tekezi and the Abay basins are shown in Table 66, together with accumulated losses for 5, 10 and 25 years.

Table 74. Annual and Cumulative losses of crop production due to soil erosion (tons)

BASIN	ANNUAL LOSS T/YR	5 YRS (tons)	10 YRS (tons)	25 YRS (tons)
Abay	25,190	125,950	251,905	**629,760**
Tekezi	1,785	8,927	17,854	**44,635**
Baro-Akobo	2,591	12,957	25,914	64,875
Total	**29,566**	**147,834**	**295,673**	**739,270**

The current annual crop grain production for the Tekezi, Abay and Baro-Akobo Basins is 1.06 million tons, 4.35 million tons and 0.514 million respectively. The annual loss due to soil erosion as a proportion of total production is 0.17 percent in the Tekezi Basin, 0.6 percent in the Abay Basin and 0.5 percent in the Baro-Akobo Basin. However, after 10 years these rise to 2 percent, 6 percent and 5 percent, and after 25 years to 4 percent, 15 percent and 13 percent of total production respectively.

To assessing the impact of net nutrient losses from the burning dung and residues, grain removal and erosion, a crop:nutrient increment ratio for N of 6 (1kg of N produces an incremental yield of 6kgs of grain) is used to estimate crop production forgone[85]. The estimated net nutrient loss per annum for the Tekezi, Abay and Baro-Akobo Sub-basins and the crop production forgone are indicated in table 75.

[85] NFIU (1988) Results of the 1986-887 Factorial Fertilizer Trials. NFIU Working Paper 29, ADD/MoA, Addis Ababa.

Table 75. Estimated net Soil N losses (from burning dung ad residues, grain removal and erosion) and grain production foregone (tons/annum)

BASIN	Nutrient N (tons)	Grain Foregone (tons)
Tekezi	1,480	**8,880**
Abay	49,000	**294,000**
Baro-Akobo	17,720	**204,396**
Total		**507,276**

The production foregone represents 1 percent, 7 percent and 13 percent of total grain production for the Tekezi and the Abay Basin respectively. The lost N represents 3,220 tons, 106,520 tons and 38,762 tons of urea for the Tekezi, Abay and Baro-Akobo Sub-basins respectively.

(ii) Off-site Consequences

The most important off-site negative consequences of soil erosion are sedimentation of streams and water storage infrastructures. High sediment loads in streams pollute water supplies, and cause siltation of dams, reservoirs, water-harvesting structures and irrigation canals, reducing their effective capacities, shortening their service lives, and incurring high maintenance cost, at national, community and individual levels.

In Tigray in the Tekezi Basin a recent survey of 54 recently built small dams found that 70 percent had significant siltation problems (in addition to problems of seepage and insufficient water supply)[86].

In Gondar in the Angereb Watershed in the Abay basin a reservoir for the town water supply of Gondar town was constructed in 1986. Annual sediment yield in the catchment is 1,200 tons/km2. It is estimate that by 2010 the reservoir capacity will only be 50 percent and water shortages can be expected thereafter[87]. Sisay Asres (2005)[88] reported that of the 7 dams built by

[86]Nigussie Haregeweyn, Poesen, J., Nyssen, J., De Wit, J., Mitiku Haile, Govers, G., Deckers, J., Reservoirs in Tigray: characteristics and sediment deposition problems. Land Degradation and Development, in press.

[87] Ahmed Musa Siyam et al (2005) Assessment of the current state of the Nile basin Reservoir sedimentation problems. Reservoir Sedimentation (Group 1), River Engineering Research Cluster of NBCBN-RE.

[88] Sisay Asres (2005) Watershed planning and implementation in relation to controlling sediment through soil and water conservation measures; the experience of CO-SAERAR

COSAERAR in Amhara Region in the Abay Basin five are seriously affected by siltation,

Sediment originating from Ethiopia in both the Tekezi and Abay basins impacts on water infrastructures outside Ethiopia. In particular the siltation is a problem in the reservoirs behind the Kashm el Girba dam on the Atbara, and the Roseire and Sennar dams in Sudan, and the Aswan high dam in Egypt and Sudan. Siltation in the irrigation canal systems of the Gezira and Managil schemes from sediment in the Blue Nile is also a considerable problem, involving expensive dredging. The high seasonal suspended sediment load in the Blue Nile necessitates special flushing and release regimes in the Sennar, Roseire and Kashm el Girba (and the future Meroe) dams with negative impacts on hydro power generation and irrigation scheduling.

7.6.2 Consequences of Degradation of Vegetation

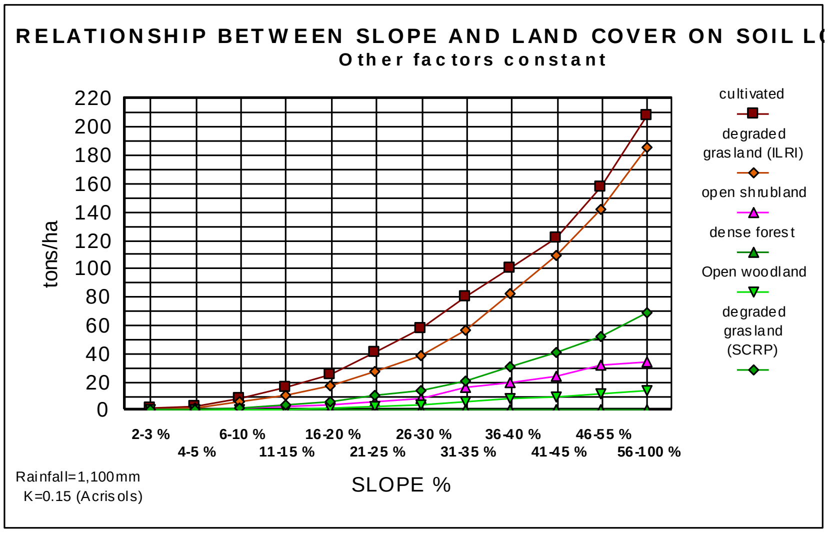
(i) On Erosion and Sedimentation

Clearing shrubland, woodland or forest for agriculture immediately increases the potential soil erosion hazard. In figure 24 rainfall and soil type are kept constant, and slope and land cover allowed to vary. It is clear that the biggest soil loss rates for the same slope are experienced on cropland. A landcover factor for "degraded grassland" was derived from field experiments conducted by ILRI at their Ginchi (East Wellega) site[89]. This is considerably higher than that determined by the Soil Conservation Research Project (SCRP).

There is a close resemblance between soil loss rates on cultivated land and those on degraded and overgrazed grassland as determined by ILRI, confirming the oft-stated observation of the negative impact of overgrazing on soil loss rates. The difference between soil loss rates on cultivated and overgrazed grassland (ILRI) and open shrubland and open woodland is very significant indicating the very positive impacts even open shrubland can have on soil loss rates.

[89] Girma Tadesse & D. Peden (2003) "Livestock Grazing Impact on Vegetation, Soil and Hydrology in a Tropical Highland Watershed.", In: "Integrated Water and Land Management Research and Capacity Building Priorities for Ethiopia". Proc. of a MoWR/EARO/IWMI/ILRI International Workshop held at ILRI, Addis Ababa 2-4[TH] Dec. 2002. ILRI, Addis Ababa.

Figure 24. Soil loss rates on different slopes by land cover types holding



Area closures and controlled grazing schemes even in relatively dry areas can increase both woody and herbaceous ground cover. The substantial impacts that they can have on reducing soil erosion can be seen in figure 25. The positive impact increases exponentially with increasing slope. On a 36 to 40 percent slope soil erosion can be reduced from 80 tons to 30 tons per hectare with no shrubs/trees and 20 tons per hectare with shrubs and trees.

Research in Tigray on closed areas found they achieved trapping efficiencies approaching 100 percent. Closed areas were trapping sediment per unit area 3 to 4 times the rate of erosion[90]. In most cases it was vegetation that controlled the rate of sedimentation rather than slope. The researchers considered that strips of vegetation closures 50-60 m wide would be sufficient to protect water reservoirs and dams. Additional benefits include soil enrichment and increased infiltration of water.

(ii) Consequences of Vegetation Clearing and Degradation on Water Yield

The key impact of reducing vegetation cover is to increase runoff and reduce evapotranspiration[91]. Evapotranspiration rates of forests and woodlands exceed those of grass and crops by a considerable margin. Generally flood peaks increase and dry season flows decrease as does groundwater recharge.

World-wide estimates a 10 to 25 mm increase in run-off for every 10 percent reduction in cover from woodland or shrubland to grass or crops. There are two aspects related to this. The first is due to increased overland flow as a result of

[90] Descheemaeker, K et al (2005) "Sediment deposition and pedogenesis in enclosures in the Tigray Highlands, Ethiopia", Geoderma, accepted 27 April, 2005.
[91] Calder, I.R. (1993) "Hydrologic effects of Land Use Change", ch 13 in Ed. Maidment, D.R. "Handbook of Hydrology", McGraw-Hill.

decreased ground cover. The second is due to a reduction in rainfall interception and its evaporation by the tree crowns, which can be very high, and also by a reduction in evapotranspiration by deep rooting trees. Increased overland flow generally results in less groundwater recharge, a lowering of water tables and a reduction in dry season flows and an increase in flood peaks.

It is now generally recognized that forest cover in the Tekezi and the northern Abay Sub-basins was largely removed by at least the end of the 19th century. Forest cover in the southern Abay Sub-basin may have been removed within the 20th century. Thus the long-term flow records of the Abay (at Khartoum) and the main Nile do not indicate any long-term increase in flows with annual and cyclic changes in rainfall apparently masking any long-term changes in run-off. However, more rigorous statistical analysis may yet reveal such long-term changes.

Forest cover over the Baro-Akobo basin may have seen a gradual clearance during the 18th and 19th centuries, a period of re-afforestation at the end of the 19th and the beginning of the 20th centuries, and a subsequent clearing of the forest from 1930's onwards[92]. The Ethiopian Wetlands Research programme (EWRP) found buried cultivation layers in valley swamps around Metu indicating forest clearance, swamp cultivation and reforestation[93]. The same project found evidence of large soil conservation terraces now overgrown with high forest trees indicating that the area was under cultivation in the 19th century or earlier and has since reverted to forest. Chaffey (1976)[94] found evidence of forest disturbance in the past throughout the southwest forests.

The 1928 – 1960 flow data for the Baro at Gambella (figure 7.1 in Sutcliffe and Parks) shows no indication of increasing nor does the data for the Sobat at Doleib Hill (figure 7.4 in Sutcliffe and Parks) for the years 1905 to 1983. The low flows for 1975 – 1983 do show up in the Sobat data indicating that cyclic changes in rainfall are likely to mask any long-term changes in runoff for the foreseeable future at the Sub-basin scale.

This is not to say that locally, catchments and sub-catchments within the Sub-basin may exhibit such changes in long-term runoff. Research reviewed by Calder (2005)[95] on the impact of deforestation of the incidence of flooding indicates that whilst such impacts can be seen at the small catchment/sub-catchment level, such impacts are not discernable at the larger sub-basin scale.

[92] McCann, J (1995) "People of the Plough: An Agricultural History in Ethiopia 1800 - 1990", Univ. of Wisconsin press.
[93] Belay Tegene & C.Hunt (2000) "The Characteristics and Management of wetland Soils of Metu wereda, Illubabor Zone of Oromiya region", EWRP, Addis Ababa.
[94] Chaffey D.R. (1982) "Southwest Ethiopia Forest Inventory project: Reconnaissance Inventory of the Forests of Southwest Ethiopia", Report No. 31, LRD, Surbiton.
[95] Calder, I.R. (2005) "Blue Revolution: Integrated land and Water Resource Management", Earthscan.

8. IDENTIFICATION OF WATERSHED MANAGEMENT INTERVENTIONS

8.1 Review of Current Interventions

8.1.1 Overview of current watershed management interventions

Watershed management for medium to large watersheds and sub-basins is a new activity currently being launched by MoWR. The ENSAP fast track watershed management projects are a first step towards implementation at this level.

In a study carried out for MoWR[96], a number of watersheds in the Eastern Nile Basin in Ethiopia were studied and three sub-basins have been selected for fast track watershed management. A single watershed in each target area was been earmarked for implementation, and TOR were prepared for the project design phase. More recently, the watersheds that were recommended have been changed to locate all three watersheds in Lake Tana sub-basin. Tender procedures have started for a project covering the Ribb, Gumera and Jama watersheds. This decision was taken within the context of government's renewed focus on the "Tana-Beles development corridor", an area where federal as well as regional integrated development efforts are to be concentrated. Development will include hydropower development (at the inter-basin water transfer tunnel, now under construction, replacing the current plant at the Tissit Falls), large-scale irrigation and related infrastructural development in the Beles area, and agro-industrial development around the town of Bahir Dar.

The first objective of this watershed management project will be watershed protection so as to reduce sediment transport into Lake Tana, with integrated development in these watersheds as a second objective.

Productive Safety Net Programme (PSNP):[97] The objects of the PSNP are to provide transfers to the food insecure population in chronically food insecure weredas so as to prevent asset depletion at the household level and create assets at the community level. Through the programme block grants are provided to weredas for a range of activities including (i) resettlement, (ii) water harvesting, (iii) irrigation, (iv) feeder roads, and (v) agricultural packages. The programme is complementary and has linkages to other programmes including the Food Security programme, Emergency Drought Recovery programme, Integrated Food

[96] Geoffrey J. King and Leul Kahsay Gezehegn: Watershed Management Consultancy 1 - Prioritization of Fast Track projects. Final Report, for ENSAP – ENTRO, 2005.

[97] GFDRE (2004) "Productive Safety Net programme: Programme Implementation Manual", August 2004.

Security projects. In 2005 1.6 billion EBirr was transferred to Regions and in 2006 a further 2.6 billion EBirr has been allocated.

Watershed protection for some of the small dams has been undertaken by MoARD, and in Tigray also by REST. "Watershed management" must be seen here as straight-forward watershed protection without provisions for future management or maintenance or utilization of resources created.

A considerable number of small dams have been constructed for irrigation development during the previous decade by MoWR, and by COSAERAR in Amhara region and COSAERT and REST in Tigray. In Tigray alone, 54 dams have been constructed. In Amhara Region, COSAERAR constructed 59 irrigation schemes, 9 of which with a small dam (4 in Tekeze basin, 3 in Abay, 2 in Awash), the others being fed by diversion structures (Sisay Asres, 2005).

Small dam construction has faced considerable problems of various kinds, both technical and organizational: low construction standards, no sediment monitoring, lack of coordination with MoARD resulting in delay or lack of catchment protection, severe siltation problems, lack of follow up by MoARD in irrigation management and extension, single-event watershed protection instead of long-term watershed management provisions.

Sisay Asres (2005)[98] reported that of the 7 dams built by COSAERAR in Amhara Region,

- all dams are functioning but none according to the design and five are seriously affected by siltation,
- a watershed plan was developed for each dam but implemented only in two cases.

Irrigation planning, dam site selection, implementation and watershed protection (if undertaken) have all followed a top down approach, with obvious consequences. Land users in the catchment and in downstream areas have no sense of project ownership and have no commitment to maintenance of watershed protection measures. Cases are also observed where the local population was strongly against construction of a dam[99].

In Tigray, as a result of these problems, and because of a shift in government focus to micro-irrigation, construction of small dams (i.e. dams for irrigation purposes, with a storage capacity of 0.5-3 million m3, equipped with a spillway)

[98] Sisay Asres (2005) Watershed planning and implementation in relation to controlling sediment through soil and water conservation measures; the experience of CO-SAERAR

[99] Mulder, 2002, Assessment and Monitoring of Sedimentation and Erosion Problems in Ethiopia, Final Project Evaluation.

stopped in 2001. Construction of ponds (up to 0.5 million m3, for water supply or micro-irrigation, without a spillway) has continued although facing similar problems.

COSAERAR and COSAERT have been dismantled and responsibility for medium scale irrigation development remains solely with MoWR. The focus of REST activities is now on local level water supply, water-harvesting, micro-watershed development and other fields of rural development.

According to the BoWR & Mines in Tigray, around 30 small dams out of the constructed 54, are still functional, partly with help of the IFAD–financed, federally based, Small-Scale Irrigation Support Project.

In Tigray, the irrigation department has plans to restart construction of small dams. It has identified 5 new dams, for two of which feasibility studies are ongoing and construction is scheduled for next year. Improved harmonization with MoARD, through joint participation in Cabinet discussions, are designed to ensure better sustainability of the projects.

In Tigray Region, Chinese experts, under the FAO Special Programme for Food Security (SPFS) South-South Cooperation (SSC) initiative, have carried out two **watershed studies** to design level:

- Hadnet watershed, in Wukro, Atsbi Wemberta and Enderta Weredas;
- Adikesandid watershed, in Atsbi-Wonberta and Kilte-Awlaelo Weredas.

Another watershed, in the Tserare sub-basin, has also been studied by a Chinese consulting firm. It is understood that there are similar project designs elsewhere.

From the study reports, it appears that these studies are essentially technical and directional (top-down), with little or any participation of the concerned communities (although socio-economic studies were conducted). While it is assumed that the basic data are good, the designs do not appear to be implementable in their current form; they would need complete re-design based on the participation of the concerned communities. The target areas, although small, both cross Wereda boundaries, which is likely to complicate implementation.

Koga Irrigation and Watershed Management Project*:* The Koga watershed is in the Lake Tana sub-basin, Gilgel Abbay watershed. This ADB-supported project involves a dam (21.5m high, 1860 m length, 83.1 M m^3 volume), a reservoir (submerging 1,859 ha of grazing), irrigation (7,200 ha command area), and watershed management. Construction of the dam is currently underway and a watershed management plan has been prepared.

The **Environmental Support Project** (ESP - Netherlands funding, 2000-2002) prepared a reconnaissance land use plan (1:250,000 scale) for North Wollo zone and semi-detailed plans (at 1:50,000 scale) for Bugna Wereda, situated in the upper Tekeze basin in Amhara Region. The overall project purpose was improved decision making on natural resources management; capacity building was central to the project. The Wereda (Bugna) land use plan focuses on opportunities for agricultural development and improved natural resource management within the present socio-economic context and taking into account the projected population growth for the foreseeable future. Land use planning guidelines were also prepared as well as a detailed project proposal for Community-Based Natural Resource Management. The latter has not been implemented.

Small-scale **watershed development in micro-catchments** is practiced by the Regional bureaus and wereda offices of agriculture, with support from several donors, the main ones being the WFP supported MERET (Managing Environmental Rehabilitation in Transition to Sustainable Livelihoods) project and the GTZ/KFW supported SUN (Sustainable utilization of natural resources) project. This component is discussed in more detail in the following section.

8.1.2 Local Level Watershed Management

(i) Historical overview

In Ethiopia a major review of past watershed management activities started following the fall of the Derg and the formation of the Transitional Government of Ethiopia in 1991, although some evaluations had started before. A number of studies have evaluated the pre 1991 watershed management activities in particular the "narrative" or "discourse" that shaped the very large soil and water conservation programme that was implemented during this time[100] [101]. Other studies have focussed on more technical aspects of the conservation structures[102]. An overall assessment has been provided by Alemneh Dejene (2003)[103] and may be summarized as follows:

[100] A. Hoben "Paradigms and Politics: The Cultural Construction of Environmental Policy in Ethiopia", World Development Vol. 23, No. 6 pp1007-1021.

[101] Dessalegne Rahmato (2003) "Littering the Landscape: Environmental Policy in Northeast Ethiopia", in "African Savannas: Global Narratives & Local Knowledge of Environmental Change", Eds. T.J.Bassett & D. Crummey, James Currey, Oxford.

[102] K. Herweg (1992) "Problems of acceptance and adaptation of soil conservation in Ethiopia", paper at 7th Int. Soil Cons. Conf., 27-30 September, 1992, Sydney.

[103] Alemneh Dejene (2003) "Integrated natural Resources management to enhance Food security: The Case for Community-Based Approaches in Ethiopia", Environment and natural Resources Working paper No. 16, FAO, Rome.

- In many areas there were substantial benefits with improved soil conservation, planting of woodlots and improved pastureland.
- Many structures were costly in terms of land taken out of production, labour inputs for physical structures were very high, and there was little attempt to incorporate indigenous soil and water conservation techniques. In some areas structures were technically inappropriate and caused water logging.
- The programme focussed narrowly on arresting soil erosion without considering the underlying causes of low soil productivity, the socio-economic factors and the need for immediate tangible benefits to be attractive to poor farmers.
- The programme adopted a very "top-down" approach in its planning and implementation. There was little or no consultation with farmers or communities on felt needs. Woodlots were implemented with no harvesting plans.
- Although a "watershed" approach was adopted the basin size was too large to acquire an understanding of the socio-economics of land degradation and farmers willingness to invest in improved land management.

The result was that many structures and woodlots were destroyed following the change in government.

Since 1993 watershed management activities in Ethiopia have undergone a radical change in approach. Alemayehu Tafesse (2005)[104] provides an overview and assessment. The major programme is the MERET (Managing Environmental Resources to Enable Transitions to More Sustainable Livelihoods") Project, which is a successor to the previous large scale Soil and Water Conservation Project (ETH-2488, Phase I, II, III, IV) that ran from 1982 to 2002. An assessment of this Project is provided by Gete Zeleke (2005)[105].

The most important change has been from a highly centralized to a decentralized approach. The new approach uses local level participatory planning as its main tool. The community is in control of decisions regarding development options to implement. The focus is on resource conservation as well as productivity enhancement.

[104] Alemayehu Tafesse (2005) op. cite. (f.n. 41)
[105] Gete Zeleke (2005) "An Example of Integrated Watershed management Experience in Ethiopia: The Case of the MERET Project", paper presented to Regional Workshop on Watershed Management CRA, 5-7th December, 2005, Barhir Dar.

The basic unit for planning is a micro-watersheds (200-500 ha) at the Kebele level. However, although watershed logic is followed it respects community boundaries. Food for work is used for community motivation. Self-help is increasingly encouraged, however with limited results. Quality control and maintenance of good standards are seen as very important, but in reality are facing serious constraints that threaten sustainability. An appropriate and effective system of monitoring and evaluation should ensure timely and useful feed back to the overall programme.

(ii) Ongoing activities in local level watershed management

Watershed activities have long been centred on soil and water conservation (SWC) activities. More recently, a stronger link has been established with water harvesting, tree plantation and horticultural crop diversification.

Activities are always coordinated through the agricultural bureaus, implemented with help of the population and with donor support in various forms (budget support, financial support linked with technical support, food-aid) and from various parties. Contributions of the population are in the form of manual labour and are compensated in cash or in kind (food rations). Part of the work is still done on a voluntary basis, i.e. unpaid but in mass mobilization campaigns (20 days per year per able person).

The MoARD has designed and launched a **Community Based Participatory Watershed Development** Approach (CBPWD), intended to spearhead the process of rural transformation and the generation of multiple and mutually reinforcing assets. It is now general policy that interventions in soil conservation, water harvesting, afforestation and land rehabilitation should follow a watershed approach.

Local level watershed activities are carried out in all regions, and, in terms of areas covered, are most advanced in Tigray. The Tigray Region claims that some 560 micro-catchments have been treated, mostly with MERET/WFP support.

The Amhara Region, following the MoWR directive at federal level, has endorsed watershed based rural development as its strategy to address the issue of food security[106] and it is declared policy that all resource development projects should be "watershed based". There are four demonstration micro-catchments currently being implemented directly through the BoARD. Additional watershed projects are being implemented by agencies working with/through the BoARD – 4 watersheds by the Organisation for Rehabilitation and Development in Amhara NGO (ORDA), 3 by USAID, and 192 watersheds in 23 weredas by the MERET

[106] BoARD, Round table discussion on watershed management in Amhara Region, 2006

project. GTZ has been active on an unknown number of sites in 4 weredas in South Gondar (in the former IFSP project). SIDA is also strongly active in watershed management. Using lessons learned from the model watersheds, every Wereda BoARD is facilitating the preparation of watershed development plans by each Wereda Development Centre in collaboration with the respective communities.

The Oromiya Region also has a commitment to watershed management, and is receiving support from the GTZ SUN programme.

The principal actor in watershed management is the WFP supported **MERET project** within the Ministry of Agriculture and Rural development (MoARD). This project, started in 2002, follows on from previous projects supported by the WFP (Land Rehabilitation Project, Project ETH 2488). The project is concerned at farm level with conservation, intensification, expansion of cultivated land, and diversification of income opportunities (WFP, 2005)[107]. The Local Level Participatory Planning Approach (LLPPA) developed within this project has gained national acceptance and ownership. The Guidelines on Community Based Participatory Watershed Development (CBPWD) are commonly used, directly or in some modified version. Vast areas have been 'treated' under this programme, usually supported by food-for-work. The area focus has been food insecure (and generally moisture deficit) Weredas; activities have been largely limited to soil and water conservation measures and area closures. The performance of the biological conservation measures (primarily forestry plantations) has generally not been satisfactory. In total, some 600 micro-watersheds in 74 vulnerable Weredas have been supported (WFP, 2005). In Tigray, MERET is active in 17 out of the 31 food deficit weredas. In Amhara, 23 food deficit weredas are supported. MERET is partly financed by other donors (USAID, CIDA).

MERET has recently undertaken a cost-benefit analysis of its interventions (WFP. 2005). In the absence of baseline data, reliance was made on farmer perceptions of change, as assessed in 66 sample catchments in eleven Weredas, and theoretical calculations (e.g. application of the USLE). Both financial (farmer) and economic (impacts on the national economy) analyses were undertaken, with a 25 year time horizon. The aggregate Economic Rate of Return (ERR) was assessed at 13.5% over 25 years, indicating economic viability (assuming a 10% discount rate), without accounting for downstream benefits and intangibles. This was largely attributed to the moisture effect of SWC. Forestry was found to be unprofitable (although that might change as forests mature and become marketable). Financial analysis (farmer level) offered higher Internal Rates of Return (IRR) between 9.5% and 19.3%, again economic (assuming a 12% discount rate), with higher returns in the drier sites.

[107] World Food Programme (2005) 2003-2006 Ethiopia Country Programme. Mid-Term Evaluation

The study reported that “There are serious constraints that inhibit farmers from adopting conservation measures even though it may be in their interest to do so. A major (market) imperfection and ultimate constraint on widespread adoption is food insecurity, limited market access and possibly uncertainty of land tenure.”

A number of other donors are known to be active, or to have been active, in projects involving watershed management. These include GTZ, SIDA, USAID, and CIDA (water harvesting). Writing in year 2000, ARD-RAISE claimed that donor support to Amhara alone amounted to ETB 750 million – almost US$100 million. Although this covered support to all sectors, “the predominant themes related to food security, improved agricultural productivity and rural development in general.”

GTZ is involved in watershed management in four Weredas in Amhara, 23 watersheds in 20 Weredas in the centre and east of Tigray, and on 15 Kebeles in 6 Weredas in Oromiya. Working with the Tigray BoARD and the Food Security Coordination Office, the objective is to provide short term benefit to farmers in terms of food production, forage, or cash income. Broadly, three land types are recognised (i) gullies (check dams, reshaping, forage production; but subsequent issue of ownership), (ii) hillsides (closures, trench bunds, micro-basins, for food and tree production), and (iii) farmland (terraces, with bunds planted, and use of vetiver grass as a stabiliser, recession farming around micro-dams, small-scale irrigation). Labour is mostly paid (free labour was noted as difficult except where access to water is concerned). The cost per micro-watershed over the 2 to 3 year implementation period was estimated to be about 1 million birr (US$115,500).

In the Oromiya Region, the Land Use Planning and Natural Resources Management Project (previously known under Land Use Planning for Oromiya – LUPO) was implemented from 1997 to 2006, with a total budget of 6.8 million Euros. The project addresses participatory land use planning, capacity building, and strategy and policy in land use planning and natural resources management. Field activities include soil and water conservation (erosion control, check dams, vetiver grass), increased agricultural productivity (diversification, drought resistant species, off-farm activities, small scale credit), and improved rural living conditions (springs, afforestation, energy saving stoves).

In Amhara Region, the previous South Gondar - Integrated Food Security Project was one of the first projects putting an explicit emphasis on biological SWC measures, including gully stabilization (integration with mechanical measures) and Vetiver hedges on fields. The project further had success with the (re)introduction of Triticale, a highly productive grain species well suited for South Gondar conditions, and production of an improved version of the traditional Maresha plough.

GTZ has put all their former NRM/food security related projects under one SUN umbrella (Sustainable Utilization of Natural resources) and a SUN project coordination office exists now in ANRS (Debre Tabor – the previous South Gondar Food Security project), in ORNS (Addis Ababa based – the previous Land Use Planning in Oromiya project) and TNRS (Mekele – the previous social forestry project). SUN has four main fields of activities:

- technology innovation,
- planning (support to development of approaches, participatory land use planning and forest management),
- capacity building at all levels,
- support to policy development related to NRM and food security.

The **Canadian International Development Agency (CIDA)** is supporting capacity building in water harvesting and management in Tigray and Amhara.

In Tigray, the Water Harvesting and Institutional Strengthening (WHIST) project started in 2000 and will continue to 2007. Although a capacity building project, it has provided technical support in various water harvesting actions within Tigray. It has established research into the impact of watershed management on ground water/aquifer recharge. It is also proposing to provide high resolution satellite imagery for all of Tigray.

In Amhara, the Sustainable Water Harvesting and Institutional Strengthening (SWHISA) project is just starting, and is focussing more on research than WHIST in Tigray. This project is targeting six Weredas (East Belesa and West Belesa in North Gondar; Goncha Siso Inese in East Gojam; Delanta Dawunt in North Wollo; Lalo Mama in North Shewa; and Were Illu in South Wollo).

In Amhara Region, the **Swedish International Development Agency SIDA** is supporting 23 micro-watershed management projects within 16 Weredas (to be extended to 25 Weredas this year) under the Amhara Rural Development Programme. This programme covers agriculture and natural resources (including watershed management); infrastructure (roads, health, education, and irrigation); micro-income generation; good governance; and gender and HIV. Funds are made available to Weredas to support their own development goals and plans in these sectors. Seven watersheds have been completed and identified as model field sites. A benefit assessment has reportedly been completed through the Amhara Regional Agricultural Research Institute (ARARI). Despite the successes achieved, the programme is not proving to be self-replicating as originally expected.

In Amhara Region, **USAID** is supporting the BoARD in (i) integrated watershed management policy, planning and implementation capacity; and (ii) four micro-watershed management projects. These are intended as integrated watershed management projects and were selected based on criteria such as accessibility, agricultural potential, environmental variation, food insecurity, and rainfall. Three of these are well advanced and provide some basis for understanding implementation realities. It is understood that efforts of regional capacity building have been less successful than originally envisaged. Conversely, the watershed management projects appear to be well established. Key to success has been development of community organisations.

Several **NGOs**, both national and international, are also active.

In Amhara, the Organisation for Rehabilitation and Development (ORDA), a local NGO, is supporting four micro-watershed management projects in Amhara Region. ORDA has shifted its activities from resource development to watershed development at the PA level. Aiming at a more integrated approach and concentration of efforts, it has finally moved to an integrated watershed approach within a single watershed. One project (watershed) has now been completed in East Belessa, including a case study on project impacts.

The Relief Society of Tigray (REST), another local NGO, is also active in watershed activities. REST used to practice “integrated watershed management” in 78 micro-watersheds in 9 weredas in the Central Zone, 1 in the Southern Zone and 1 in the Eastern Zone. In the last three years, working under the PSNP (Productive Safety Net Programme), activities are more scattered and include SWC, tree plantations, gully stabilisation and water harvesting. A new technique introduced from India to Ethiopia is the check dam for combined water/sediment retention (21 units built in 2005).

The Ethiopian Orthodox Church is also said to support projects involving watershed management.

GOAL/Irish Aid is active in Tigray. Irish Aid was financing a long term multi sectoral programme in the Eastern and Southern Zone of Tigray (since 10 years), but now provides concentrated budget support to 4 weredas, one in each of the four zones. Activities are financed in the water sector, agricultural sector and education. Water harvesting and SWC are practiced in 11 micro-watershed sites of about 500 ha on average. Implementation is done by the agricultural bureau. Sustainability is pursued by creation of sectoral user groups (e.g. gully group, irrigation group, bee keeping group) adopting management responsibility after project implementation. Monitoring is based on implementation achievement indicators, which are evaluated in cooperation with the target population (each semester) and BoARD (quarterly).

In the field of research, the Soil Conservation Research Project (SCRP) in name still exists. The Soil Conservation Team of MoARD is managing the SCRP data in a database. It is not clear whether the erosion research stations are still operational. No new stations have been built.

World Vision, CARE and Save the Children are also supporting projects involving watershed management.

8.1.3 Irrigation development

Only a broad overview is given here of irrigation activities, since there will be a separate CRA study on irrigation.

Irrigation development is divided in small-, medium- and large-scale projects. Command areas are, respectively, less than 300 ha (small-scale), 300-3,000 ha (medium-scale) and more than 3,000 ha (large-scale).

MoWR has the responsibility for large-scale irrigation development. The Irrigation Departments of the regional Water Bureaus are responsible for medium-scale (300-3000 ha) and small-scale irrigation (less than 300 ha) development. Several partners (donors and NGOs) are active in development of small-scale irrigation fed by water harvesting structures. Construction of medium-scale projects is subcontracted. Coordination and approval of small projects, identified and supported by donors and NGOs, remains the responsibility of the Regional irrigation departments.

(i) Large-scale irrigation

An overview of ongoing and upcoming activities in large-scale irrigation development is given in table 76.

Table 76. Overview of large-scale irrigation schemes and projects in the ENB

Name of project/scheme	Area (ha)	Location	Source of finance	Status
Existing irrigation schemes				
Finchaa Sugar project	6,200	Abbay	-	Existing, 3,100 ha to be developed
Koga dam	7,200	Abbay	ADB	Under construction
Ethio-Nile Irrigation projects				
1. Megech gravity	7,000	Lake Tana sub-basin	World Bank	Prefeasibility study
2. Megech pump	10,000	Lake Tana sub-basin	World Bank	Earmarked for fast-track implementation
3. Ribb gravity/pump	20,000	Lake Tana sub-basin	World Bank	Prefeasibility study
4. Upper Beles	5,000	Beles sub-basin Tana Transfer	World Bank	Earmarked for fast-track implementation
5. Negeso	23,000	Didessa sub-basin	World Bank	Reconnaissance
6. Anger	5,000	Anger sub-basin	World Bank	Earmarked for fast-track implementation
7. Nekemte	11,000	Anger sub-basin	World Bank	Reconnaissance

8. Anger RoR	900	Anger sub-basin	World Bank	Reconnaissance
9. Angereb	23,000	Tekeze basin	World Bank	Prefeasibility study
Other schemes planned for near future				
Gumera irrigation and drainage feasibility study	23,000	Lake Tana Sub-basin	GOE	Feasibility study in process
Lake Tana sub-basin dams feasibility study and detailed design project	37,000	Lake Tana Sub-basin	GOE	Agreement for 5 dams. Technical proposal under preparation
Arjo-Didessa irrigation and drainage feasibility study project	20,000	Abbay basin	GOE	Feasibility study in process
Humera irrigation feasibility study project	43,000	Lower Tekeze basin	GOE	Feasibility study in process
Welkayit	30-40,000	Lower Tekeze basin	GOE	Feasibility study to be started

Source: MoWR, Irrigation Department

The Humera project is a follow up of the Tekeze river basin master plan study. Similarly, 16,000 hectares in the Angareb area, proposed by the Tekeze study, will be included in the World Bank project. The other area studied under the Tekeze study, i.e. Metema area, was considered not feasible.

(ii) Small-scale irrigation

The Abay Institutional Study found that some projects in the formal small-scale irrigation sector and the multiple small diversion schemes in inaccessible areas of the highlands had shown that farmers were willing and able to adopt new technologies and crops if markets and production factors were not a constraint. Recession cultivation around Lake Tana, with maize as the principal crop, shows that farmers are able to combine human, land and water resources in a profitable way. Further, multiple small diversion schemes can be seen from the air in inaccessible areas of the highlands, where marketing is certainly a constraint. Farmer-built water control programs fed mainly by groundwater are common along the foothills of the valley sides and in the valley bottoms of the Nekemte-Arjo-Didessa area. The extent of this development is unknown but, based on FAO and Zonal Agriculture Offices estimates, an estimated 30,000 ha were developed in small-scale schemes, of which 3,500 ha were under Government schemes and the balance under traditional farmer irrigation.

The Abay Master Plan assessed that some 5.8 M ha of land were potentially suited to irrigation, based on land characteristics alone (soil and a maximum 6% slope). When water availability was added and excluding inter-basin transfers, this area was reduced to about 1.7-1.8 M ha. Inter-basin transfers, via the Abay River, could add 0.3 to 0.7M ha, for a total potential of 2 to 2.5M ha.

According to the Abay Institutional Study, COSAERAR, during the 7 years following the master plan, has constructed and rehabilitated 44 projects with a capacity of irrigating 7,177 ha, and benefiting 20,420 households. Most of these projects (around 75% of them) were said to be concentrated in the semi-arid areas of the Region (drought prone zones of Wag Hamre, Wello, and Gondar – so partly in the Abbay basin) where food production is more stressed by climatic problems. The average cost per ha of development amounted to 5,476 USD (between 4,100 USD for a river diversion project and 6,800 USD for a dam construction project). This calculation includes the beneficiary contribution (labour and grain).

ORDA, a regional NGO, has also been active in small scale irrigation. Between 1996 and March 2003, they have implemented around 30 projects for a total 1372 ha (40 ha per project in average) with the financial assistance of the regional government and different donors. This means a rate of around 200 ha per year. The total costs of the projects implemented amounted to EBirr16.6 million for an average cost of around EBirr12,000 per ha, i.e. less than 1,500 USD per hectare.

In Oromiya region, the OIDA, established in 2002, has developed around 700 ha per year of small scale irrigation schemes in the basin.

Small scale irrigation in BeneShangul-Gumuz appears much less developed than in the other regions.

The Irrigation Department of the Water Bureau in Tigray reports that 54 small dams for irrigation have been constructed in Tigray, 30 of which are still operational, partly after rehabilitation with help of the IFAD funded Small-Scale Irrigation Support project.

8.1.4 Support to Agricultural extension

A CIDA funded 5 years extension research (learning by doing) project, IPMS Ethiopian Farmers' project (Improving Productivity & Market success of Ethiopian Farmers) is being implemented by ILRI and MoARD. The project aims at contributing to improved agricultural productivity and production through market-oriented agricultural development, as a means for achieving improved and sustainable rural livelihoods.

The project works in 8 weredas (2 in TNRS, 2 in ANRS, 2 in ONRS, 2 in the South) on:

- an improved agricultural knowledge management system for farmers,
- strengthening the current information network among Regions and weredas, being developed within MoARD,
- strengthening institutional capacity through creation and support to Wereda Advisory Learning (WALC)
- capacity building for community-based and private organizations,
- policy development

The upcoming CIBAS project is also aiming at capacity building in the agricultural sector. Extension of innovative technology will continued to be supported through the Sasakawa Global 2000 project.

Local networks for information exchange are also being developed. An example of this is the Prolina network for farmers based innovative technology.

8.1.4 Observations and lessons learnt for Watershed Development

(i) Priority for interventions

The strong relation between SWC and food aid, the latter being concentrated in food deficit areas, has led to a relative neglect of this work in food sufficient or surplus areas such as West Gojam and Wellega in the Abay Basin and many parts of the Baro-Akobo basin. In these areas similar works are required but with an emphasis on erosion control. This is confirmed by many, also by the WFP Mid-Term evaluation (2005).

(ii) Innovative approaches

The better linkage between SWC, water harvesting and agricultural diversification (based on micro-irrigation), introduced by the MERET project, was certainly innovative for the Ethiopian context. It is fully compatible with the “improved ADLI policy” and is now applied by all.

Promising trials of genuine community participation have been practiced in a SNV supported project in Bugna wereda (N.Wolo in Tekeze basin), and in a project of SOS-Sahel in Meket wereda in the far north of the Abbay basin. Agreements had been made with Kebele leaders that farmers could use the 20 days of unpaid “community participation” labour for SWC on their own lands, and that these lands were exempted from land re-distribution. In both cases, the wereda did not have the capacity to adopt these approaches after project termination in 2002. SOS-Sahel is still active in Meket, in capacity building to weredas and in impact studies of land certification. It is up-scaling local-level NRM to Wadla wereda.

(iii) Technology innovation

Some important technology innovations have taken place in watershed treatment. Currently these are at a small scale. The former GTZ-supported Integrated Food Security Project in South Gondar (ANRS), now coming under the SUN programme, had put the largest possible emphasis on biological measures, both for on-farm conservation and for gully stabilization. Introduction of Vetiver grass was strongly promoted there and by MFM in Illubabor.

The most substantial change has been the greater emphasis on water resource development enabling the expansion of micro-irrigation, and thus agricultural/ horticultural diversification and commercialization. This change has been introduced by the MERET Project but has now been adopted by most actors. Water resource development (e.g. construction of shallow wells) is a logical step following improved water retention through SWC measures. It proves to be most productive in watersheds where SWC is widespread. An example is the case of Abraha Atsbaha Tabia, in the Northern Zone of Tigray, where long term activities in separate Kebeles have now resulted in an aggregated protection of almost the entire watershed (of some 3,000 hectares).

(iv) Water harvesting

Water-harvesting (e.g. ponds, small earth dams, river diversion) has become an essential ingredient of SWC programmes, although it has known limitations. The IDEN-ENSAP Watershed management Study[108] reviewed water harvesting experiences in Ethiopia and concluded as follows:

- Pond and canal seepage are limiting factors, reflecting problems in design, construction and supervision.
- Inflows from harvesting areas have been less than expected due overly optimistic runoff coefficients.
- Excessive sedimentation is a problem, pointing to need to integrate water harvesting with the overall catchment management.
- Pond water is insufficient for dry season irrigation, and is often actually used for supplementary irrigation in the wet season.
- Water should be used on high value crops, but horticultural crops have high input costs and have limited storage capacity (where markets are thin).
- Water borne diseases (malaria and bilharzias) and safety need to be considered.
- Success was achieved where both technical and social aspects were adequately covered.

[108] ENTRO, 2003: "Watershed Management experiences and Lessons learnt: Some Ethiopian Examples", Review paper prepared for the watershed management Project – Ethiopia.

(v) Impacts and implementation efficiency

Local level watershed protection has been undertaken for three decades, at enormous cost. Large areas have been treated now, particularly in Tigray. The NRM Department in Tigray admits that “impacts are not yet in relation to the efforts made through time”, but that the achievements are considerable:

- about 25 % of cultivated land treated,
- 200,000 hectares under area closure,
- 300,000 hectares of natural forest being exploited in a proper way.

Improved crop transformation and improved livelihood conditions are also mentioned as main achievements.

Research activities (Mekele University, project’s own evaluations, and in earlier days, the SCRP) have shown that SWC has a positive impact in terms of erosion control, moisture retention and land rehabilitation. The Inter-University Cooperation project (IUC) of Mekele University estimates that terracing on cropland produces an average net increase in crop production (including the loss of land) of 3 %. Revival of natural springs is also mentioned as an important indicator.

However, the cost efficiency of all the work is rarely questioned. After many years of SWC practice, field observations still lead to similar conclusions:

- SWC implementation follows a blanket approach, structures are often over-designed; no flexibility or refinement in measures can be observed based on varying terrain conditions,
- maintenance is generally inadequate or lacking,
- there is a strong predominance of mechanical, loose rock structures which could be replaced in many places by cheaper, biological measures contributing in the same time to productivity,
- quality control is limited to target fulfilment and is not concerned with optimum impact of measures.

The type of data collected with regard to SWC implementation generally focuses on physical achievements (i.e. length of terracing, seedlings produced, etc). After three decades of massive soil conservation campaigns, it is possible to trace exactly how much food was spent, but it is not possible to say what the impact has been on agricultural production, farm incomes, which areas have been covered (and even covered how many times) and whether the work was carried out in an efficient way.

(vi) Some selected cost figures

A few data on average overall costs of micro-catchment treatment are available:

- King and Leul Kasahay (2006) estimate the average cost of micro-catchment treatment following the CBPWM approach, at about US$180,000 for a catchment of some 200-500 hectares, i.e. about US$ 360-900/ha or ETB 3,000-8,000/ha.

- GTZ has calculated an average cost of US$ 115,500 (ETB 1 million) per micro-catchment, which is in the same order of magnitude (two thirds) of the previous estimate by King and L.Kasahaye.

- The evaluation report of Irish Aid activities calculated a cost of ETB 3,000 /hectare (85 % of which is SWC and gully treatment) for investment cost only and excluding project overheads. The same document reports the possibility to recover the program investment costs of ETB 1.8 million within 3 years.

- The IUC project (Mekele University) gave as a rough estimate an average cost of about ETB 5,000/hectare, to be repeated every 10 years.

- The MDG needs assessment document estimated unit costs of watershed treatment to amount to an average of 2,500 – 3,000 ETB/ha (based on standard WFP work norms, including materials and equipment but excluding project overhead costs).

The above indicative figures all relate to activities compensated in food or in kind, and are probably based on the same standard work-norms developed by MoARD and WFP. The variation is probably related to different average intensity of works assumed, and different proportions e.g. of hillside closure (relatively cheap) and gully treatment (expensive).

The dominant role of food aid is also expressed in WFP project budgets. In the overall budget for the 2003-2006 MERET programme, the combined cost of food commodity and of local transport/storage/handling amounts to US$ 40.7 million, which is 94 %, of the total WFP contribution plus 92 % of GOE contribution. Other direct operational costs (staff, training, capacity building, M&E, equipment and materials) take only 6 % of the WFP contribution, and 8 % of the GOE contribution.

(vii) Budget transparency

The pattern of actors in watershed activities, amounts of work achieved, and budgets dispensed, is often complex, especially in weredas where several donors are active. It may be assumed that individual donors know what they have spent. Also, for larger donors, such as WFP, special regional and wereda project coordinators are nominated. But the form of support varies from direct compensation by food or cash to budget support, and is entered differently into the wereda overall budget (block grants, federal budget support, direct payment per activity. In addition, food-aid may be used for identical activities under different headings (FFW, employment generation under the safety net programme) and food is also distributed directly as relief aid.

Individual wereda technicians keep records of works performed within their respective areas or responsibilities. But no annual synthesis is made at the wereda level of all activities carried out, differentiating between donor, source of funding, and type of activity (paid or unpaid). Also, the conversion of works performed into areas treated, is a mathematical and artificial one. No cartographic record is kept of areas treated. After some years, as a result of high staff turn-over, nobody knows anymore who has done what and where.

The need for greater transparency and better record keeping is obvious. Given the ongoing land degradation and the enormous amounts of work ahead, it will be necessary to know better how and where to select future priority areas, and at what costs these could be treated.

(viii) Positive experiences but limited up-scaling

The recent document on a joint EEFPE/IFPRI stakeholder analysis (Gete Zeleke et al., January 2006) reports that “enormous efforts in massive land rehabilitation were undertaken since the 1980s, with the aim of arresting land degradation and improving rural livelihoods in the country. Despite these efforts, there has been limited success in controlling land degradation, in comparison to the efforts applied, the organizational structure and the resources mobilized. The problems with past conservation efforts were largely rooted in a lack of understanding of the important interface between resource conservation and agriculture, and of the factors that motivate farmers to invest in sustainable land management (SLM) over the long run.

(ix) The Role of Food/Cash for Work

The overriding role of food-for-work is often ignored. Possibly, the support provided by food or cash is taken for granted without realizing that,

- in the approach followed, it has only been the availability of food/cash that has made the work possible,

- the cost of watershed protection activities is almost entirely determined by the cost of food rations,
- the amounts of food/cash available automatically sets the upper limit for potential implementation achievements,
- the very existence of FFW/CFW has created a “dependency syndrome” and in general discourages individual initiative by farmers.

In a regional round table discussion on watershed management, with participants from many organizations (government, donors and NGOs) dealing with watershed management, “a number of participants held that food/cash-for-work is a major obstacle to scaling up. The concept has been institutionalized in such a way that farmers are unwilling to undertake any measures without payment, even when these are to their own benefit”.

There are some examples of voluntary replication, for example in the Irish Aid supported activities in Tigray, where 200 hectares were said to have been implemented on a voluntary basis. Also some cases were reported and observed where farmers have dug shallow wells without external support (of a lower technical standard but unpaid).

In its cost-benefit analysis, the MERET project (WFP, 2005) also reports some (un-quantified) voluntary replication, especially of measures that can be implemented on individual basis and which contribute to production increase (mainly biological measures). The changing approach towards local level participatory planning (LLPP) is given as the main reason for improved farmers commitment and more positive appreciation of measures. Limiting factors for replication (of both labour intensive measures and private forestry activities) mentioned by farmers, are mainly inadequate availability of labour and lack of capacity and skills (almost 60 % of respondents). Lack of food aid or capital are mentioned by 35 % of respondents. Land tenure problems score surprisingly low (only 2 %).

According to GTZ, replication rates are better in non-food-deficit weredas, where farmers have not developed as strong a dependency syndrome. This is also experienced by others, e.g. the NGO “Menschen für Menschen” (People for people), working far from areas affected by the dependency syndrome, and facing no problems with their approach of genuine, unpaid, community participation.

(x) Building on the Past

The MERET/WFP project has been operating some 25 years (under different names), and offers a wealth of experience. The approach to this project has changed considerably over the years, reflecting experience of what does and does not work, and paralleling changes within government, as outlined above. Thus, the early approach to watershed management was large scale and top down; the achievements proved not to be sustainable and, in some cases, were detrimental. This has been attributed largely to the unmanageable size of the target areas and the lack of community participation (WFP mission 2002). Over the last 10 years, paralleling the decentralization process, the project has been re-designed to a ‘bottom-up’ project, owned and driven by communities. Target areas have been reduced to micro-catchments – or community catchments – on a scale of 200 to 500 ha. And the focus has shifted from protection – conserving the resource base – to production and improvement in rural livelihoods. This is in line with national policies and with international experiences. Most organisations working in watershed management now follow similar practices.

Overall, the various experiences provide guidance on what is implementable and at what rate. The 2005 guidelines Community-Based Participatory Watershed Development build on local experience and provide a reference to the projects.

The experiences in watershed management (including water harvesting) suggest a few key considerations for future projects:

- Community ownership and institutional structures are basic to project success
- The ‘building blocks’ for watershed management should be community catchments in the 200-500 ha range
- Larger projects (e.g. the current projects) should be seen as target areas for coverage by ‘micro-projects’ at the 200-500 ha level i.e. should be assemblages of micro-watersheds grouped and linked at a broader scale
- Conversely, larger projects can ‘add value’ by allowing physical integration of the micro-projects and by allowing a more holistic approach than possible at the micro scale
- Projects benefit from an ‘integrated’ approach. However, concepts on ‘integrated’ vary and rarely extend beyond agricultural production
- Due to the diversity of landscape and socio-economic conditions in Ethiopia, interventions need to be adapted to local conditions rather than following standard models.
- Implementation is easiest in areas offering most immediate benefits, i.e. in moisture-stressed areas. By extension, water conservation offers more immediate and visible benefits than soil conservation.
- Extensive support by Development Agents is required for project implementation. Optimum support levels are around 3 diploma level development agents per development centre. This has important implications for project implementation and management. The scale of

the proposed projects will make major impositions on the capacity of the Regional Bureaux of Agriculture. Future projects may need to either provide support to these bureaux or to have a separate implementation management (albeit linked to the bureaux)

- Payment (food or cash for work) will most likely be required for a large part of project implementation.
- A key issue yet to be resolved is how to 'scale up' from the micro-watersheds to larger areas – a question to which upcoming watershed management projects should make an important contribution.
- It is difficult to sustain watershed management on increased productivity of food grains alone; diversification for cash crops adapted to local markets or other income generating activities is an essential part of the mix. This emphasizes the importance of markets and marketable products to offset the cost of investment in conservation.
- Key constraints are institutional capacity limitations at Regional, Wereda and Kebele/community levels; free grazing of livestock; the requirement of external support (generally food-for-work) to support community mobilisation; and lack of maintenance after completion of the project.
- There are no evaluation data available on post project benefits as compared to baseline situations. Most observers agree that, within the moisture deficit and food insecure Weredas, crop and forage production benefits are positive. MERET has undertaken an economic analysis which suggests that activities are economically viable.
- Despite the previous point, there is limited evidence of community driven watershed management and self-replication is limited. Efforts have been, and remain, primarily supply-driven by government and donor agencies, and supported by payment (food or cash for work).

(xi) Integrated watershed management

Considerable experience has been built up in the Region and elsewhere in the world on the technological aspects of integrated watershed management. In particular there has been an increasing emphasis on biological measures using where possible locally available materials and away from physical structures. Biological measures include those under the headings of better "land husbandry", "crop husbandry" and "livestock husbandry".

At the small dam watershed level, technical interventions will need to be developed in an integrated manner that takes into account the nested nature of watersheds and the hydraulic system. Small dams need to be integrated into other components of the watershed management plan with catchment management interventions being implemented in the upper micro-catchments and moving progressively downstream. Similarly, external water-harvesting measures will need to be similarly planned and executed. In-field water harvesting measures will need to be integrated with soil fertility enhancing measures if full benefits are to be achieved.

Proposed interventions will need to range beyond soil and water conservation technologies and include inter-linked technologies related to crop, animal and tree husbandry.

A thorough understanding of the land use systems and their inter-linking components will ensure that any potential technical interventions will not adversely impact on and where possible support the other components in the system.

8.2 Regional Watershed Management Planning Framework

8.2.1 Strategic Considerations

The principle of integrated watershed-based development is the declared policy of Government and thus provides a suitable guidance for watershed management. Rehabilitation and protection of land and water resources are at the centre providing the basis for sustainable development.

It is known from lessons learned that watershed management planning can be undertaken at various levels, but **implementation has to take place at grass root level**. The conventional options for purely administrative and regulative solutions to land and water use problems appear to have reached their limits. It is becoming increasingly apparent that a more consensual approach to natural resource management is a more attractive solution for harmonizing interests of resource users, managers and regulators. Allowing and facilitating local communities to develop their own resource management systems is proving a more effective, economic and efficient approach than central or regional government control.

Sustainability of achievements requires ownership of its users and these are the local communities. A sense of ownership is created only through their **genuine participation** in planning and decision making. Decision making should not be the privilege of nominated leadership only. Motivation for genuine participation can only be based on **tangible benefits** and a sustained resource-base. Many benefits can be achieved through integrated watershed management for improvement of livelihoods.

The requirement of genuine participation sets preconditions to the organizational structure and approach of watershed management projects. Emerging lessons from watershed management projects in Ethiopia and elsewhere include the following:

- A participatory project cannot be target-driven right from its start. In its initial phase, the project design should focus on the process of establishing participation rather than on seeking to achieve physical targets. It also requires appropriate institutional development at community-level; appropriate in the sense that institutions are created (or strengthened if already existing) to respond to the emerging needs, and may therefore differ from place to place. Needs depend on priorities in watershed management activities, functionality of existing traditional institutions and prevailing group dynamics within a community. A standardized institution for all communities (such as a Kebele watershed committee) will be an imposed one and will undermine the feeling of project ownership in the community.

- It is important to strive for a simple organizational and coordination structure, based on existing structures and clearly stipulating linkages with higher levels (need for support.

- Institutional arrangements are required that allow for multi-disciplinary and multi-agency collaboration and across ministries, contributing to breaking through single sector approaches.

8.2.2 Technical Interventions: Levels and boundaries of analysis

It is often stated that a watershed approach to development conflicts with the administrative and political reality and that their boundaries rarely coincide. Implementation activities are initiated and carried out within an administrative jurisdiction. This argument is countered by pointing out that the physical world has no respect for administrative or political boundaries and activities in the upper part of a watershed can serious impact on people in the lower parts in another administrative or political jurisdiction. In practice the two approaches need to be complementary and an administrative/political realism should be superimposed on watershed planning to obtain administrative support and action.

Watershed management is a system-orientated concept with a holistic approach to problems and potentials. For this reason it will be necessary to identify “bundles” of interventions that complement each other where possible in a synergistic way. Given the cross-sectoral, sustainable livelihoods and poverty focus of the Watershed Management CRA with its stated objective of tackling the underlying problems of natural resource degradation in the East Nile Sub-basins, many of these “bundles” will comprise technological, institutional and policy components.

Most technological interventions are targeted at the agricultural[109]/pastoral household and rural community level although some are targeted at medium scale watersheds. The organizational, institutional and policy interventions/recommendations are targeted at the higher administrative and political levels.

In addition, strategic choices in development have to be made to achieve the following:

- balanced identification of priority areas for watershed protection, based on an agreed set of criteria;
- dual attention for both rehabilitation of degraded food-insecure areas and timely protection of strongly eroding high potential areas,

8.2.3 Technological Interventions: Basic Considerations

Considerable experience has been built up in Ethiopia, the Eastern Nile Region and elsewhere in the world on the technological aspects of integrated watershed management. In particular there has been an increasing emphasis on biological measures using where possible locally available materials and away from physical structures.

A thorough understanding of the land use systems and their inter-linking components will ensure that any potential technical interventions will not adversely impact on and where possible support the other components in the system.

At the micro/mini watershed level technical interventions will need to be developed in an integrated manner that takes into account the nested nature of watersheds and the hydraulic system. For example the development of small dams should be integrated into other components of the watershed management plan with catchment management interventions being implemented in the upper micro-catchments and moving progressively downstream. Similarly, external water-harvesting measures will need to be similarly planned and executed. In-field water harvesting measures will need to be integrated with soil fertility enhancing measures if full benefits are to be achieved. Proposed interventions should range beyond soil and water conservation technologies and include inter-linked technologies related to crop, animal and tree husbandry.

[109] Included here are tenant farms on government irrigation schemes, farm workers on large-scale mechanized farms and as well as smallholder farmers.

8.2.4 Targeting Interventions

(i) Development Domains

In Ethiopia the MoARD Guidelines for Watershed Management provide details of many land management options. The suitability of these options depends on the bio-physical and socio-economic characteristics of a particular area. Given the large number of agricultural/pastoral household units and their extremely wide range of environmental, social and economic circumstances, it is necessary to stratify households and communities into some form of spatial unit. For this reason it has been necessary to sub-divide the three Sub-basins into spatial units of similar environmental, socio-economic (include market access) conditions and related problems and potentials. These form the basis of "**Development Domains**[110]". These have a common set of interventions, impacts, costs and benefits.

Three criteria have been used to define the Development Domain: (i) agricultural potential, (ii) accessibility to markets, and (iii) Highland or Lowland.

Agricultural potential is defined on length of growing period (LGP) and rainfall variability (CV). Thus high agricultural potential weredas have LGP >6 months or 4 months with rainfall CV <100 percent. Low agricultural potential weredas have an LGP <3 months or 4 months with rainfall CV >100 percent. Medium potential weredas lie between these values.

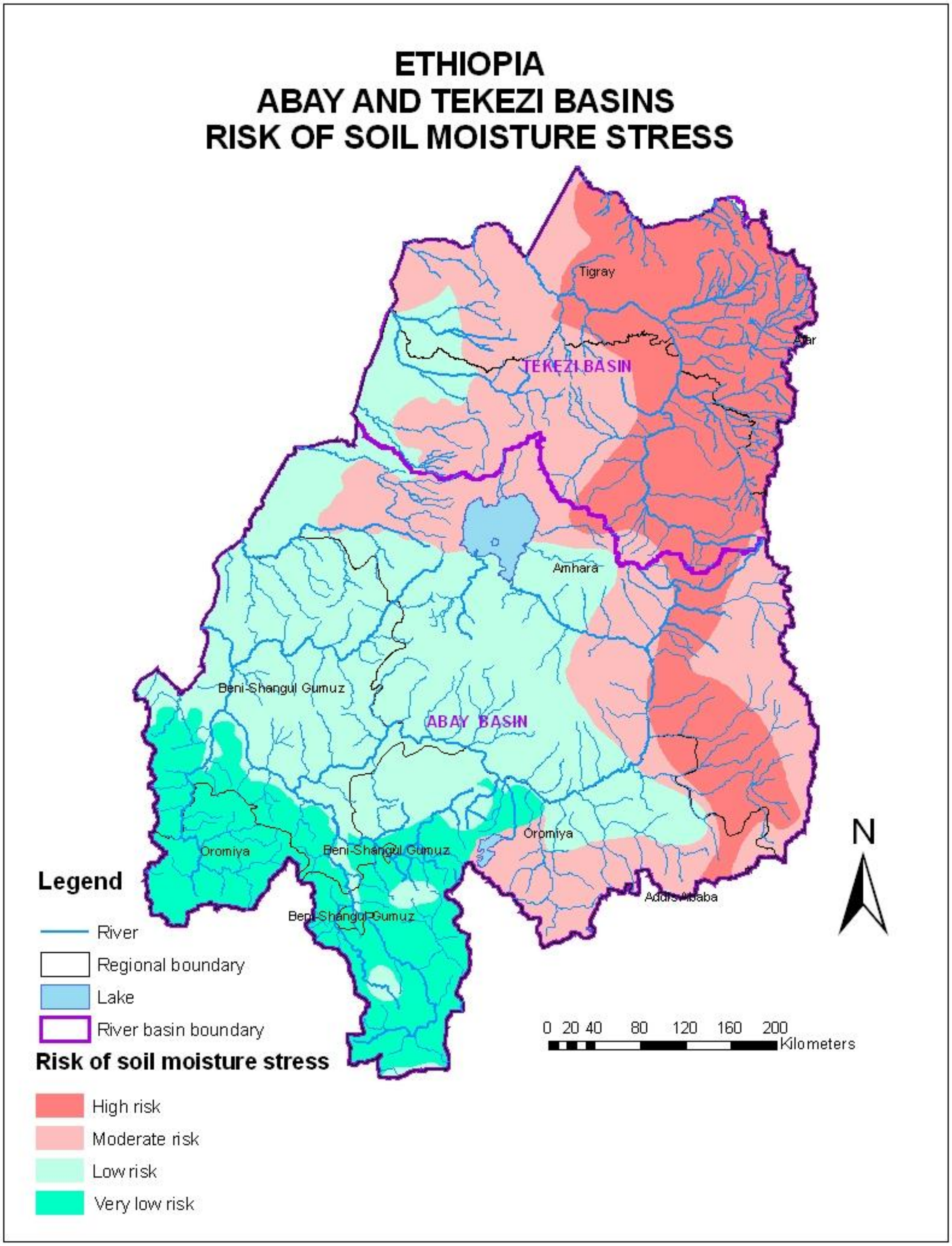
Access to markets is also a key factor in targeting interventions. Areas with good access to markets have advantages in terms of producing high value perishable crops, livestock intensification and greater possibilities for off-farm income. Conversely, areas remote from markets will need to focus more on higher value but easily transportable commodities such as small livestock and apiculture. Good market accessibility is defined as being within 4 hours vehicle travel time to a town of >50,000. Highland and Lowland are defined as >1500 masl or <1,500 masl respectively. Pender at al (1999) used population density as their third criterion. However, in Ethiopia the Highland/Lowland distinct covers not only population density but a range of socio-cultural and environmental factors.

Within each Development Domain are a number of Farming Systems that have been described in the Sub-basin Socio-economic descriptions. The distribution of In terms of targeting specific land management technologies the available evidence suggests that there is a clear distinction between frequently moisture stressed and areas that are infrequently stressed. These distinctions are brought in Map 60 for the Tekezi and Abay Sub-basins. The pattern of high risk of moisture stress is similar to that of the Development Domains but includes a

[110] Pender J, F. Place & S. Ehui (1999) "Strategies for sustainable agricultural development in the East African Highlands" EPTD Discussion paper 41, IFPRI, Washington DC.

southward extension just to the west of the eastern rim of the Abay Basin. This area does not receive the short (or *belg*) rains experienced by the area just to the east and is not picked up in the wereda level analysis.

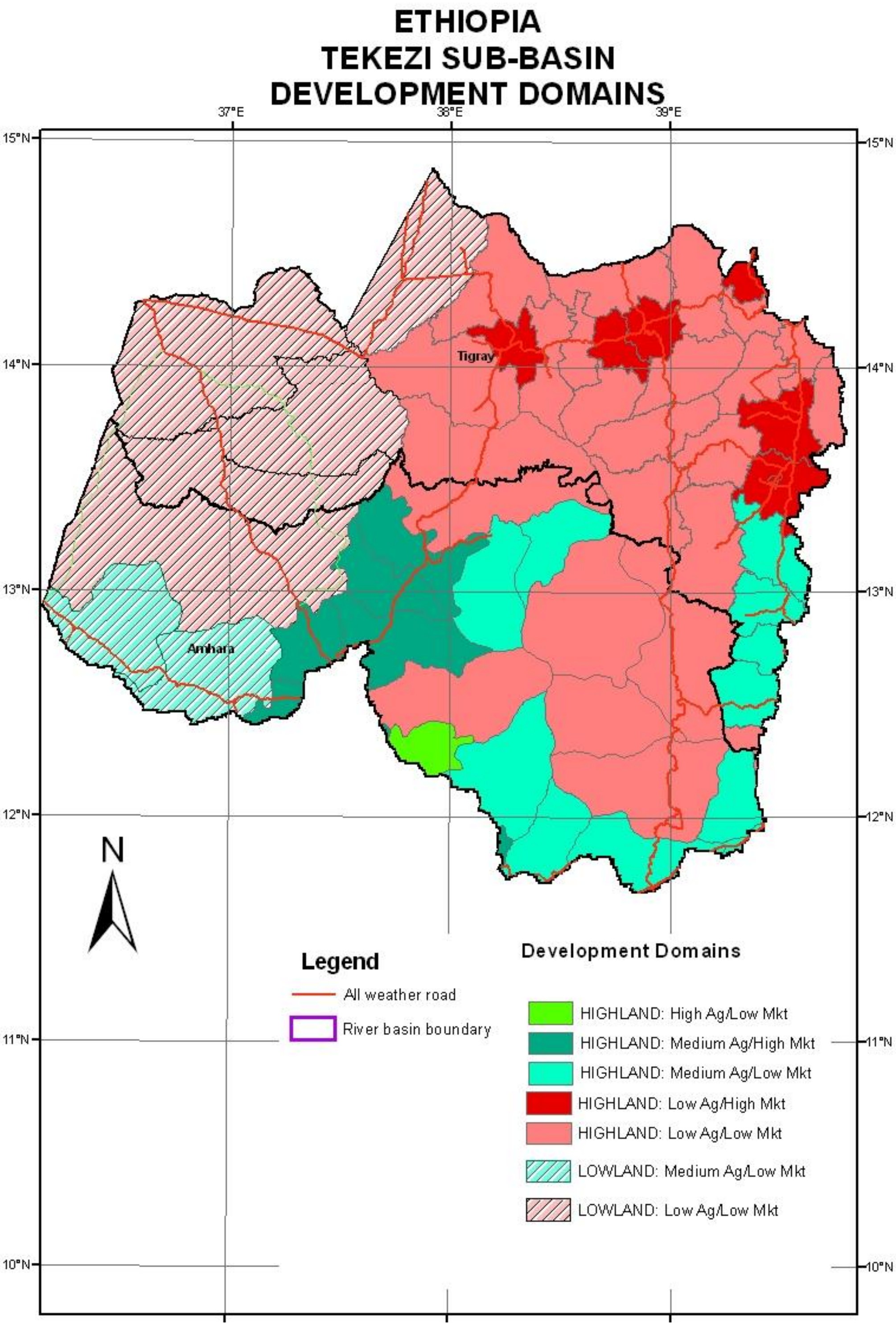
Development Domains and their component Farming Systems are described below by Sub-basin.



Map 60. Ethiopia – Eastern Nile Basin: Risk of soil moisture stress during the growing season.

(ii) Development Domains in the Tekeze Sub-basin

Seven of the nine Development Domains occur within the Sub-basin. These are shown in Map 61.



Map 61. Ethiopia – Tekeze Sub-basin: Development Domains.

Highland Development Domains with low agricultural potential occur mainly in north and in the inner Tekeze Valley, whilst the medium potential Domains occur along the eastern edge of the basin. Lowland Domains with low agricultural potential occur in the central and northern Lowlands, whilst those with medium potential occur in the higher rainfall southern Lowlands.

A matrix showing the occurrence of the Farming Systems within each Domain is shown in table 77.

Table 77. Ethiopia – Tekeze Sub-basin: Occurrence of Farming Systems within Development Domains.

FARMING SYSTEM	ACCESSIBILITY	HIGHLAND			LOWLAND		
		High Potential	Medium Potential	Low Potential	High Potential	Medium Potential	Low Potential
T1	High Mkt Access						
T1	Poor Mkt Access					X	X
T2	High Mkt Access		X				
T2	Poor Mkt Access	X	X				
T3	High Mkt Access						
T3	Poor Mkt Access		X				
T4	High Mkt Access			X			
T4	Poor Mkt Access			X			

FARMING SYSTEMS – TEKEZE SUB-BASIN:

T1 = LOWLAND SORGHUM+MILLET+TEFF (INCLUDES SHIFTING SORGHUM)
T2 = TEFF+MAIZE+SORGHUM
T3 = TEFF+WHEAT+SORGHUM
T4 = TEFF+WHEAT+BARLEY (INCLUDES WHEAT+BARLEY)

The Highland teff+maize+sorghum farming system that occurs through western Amhara Region occurs in both medium and high agricultural Development Domains as does the Lowland Sorghum+Millet+Teff farming system.

(iii) Abay Sub-basin

Highland domains with high agricultural potential generally occur to the west whilst those with lower potential occur in the drier east. Lowland Domains have medium agricultural potential given their higher rainfall.

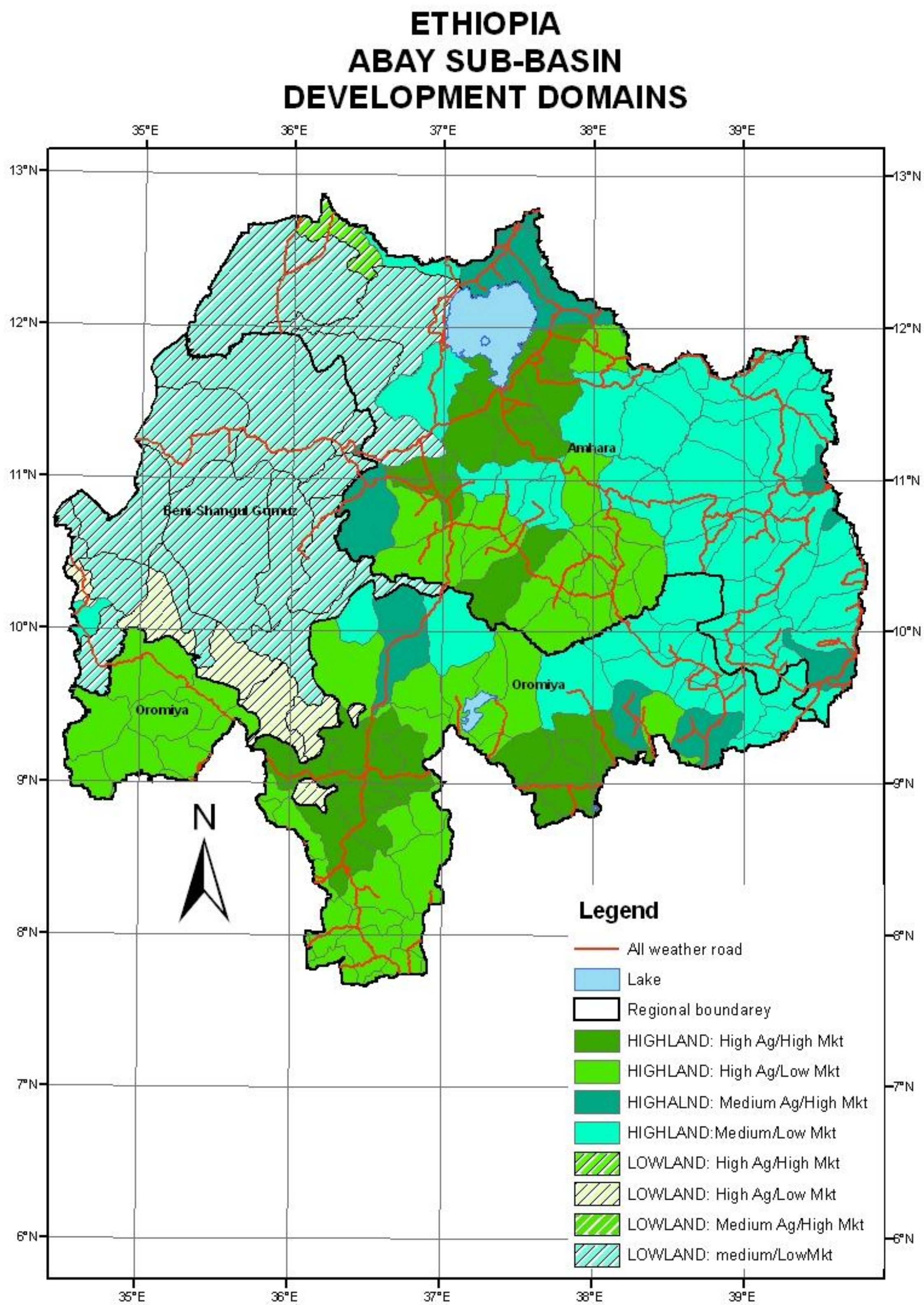
A matrix showing the occurrence of the Farming Systems within each Domain is shown in table 78.

Table 78. Ethiopia – Abay Sub-basin: Occurrence of Farming Systems within Development Domains.

FARMING SYSTEM	ACCESSIBILITY	HIGHLAND			LOWLAND		
		High Potential	Medium Potential	Low Potential	High Potential	Medium Potential	Low Potential
T1	High Mkt Access						
T1	Poor Mkt Access					**X**	
T2	High Mkt Access						
T2	Poor Mkt Access				**X**	**X**	
T3	High Mkt Access						
T3	Poor Mkt Access	**X**	**X**				
T4	High Mkt Access		**X**				
T4	Poor Mkt Access	**X**	**X**				
T5	High Mkt Access	**X**					
T5	Poor Mkt Access	**X**					
T6	High Mkt Access	**X**					
T6	Poor Mkt Access	**X**					
T7	High Mkt Access	**X**					
T7	Poor Mkt Access	**X**					

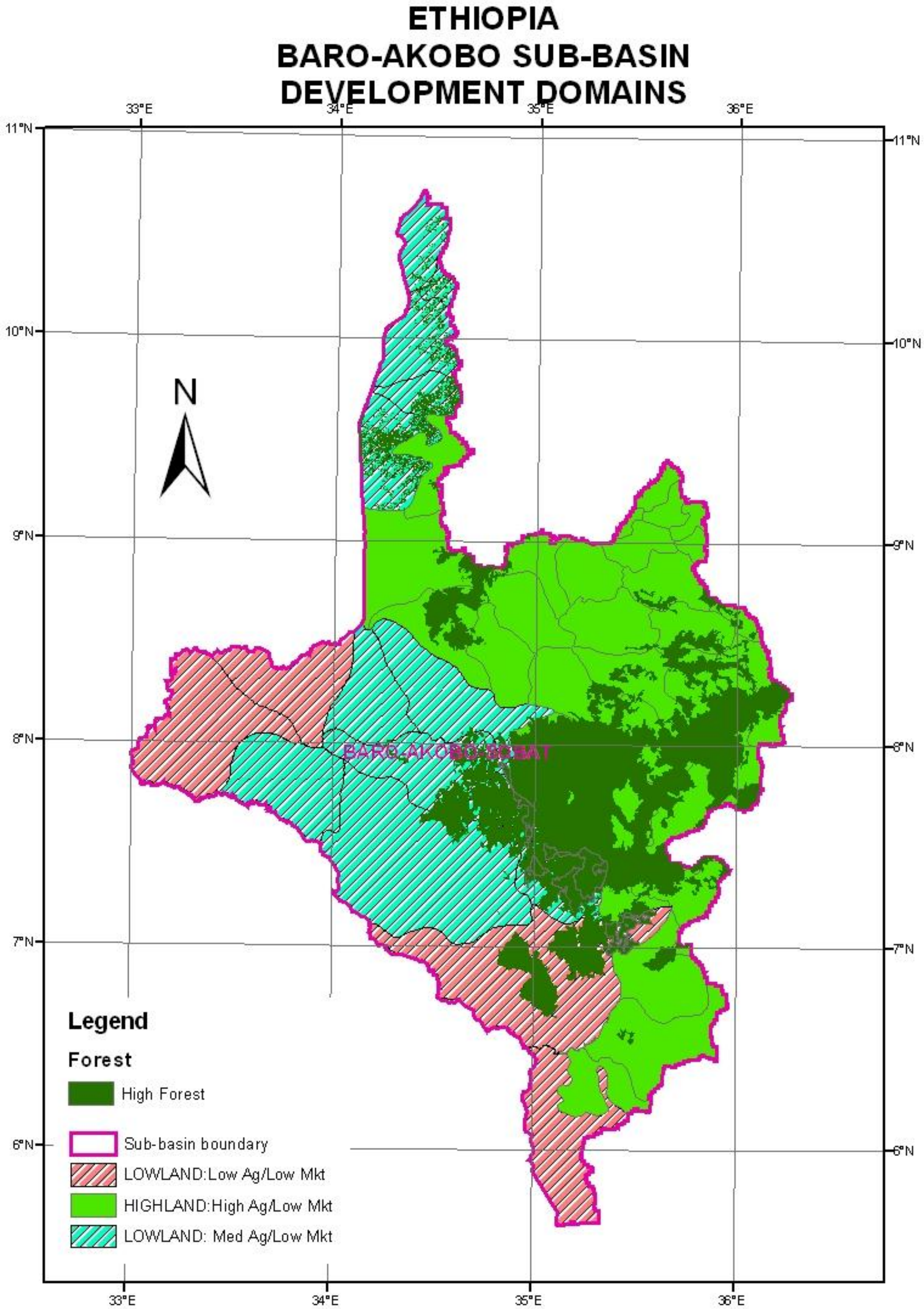
FARMING SYSTEMS – ABAY SUB-BASIN:
T1 (LOWLAND) = SHIFTING SORGHUM+MAIZE (INCLUDES SHIFTING SORGHUM)
T2 (LOWLAND) = FINGER MILLET+SORGHUM+MAIZE
T3 (HIGHLAND) = WHEAT+BARLEY
T4 (HIGHLAND) = TEFF+WHEAT/TEFF+WHEAT+MAIZE
T5 (HIGHLAND) = TEFF+MAIZE+SORGHUM
T6 (HIGHLAND) = MAIZE+TEFF (COFFEE/WHEAT)
T7 (HIGHLAND) = ENSET + MAIZE/WHEAT

Only the Highland wheat+barley and the Lowland Finger Miller+soirghum+maize farming systems occur in two Domains.



Map 62. Ethiopia – Abay Sub-basin: Development Domains.

(iv) Baro-Akobo Sub-basin



Map 63. Ethiopia – Baro-Akobo Sub-basin: Development Domains.

In the Highlands there is only one high agricultural potential Development Domain given the high and reliable rainfall patterns. The Lowland Domains with low agricultural potential occur in the west and southwest because of flooding (in the west) and low and variable rainfall in the southwest.

A matrix showing the occurrence of the Farming Systems within each Domain is shown in table 79.

Table 79. Ethiopia – Baro-Akobo Sub-basin: Occurrence of Farming Systems within Development Domains.

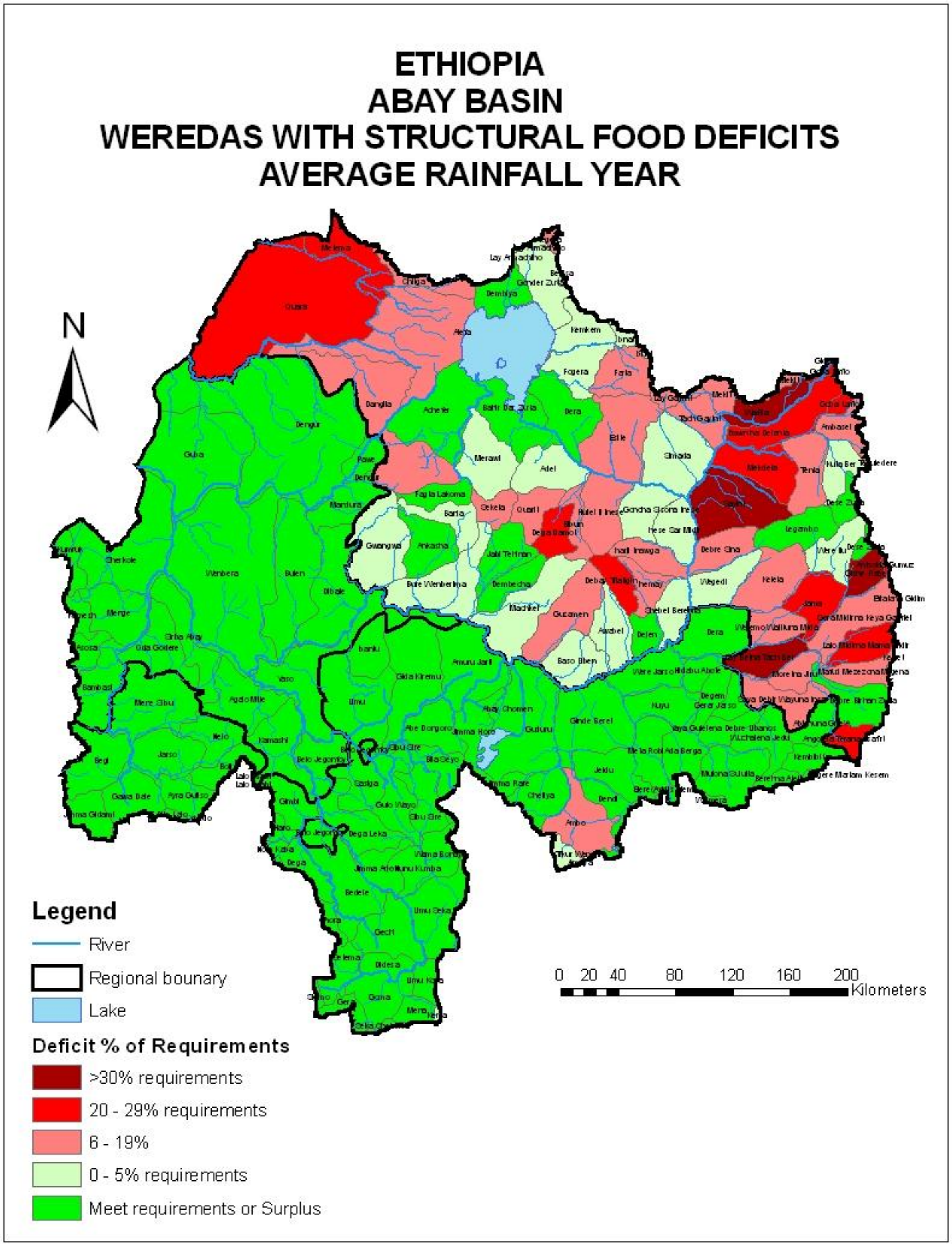
FARMING SYSTEM		HIGHLAND			LOWLAND		
		High Potential	Medium Potential	Low Potential	High Potential	Medium Potential	Low Potential
T1	High Mkt Access						
T1	Poor Mkt Access					X	X
T2	High Mkt Access						
T2	Poor Mkt Access					X	
T3	High Mkt Access						
T3	Poor Mkt Access						X
T4	High Mkt Access						
T4	Poor Mkt Access	X					
T5	High Mkt Access						
T5	Poor Mkt Access	X					

T1 (LOWLAND) = SHFTING SORGHUM+MAIZE
T2 (LOWLAND) = RIVERBANK CULTIVATION OF ANUAK
T3 (LOWLAND) = AGRO-PASTORAL NUER
T4 (HIGHLAND) = MAIZE+TEFF+SORGHUM +COFFEE
T5 (HIGHLAND) = SORGHUM+MAIZE+COFFEE

(v) Question of Priorities

Whilst a distinction is made between "High", "Medium" and "Low" Agricultural potential areas this is done to more effectively target technical and other strategic interventions and in no way suggests any priority for implementation. Opinion appears divided on whether resources should be targeted only at food deficit weredas (as defined by the MoARD/BoARD's). An analysis by WBISPP indicates that some "Medium to High Agricultural Potential" weredas may be experiencing structural food deficits even in years with average rainfall as Map 64 indicates for the Abay Basin.

A strong case can be made for conserving areas with high and medium agricultural potential as well as those areas with severe land degradation. The former currently supply a substantial proportion of the food surplus that could supply food deficit areas either through normal marketing channels or through government assisted food for work programmes. Clearly, farmers' decisions to invest in sustainable land management in the high-medium potential areas are different from those in the low potential areas and thus different forms of government support strategies may be required. It is thus not a question of which areas to prioritize. It is a question of where to target specific interventions that are appropriate to specific areas.



Map 64. Ethiopia – Abay River Basin: Weredas with Structural Food Deficit in Years with Average Rainfall.

Source: WBISPP (2003) Strategic Woody Biomass Plans for Amhara, Oromiya and BeneShangul Gumuz Regional States.

8.2.5 Technological Interventions by Development Domain

The following sets out a number of basic interventions by Development Domain. Many of the interventions require that they be integrated with other interventions. Some interventions are applicable to more than one Development Domain.

(i) HIGHLAND: High to Medium Agricultural Potential (Very low to low moisture stress risk) with Good market Access: - Located mainly in the Abay Basin.

(a) Overall Strategies:

These areas provide the greatest potential for agricultural development and are already some of the food surplus producing areas. A wide range of marketable agricultural production strategies are available. However, these areas are experiencing soil nutrient mining and declining soil fertility levels. With high population densities farm sizes are small. A key strategy is to intensify crop and livestock production taking advantages of synergies between crop and livestock production.

(b) On-farm Interventions:

External inputs: The use of fertilizer and improved seed is likely to be profitable in these areas given the declining nutrient status. Current fertilizer application rates and fertilized area are (except for Illubabor) already some of the highest in the two basins (but still only 20 – 45 kgs/ha). This intervention requires credit availability, nutrient responsive varieties and complementary crop and soil husbandry measures.

Improved Crop Husbandry: These include crop rotation, intercropping and strip cropping. Food self sufficiency is required as food insecurity pushes farmers to cereal mono-cropping. When integrated with external inputs increases water and nutrient availability.

Improved Soil Husbandry: The use of manure and compost increases soil organic matter and nutrients and increases water holding capacity. This intervention requires sufficient quantities of manure and residues, and labour. These interventions need to be integrated with improved animal husbandry interventions and the use of inorganic fertilizer.

Improved tillage: Contour ploughing assists in reducing runoff and soil movement.

Grass strips: Most effective on slopes less than 15 percent but can be used on steeper slopes. Best integrated with on-farm forage interventions and limited livestock access. Can also be integrated with on-farm multi-purpose tree production.

Fanyaa Juu: Graded in high rainfall areas and level elsewhere. Can be integrated with grass strips and trees to increase stability. However, they have high construction and maintenance labour requirement.

On-farm Forage Development: (i) Backyard improved forage: forage grasses (e.g. including but not limited to *Pennisitum purpureum*, *Panicum maximum*), tree legumes (*Leucaena leucocephala*) and pigeon pea. Undersowing into maize or sorghum with appropriate forage legumes. (ii) Improved hay production in drainage lines and bottomlands. (iii) Improved storage and treatment of crop residues.

On-farm Tree development: In many areas of Amhara Region the market for Eucalyptus coming saturated and there is a need to move away from Eucalyptus spp. to multi-purpose trees (for forage, small poles and fuelwood). This intervention could be integrated with the on-farm forage and the grass strips interventions.

(c) Interventions on Communal Lands

Cut-off Drains: A pre-requisite for in-farm soil conservation measures is a cut-off drain above cultivated areas. Even by themselves they can reduce in-field run-off and soil movement. However, it is important that water collected in the drain is safely disposed of into waterways.

Road and track drains: run-off from roads needs to be controlled with small check dams and safe outlets to streams.

Gully Stabilization: This requires the integrated stabilization of both the gully and its catchment area. This will require a combination of livestock exclusion (in both catchment area and gully), and vegetative and structural measures (check dams, etc) within the gully. This intervention can be integrated with a communal forage development programme.

Communal Forage Development: To be effective and sustainable this is best undertaken at the sub-kebelle (tabia) level. This intervention usually requires some form of area closure with cut-and-carry, or controlled grazing or controlled hay production and harvesting. The site of the intervention can vary from steep and degraded hillsides, poorly drained valley bottoms, and stream edge buffers. A key object is to reduce livestock movement. The process of natural re-generation can be supplemented with over-sowing of herbaceous (*Pennisitum* *purpureum*, *Panicum maximum*) or tree legumes (*Leucaena leucocephala*) and pigeon pea but this increases costs. The intervention can also be integrated with communal tree production.

Communal Tree Production: This is best integrated with communal forage development in area closures. As with communal forage development clear management and harvesting plans need to be established at the outset.

Small-scale Supplementary/full Irrigation: For high value marketable crops (vegetables, green maize). Given the good market access high value perishable crops can be grown. Alternatives are supplementary irrigation for larger areas when supplies are high and prices lower, and full irrigation of smaller areas when supplies are low and prices are higher.

(d) Other Strategies

Non-farm labour: Proximity to urban centres provides potential opportunities for non-farm labour, sales of fuelwood and handicrafts. To be sustainable this strategy requires skills training in such activities as brick-laying, carpentry, metal work, handicrafts, etc.

(ii) HIGHLAND: High to Medium Agricultural Potential (Very low to low moisture stress risk) with Poor Market Access: Located mainly in the Abay Basin.

(a) Overall Strategies:

The opportunities for marketable agricultural development in these areas are much more limited. Use of external inputs may be privately unprofitable (to farmers) but may be economically cheaper than importing food into the area[111]. Marketable agricultural products will be limited to high value, low volume and non-perishable products. These could include crops such as onions and peppers, small livestock such as sheep and goats, and honey production. In parts of Ethiopia improved goat production by women has proved very successful, particularly for women-headed households. The strategy for own-consumption agricultural production should be to ensure food security. The long-term Government strategy is to improve accessibility to markets through feeder road and farm to market road construction.

[111] Pender et al (1999) Strategies for sustainable agricultural development in the East African Highlands, in A./ Knox McCullough et al (Eds) "Strategies for Poverty Alleviation and Sustainable resource Management in the Fragile Lands of Sub-Saharan Africa", Food & Agric. Dev. Centre, Feldafing, Germany.

(b) On-farm Interventions

Improved Soil Husbandry: The use of manure and compost increases soil organic matter and nutrients and increases water holding capacity. This intervention requires sufficient quantities of manure and residues, and labour. These interventions need to integrate with improved animal husbandry interventions.

Improved tillage: Contour ploughing assists in reducing runoff and soil movement.

Grass strips: Most effective on slopes less than 15 percent but can be used on steeper slopes. Best integrated with on-farm forage interventions and limited livestock access. Can also be integrated with on-farm multi-purpose tree production.

Fanyaa Juu: Graded in high rainfall areas and level elsewhere. Can be integrated with grass strips and trees to increase stability. However, they have high construction and maintenance labour requirement. Given the lack of market opportunities and thus high private costs involved, a case can be made for some form of subsidy given the potential reduction in externalities.

On-farm Forage Development: Backyard improved forage: forage grasses (e.g. including but not limited to *Pennisitum purpureum*, *Panicum maximum*), tree legumes (*Leucaena leucocephala*) and pigeon pea. The focus of the intervention is on improving small ruminant productivity.

On-farm Tree development: Given the lack of markets on-farm tree production will be for own consumption only.

(c) Interventions on Communal Lands

Cut-off Drains: A pre-requisite for in-farm soil conservation measures is a cut-off drain above cultivated areas. Even by themselves they can reduce in-field run-off and soil movement.

Road and track drains: run-off from roads needs to be controlled with small check dams and safe outlets to streams.

Gully Stabilization: This requires the integrated stabilization of both the gully and its catchment area. This will require a combination of livestock exclusion (in both catchment area and gully), and vegetative and structural measures (check dams, etc) within the gully. This intervention can be integrated with a communal forage development programme.

Communal Forage Development: To be effective and sustainable this best undertaken at the sub-kebelle (tabia) level. This intervention usually requires some form of area closure with cut-and-carry, or controlled grazing or controlled hay production and harvesting. The site of the intervention can vary from steep and degraded hillsides, poorly drained valley bottoms, and stream edge buffers. A key object is to reduce livestock movement. The process of natural re-generation can be supplemented with over-sowing of herbaceous (*Pennisitum purpureum*, *Panicum maximum*) or tree legumes (*Leucaena leucocephala*) and pigeon pea but this increases costs. The intervention can also be integrated with communal tree production.

Small-scale Supplementary Irrigation: For high value non-perishable marketable crops (onions, garlic, peppers) using supplementary irrigation for maximum area (given good storability season price fluctuations are small).

(d) Other Strategies

Honey production: In densely populated areas where land is short honey production is not affected by land or cash constraints. Improved hive can substantially increase production.

(iii) HIGHLAND: Low Agricultural Potential (moderate to high moisture stress risk) with Good Market Access: Located mainly in the Tekeze Basin.

(a) Overall Strategies:

A key strategy is the conservation of soil moisture to reduce risk of crop failure as well as to reduce the risk of using inorganic fertilizers. Soil and water conservation structures should be integrated with other improved crop and soil husbandry measures. Relatively higher urban market prices for cereals in these areas are likely to make fertilizer use profitable in years of average to good rainfall. Some form of crop insurance may be feasible in these areas. Urban centres in close proximity may provide opportunities for non-farm employment.

(b) On-farm Interventions

Improved Soil Husbandry: The use of manure and compost increases soil organic matter and nutrients and increases water holding capacity. This intervention requires sufficient quantities of manure and residues, and labour and thus need to be integrated with improved animal husbandry interventions.

Improved tillage: Contour ploughing assists in reducing runoff and soil movement.

Grass strips: Given the low and variable rainfall grass strips are not likely to be successful on their own, but might be used to supplement physical structures.

Stone terraces: These are more efficient in retain soil moisture that bunds or grass strips. In many parts of the Development Domain surface stones are readily available. The high rate of adoption indicates that many farmers appreciate their use for soil and soil moisture conservation.

On-farm Forage Development: tree legumes (*Gliricidia sepium*) which could be used to supplement low quality native grasses, grasses (e.g. including but not limited to *Pennisitum purpureum*, *Cenchrus ciliaris*) and pigeon pea for supplementary feeding of calves and lactating cows.

On-farm Tree development: In Tigray (and increasingly in Amhara) Region land on degraded hillsides is being allocated to individual households for tree production (tree planting on cropland is prohibited). Cultivation of tree legumes (*Leucaena leucocephala*, *Sesbania sesban*) on these individual hillside plots (as dual purpose forage and fuelwood trees).and of *Stylosanthes spp*. (Stylo). Stylos are very hardy and resistant.

(c) Interventions on Communal Lands

Cut-off Drains: A pre-requisite for in-farm soil conservation measures is a cut-off drain above cultivated areas. Even by themselves they can reduce in-field run-off and soil movement.

Road and track drains: run-off from roads needs to be controlled with small check dams and safe outlets to streams.

Gully Stabilization: This requires the integrated stabilization of both the gully and its catchment area. This will require a combination of livestock exclusion (in both catchment area and gully), and vegetative and structural measures (check dams, etc) within the gully. However, given to low and variable rainfall, vegetative measures will require longer to establish than in high rainfall areas. Initially, there may be a need for more emphasis on physical structures to allow vegetative measures time to establish.

Communal Forage Development: To be effective and sustainable this best undertaken at the sub-kebelle (tabia) level. This intervention usually requires some form of area closure with cut-and-carry, or controlled grazing or controlled hay production and harvesting. The site of the intervention can vary from steep and degraded hillsides, poorly drained valley bottoms, and stream edge buffers. A key object is to reduce livestock movement. The time taken for vegetation to recover will be longer than in high rainfall areas and harvesting of grass and trees will need to be delayed. It will be important that individual measures for improved fodder production are in place before closure.

Small-scale Supplementary/full Irrigation: For high value marketable crops (vegetables, green maize). Given the good market access high value perishable crops can be grown. Alternatives are supplementary irrigation for larger areas when supplies are high and prices lower or full irrigation of smaller areas when supplies are low and prices are higher.

Water-harvesting: This refers to the collection of water into small ponds or micro-dams for small-scale irrigation, human and/or livestock water supplies.

(iv) HIGHLAND: Low Agricultural Potential (Moderate to high moisture stress risk) with Poor Market Access: Located mainly in the Tekezi Basin.

(a) Overall Strategies:

A key strategy is the conservation of soil moisture to reduce risk of crop failure. Soil and water conservation structures should be integrated with other improved crop and soil husbandry measures. The opportunities for agricultural development for marketable produce in these areas are much more limited. The strategy for own-consumption agricultural production should be to ensure food security. Marketable agricultural products will be limited to high value, low volume and non-perishable products. These could include crops such as onions and peppers, small livestock such as sheep and goats, and honey production. In parts of Ethiopia improved goat production by women has proved very successful, particularly for women-headed households. The long-term Government strategy is to improve accessibility to markets through feeder road and farm to market road construction.

Improved Soil Husbandry: The use of manure and compost requires sufficient quantities of manure, residues and labour. Given the poor accessibility to markets, the strategy for improved livestock production is to focus on small ruminants. Quantities of manure are likely to be limited and reserved for marketable products such as onions and peppers grown on backyard gardens or in-fields.

Improved tillage: Contour ploughing assists in reducing runoff and soil movement and is already widely practiced.

Grass strips: Given the low and variable rainfall grass strips are not likely to be successful on their own, but might be used to supplement physical structures.

Stone terraces: These are more efficient in retain soil moisture that bunds or grass strips. In many parts of the Development Domain surface stones are readily available. The high rate of adoption indicates that many farmers appreciate their use for soil and soil moisture conservation.
On-farm Forage Development: tree legumes (*Gliricidia sepium*) which could be used to supplement low quality native grasses, grasses (e.g. including but not limited to *Pennisitum purpureum*, *Cenchrus ciliaris*) and pigeon pea for supplementary feeding of oxen and small ruminants for sale.

On-farm Tree development: In Tigray (and increasingly in Amhara) Region land on degraded hillsides is being allocated to individual households for tree production (tree planting on cropland is prohibited). As the pole markets are inaccessible the focus should be on cultivation of tree legumes (*Leucaena leucocephala*, *Sesbania sesban*) on these individual hillside plots (as dual purpose forage and fuelwood trees).and of *Stylosanthes spp*. (Stylo). Stylos are very hardy and resistant.

(c) Interventions on Communal Lands

Cut-off Drains: A pre-requisite for in-farm soil conservation measures is a cut-off drain above cultivated areas.

Road and track drains: run-off from roads needs to be controlled with small check dams and safe outlets to streams.

Gully Stabilization: This requires the integrated stabilization of both the gully and its catchment area. This will require a combination of livestock exclusion (in both catchment area and gully), and vegetative and structural measures (check dams, etc) within the gully. This intervention can be integrated with a communal forage development programme.

Communal Forage Development: To be effective and sustainable this best undertaken at the sub-kebelle (tabia) level. This intervention usually requires some form of area closure with cut-and-carry, or controlled grazing or controlled hay production and harvesting. The site of the intervention can vary from steep and degraded hillsides, poorly drained valley bottoms, and stream edge buffers. A key object is to reduce livestock movement. The process of natural re-generation can be supplemented with over-sowing of herbaceous (*Pennisitum purpureum*, *Panicum maximum*) or tree legumes (*Leucaena leucocephala*) and pigeon pea but this increases costs. The intervention can also be integrated with communal multi-purpose tree production.

Small-scale Supplementary Irrigation: For high value non-perishable marketable crops (onions, garlic, peppers) using supplementary irrigation for maximum area (given good storability season price fluctuations are small).

Water-harvesting: This refers to the collection of water into small ponds or micro-dams for small-scale irrigation, human and/or livestock water supplies.

(d) Other Interventions

Honey production: In densely populated areas where land is short honey production is not affected by land or cash constraints. Improved hive can substantially increase production.

(v) LOWLAND: Medium to High Agricultural Potential (Moderate to low moisture stress risk) with Poor Market Access: Located mainly in the Abay Basin and small area in the south-western part of Tekezi Basin

(a) Overall Strategies:

Soil fertility rather than soil moisture is the key constraint to crop production. South of the Dinder River tsetse fly infestation and trypanosomiasis is the key constraint to livestock production. Malaria is the key constraint to human settlement across the whole area.

Three overall development strategies are available in these areas. (i) Intensification of existing bush-fallowing cultivation; (ii) development of medium to large scale commercial agriculture, and (iii) large-scale irrigation.

(i) Intensification of Existing Extensive Cultivation

Currently most cultivation in this domain follows a bush-fallowing system. Locally cultivation is becoming more sedentary where fallow periods are becoming too short to enable vegetation to recover. Only in these areas are intensification interventions likely to be adopted.

Improved Soil Husbandry: In the absence of bush fallowing the range of appropriate improved soil husbandry interventions are limited. Use of chemical fertilizer would not be economic given the poor accessibility, high costs of transport and lack of markets. Weed composting is a traditional method of improved soil husbandry practiced in south and southwestern Ethiopia and would be appropriate in this Development Domains Intensification is likely to take place of soils of highest fertility: alluvial and colluvial soils.

Small ruminants: As areas of vegetation are permanently cleared around villages and the tsetse challenge is reduced keeping of small ruminants is possible and provide an additional livelihood strategy.

(ii) Development of Large and medium Scale Semi-mechanized Agriculture

Since 1991 the State Farm rainfed sector has almost ceased to operate and one large State Farm in the Lower Didessa Valley has been totally abandoned following soil fertility decline. There has been a slow growth of the private large-scale rainfed cropping sector in the western Lowlands in the Beles, Dinder and Tekezi basins since the Investment Proclamation in 1995. Land is held on long-term leases from the Regional State Government. The main crops have been sesame and cotton. Most of these farms are located in areas close to the large mechanized farms in Sudan just across the border. In Sudan and in the lower Didessa Valley, the absence of 25 percent fallowing or soil fertility maintenance, soil fertility decline and falling yields have been experienced.

(iii) Large-scale Irrigation

There is one major irrigation scheme currently under development in the upper Beles Valley with plans to irrigate 5,000 ha. Others are planned in the Lake Tana Basin, the Anger and Didessa valleys south of the Abay River, as indicated in table 20.

(v) LOWLAND: Low Agricultural Potential (Moderate to low moisture stress risk) with Poor Market Access: Located in the Tekezi Basin.

(a) Overall Strategies:

Soil fertility and soil moisture are both constraint to crop production. Tsetse fly is not present in this Development Domain. Malaria is the key constraint to human settlement across the whole area.

Three overall development strategies are available in these areas. (i) Intensification of existing bush-fallowing cultivation; (ii) development of medium to large scale commercial agriculture, and (iii) large-scale irrigation.

(i) Intensification of Existing Extensive Cultivation

Currently most cultivation in this domain follows a bush-fallowing system. Currently population densities are so low that there is no immediate danger of fallow periods are becoming too short to enable vegetation to recover. However this may change if there is substantial development for resettlement, large scale rainfed or irrigated farming.

Small ruminants: As there is no tsetse challenge keeping of small ruminants is possible and can provide an additional livelihood strategy.

(ii) Development of Large and medium Scale Semi-mechanized Agriculture

The same caveats apply regarding soil fertility as in the Development Domain to the south apply here also. In addition, there is an added constraint of a much higher risk of soil moisture deficits occurring in this Development Domain.

(iii) Large-scale Irrigation

There is one major irrigation scheme being considered in the Humera area with plans to irrigate 43,000 ha.

8.3 Other Strategic Interventions

8.3.1 Incentives

A distinction needs to be made between incentives for on-farm (i.e. private) soil conservation investments and those for community investments. Clarity is required in implementing food for work as an incentive and food for work as direct food relief.

The Federal Rural Development Policy reflects the new ideas and intentions with regard to the role of food aid. It advocates the replacement, where possible, of food for work (FFW) by cash for work (CFW) and, if food is to be used (e.g. for direct relief), it is preferred that food to be procured from local sources.

A different basis needs to be created for motivating and/or compensating farmers to contribute to community work. Some measures for consideration are:

- establish a transparent distinction between on-farm work, voluntary as much as possible, and off-farm development activities that can be compensated by FFW or CFW,
- abandon the application of FFW for on-farm work, and promote the integration of SWC as to become part and parcel of farming practices,
- to harmonise the above measures with ongoing FFW through the WFP-MERET project,
- create alternative, off-farm opportunities for employment and income generation (cash-for-work, farm inputs for work),
- replace "Community Participation" and mass mobilisation campaigns by voluntary work in farmers own village areas on locations selected by farmers themselves,
- ensure that farmers exempted from Community Participation are not loosing opportunities of working in other schemes of employment generation,
- ensure that SWC treated areas will be exempted from land redistribution.

Introduction of such measures requires action at all levels, focussing in the first place on changing attitudes, both of farmers (driven by a food dependency syndrome), authorities (still used to top down planning and implementation) and donors (putting too little emphasis on impact monitoring and cost effectiveness).

The overall objective would be to achieve **genuine community participation** in development activities by empowering, facilitating and assisting local communities in:

- fully integrating SWC activities into farming practices,
- implementing these on a voluntary unpaid basis, and
- allowing farmers to take their own decisions with regard to implementation locations.

8.3.2 Resettlement of Population

In the centuries before 1975 there had been a slow drift of people from the north moving south to less populated areas. Following the Land Reform of 1975 internal movement within rural areas became difficult particularly in the north where land was already short. Peasant Associations [112]Committees allocated land and first preference was always given to dependants of existing families. Nevertheless, there was continued migration into the sparsely forested areas of the southwest.

During the early 1980's a Resettlement Campaign resulted in large numbers of people being moved from the high population density areas to areas in the western Lowlands. Two strategies were followed: (i) movement to large Resettlement Camps, and (ii) a less intense approach where families were "integrated" into existing highland areas mainly in the southwest. There were many documented instances of involuntary resettlement and following the change in Government in 1991 many of the large Resettlement Camps emptied with people returning to their home areas, although in two areas (the Beles Valley and Assossa) many families remained.

A recent study of the negative impacts of land degradation on agricultural production and strategies to alleviate these (Sonnerveld (2002) took as one of its assumptions that population was free to move within and outside the area of ethnic origin of the farmers (migration scenario). Migration within areas of ethnic origin coupled with soil conservation gave an increase in annual agricultural production of 3.28 percent and 3.8 percent with unrestricted migration. With no migration but with soil conservation the annual increase in agricultural production was 0.19 percent.

[112] Areas with defined boundaries approximately 1,500 ha in extent with about 300 – 400 families.

Since 2003 a new official voluntary resettlement programme is in place[113]. Movement of settlers is confined to within-region movement only – no inter-Regional movement of people is envisaged (the "restricted" migration scenario of Sonnerveld). The programme is designed to take into account lessons from resettlement programmes in the past. These include:

- Desperate people will move spontaneously (14 million people face food shortages in Ethiopia),
- Voluntary resettlement is essential for success,
- Resource user rights of host communities must be respected,
- Participants must be fully informed in order to make choices,
- Potential conflicts can be reduced by remaining within Regional boundaries[114],
- Risks to environment and environmental factors affecting health must be taken into account,
- The Programme must be designed with rules of access and institutionalised implementation (not as a campaign driven by the present emergency, and
- Incentives must built in at each level of design and seek to achieve sustainability.

The GoE has identified the following areas with the estimated number of population to be resettled as follows:

(a) Abay Basin and part Baro-Akobo Basin

Amahra Region) (N.Gonder, Tegede, Metema, Quara):	1,000,000 people
Oromiya Region: (W & E. Wellega, Illubabor, Jimma):	500,000 people

(b) Tekezi basin

Tigray region (Humera):	200,000 people

[113] Government of Ethiopia (2003) “Voluntary Resettlement Programme (Access to Improved Land)”, New Coalition for Food Security in Ethiopia, Nov. 2003, Addis Ababa.
[114] Although as recent events in southern and southwestern Ethiopia this is not a guarantee that ethnic conflict over natural resources will not arise.

(c) Baro-Akobo Basin and part Omo-Ghibe Basin

SNNP Region
(Sheka, Kefa, Bench-Maji, Dawro, Kenta, South Omo) 500,000 people

The Government proposes that amounts of land to be allocated to settlers and to be leased to Commercial Farming must be identified at the same time, and investment and resettlement plans must be harmonized. Initially settlers will be allocated use rights for three years after which if land management is successful full use rights are to be issued for a period to be determined by government.

The programme started in 2003 and is being implemented with domestic funds. A number of potential risks were identified and counter-measures specified in the planning stage. These include:

- Risk of pressure from above for speedy implementation: (built-in triggers in source and target areas with regard to preparedness, suitability and capacity).

- Risk of exposure to malaria and other diseases: (health resources to be made available including clinics, bed-nets provision, etc.)

- Environmental damage (Environmental assessments to be undertaken, potential for forestation and carbon sequestration to be explored).

- Potential conflict over resources, competing claims for land: (land made available to be subject to public consultation, mechanism for adjudication of claims and for compensation to be put in place).

- Insufficient capacity for implementation: (keep demands on local capacity to a minimum, draw on Capacity Building for Decentralized Service delivery programme).

- Dependency on initial food aid and lack of sustainability: (efforts made to bring attitudinal change in programme design and implementation).

- Budget constraint and delays in funding: (proposed budget considered adequate.)

8.3.3 Improving Rural and Urban Domestic (traditional/biomass) Energy Systems.

The focus here is on domestic biomass (or "traditional") energy sources. "Modern" energy sources are considered only in respect of their role as substitutions for biomass sources.

The reason for this focus on biomass energy is because of its very large contribution to household energy consumption, even where modern energy sources (electricity, LP gas, kerosene) are available. This is because a large proportion of household energy is used for cooking and the relative total costs of using biomass fuels for cooking is often lower than modern fuels, particularly when the capital costs of modern energy stoves are taken into account. The widespread and increasing total consumption (with rising population) of biomass fuels has obvious implications for vegetation cover and land degradation. The continued use of biomass fuels and emissions of smoke and corrosive gases in enclosed kitchen spaces also have very important implications for the health of women and children.

Many recent studies of rural (and to a much lesser extent urban) energy consumption have revealed an often complex spatial and seasonal patterns to the various biomass fuels consumed (wood, charcoal, crop residues and cattle dung). Generally there is a clear distinction between rural and urban household consumption patterns with the consumption of a higher proportion of modern energy, and within biomass fuels of charcoal. Except in some parts of Tigray Region, there is virtually no consumption of charcoal by rural households in Ethiopia.

Within the three Sub-basins there are four broad patterns of rural domestic biomass energy systems. In highland Ethiopia (within the Abay/Tekezi basins) a broad distinction can be made between the more humid western and the more arid eastern part related in part to the better natural vegetation cover and also to the much higher number of on-farm planted trees in the higher rainfall areas of the west. The higher number of on-farm trees in the west is also due to the better road system and well developed markets for construction poles. In the western parts wood fuel and crop residues tend to predominate, whilst in the drier east wood, crop residues and dung are used. In the western Lowlands of Ethiopia where population densities are much lower and tree cover still intact, wood is generally the only fuel used.

WBISPP surveys indicate that women and girls are most involved in collecting biomass (mainly wood) fuels[115]. They spend on average 6 and 3 hours per week

2. [115] WBISPP (2005) Energy and Wood Utilization Surveys: Women's' Groups.

respectively collecting biomass fuels, compared with one and half hours per week for men and boys. Women spend an additional 14 hours a week transporting biomass fuels. Boys and girls spend on average 6 hours and men 2 hours per week transporting biomass fuels. The burden of collecting and transporting biomass fuels involves considerable energy - most particularly on children and women. This has negative impacts on nutrition. The considerable time spent on collecting and transporting fuel means less time for other activities (child rearing) and rest. In addition, women and children are exposed to natural hazards and injury.

In the World Bank funded "Access to Energy" Project a number of strategies are currently being pursued. In summary these are:

1. Improved Biomass Energy Utilization Technologies for Rural and Urban Households: Support to private investment in construction and dissemination.

Improved Mitads: The annual reduction in wood use for mitad baking by year 10 would be 7.8 million tons per year.

Lakech Charcoal Stove: publicity campaigns by Regional Bureaus of Rural Energy to maintain the momentum of stove adoption over the ten year period.

Improved ceramic '*gounziye*' Stove with an annual fuelwood saving of 1.8 million tons per annum after ten years.

2. Improved and Sustainable Supplies of Traditional and Improved Biomass Fuels

On-Farm Tree Production: main strategy for supplying fuelwood and poles for rural consumption, and partially meeting urban demand for these products. Sales of fuelwood and poles by farmers to rural and urban markets will support farm income generation and improving rural livelihoods. The programme will also support, and seek to accelerate, the integration of on-farm tree production with crop and livestock production, and sustainable land management.

Sustainable Management of Highland Woodlands and Shrubland Remnants: "hillside closure" to be self-financing by the Communities themselves. Payment of guards and other expenses will be met from fees and charges for cut and carry of hay, fuelwood collection, tree harvesting, etc as may be determined by each individual Community. No external investment funds are required.

Sustainable Management of Highland Forests: develop regional overall land use plans for these forests, and provide support communities to manage High Forests within their jurisdiction.

Sustainable Management of Lowland Woodlands and Bamboo Resources: to ensure the long term sustainable management and utilization of the Ethiopian lowland woodland resources and their associated areas of Lowland Bamboo.

Promotion of Efficient and Sustainable Production of Charcoal: promote the concept of Group Charcoal Burners who would adopt the improved kilns.

Production of Modern Fuels: Ethanol: to be developed and funded by private enterprise with possible concessional funding from the Global Environmental Fund under the "Clean Development Mechanism". Support to comprehensive programme of consumer education.

Briquetting of Agri-residues and Charcoal: Briquetting of agri-residues and charcoal are to be developed and funded by private enterprise.

8.3.4 Improving Rural-urban socio-economic linkages in the context alternative livelihoods.

One of the primary objectives of the Framework for Watershed Management is "to create alternative livelihoods". The proportion of households dependant on agriculture in Ethiopia is 85 percent although the contribution of agriculture to the country's GDP is only 45 percent and declining, with the Service and Industrial sectors providing the remaining and increasing proportions. Much of the latter's activities are taking place in the major urban centres, but also in the small and intermediate centres.

Experience in Ethiopia and elsewhere suggest a number of possibilities for small and medium sized urban centres[116] [117]. These include:

- Increasing rural agricultural income by acting as demand and market nodes for agricultural produce from rural hinterlands.

[116] Barret, C.B., T. Reardon & P. Webb (2001) "Non farm income diversification and household livelihood strategies in Rural Africa: Concepts, dynamics and policy implications", Food Policy Vol.26 No. 4, 315.

[117] World Bank (2004) "Ethiopia: Country Economic Memorandum. Background Paper: Case Studies of agricultural based growth strategies: Options and Tradeoffs with relevance for Ethiopia", World Bank, April 2004.

- Reducing costs and improving access to a range of public and private services and goods from within and outside the immediate region by acting as a centre for production, processing and distribution of goods and services to rural hinterlands.
- Becoming centres for growth and consolidation of non-farm economic activities and employment for rural residents through the development of small and medium size enterprises or the relocation of branches of large private or public enterprises.
- Attracting rural migrants through the demand for non-farm labour.

A study on employment and labour mobility in Ethiopia[118] concluded that migratory labour is an important source of additional income for poor rural households and likely to play an increasing role as a coping mechanism for households facing food insecurity. It noted that little attention has been devoted to this topic than hitherto. Another study in Ethiopia[119] also noted that the development of the non agricultural sector in general and the issue of urbanization in particular should be taken very seriously. The study questioned whether development of the agricultural sector by itself could serve as the engine of growth for industrialization.

A number of key strategies have been identified:

- Develop and improve access to markets through improved road and other forms of communication (e.g. telecommunications);
- Improve access to capital and credit sources;
- Provide basic technical skills (e.g. bricklaying, carpentry, etc) to improve employability;
- Provide support to traders through improved working capital and credit (they provide the link between farmers and non-farm activities and between local, national and international markets).

Together with accessible markets, access to credit and input supplies are main ingredients for rural development. Despite a number of efforts in the past, all

[118] RESAL-Ethiopia (1999) “Employment and Labour Mobility in Ethiopia”, European Food Security Network (RESAL), implemented by Ade, Belgium, October 1999.
[119] Berhanu Nega (2004) “Is Agricultural Development Led Industrialization Strategy a Viable Strategy for Ethiopia?, paper prepared for a symposium to celebrate the 50th Anniversary of Alemaya University, October 30th, 2004.

three are poorly developed, let alone their appropriate linkage. The Millennium Development Goals Needs Assessment Report (Seme Debela et al., 2004) reports, that "consumption levels of fertilizers and pesticides are one of the lowest in the world, and that there is an enormous potential for agricultural development if inputs are made available timely and at affordable prices and acceptable quality and quantity, supported with favourable policy environment."

As far as credit and inputs are concerned, it is very difficult to get out of the vicious circle of poor farmers, high interest rates of private credit providers, low reimbursement rates, limited government capacity to provide soft loans, and non-sustainability of incidental soft loan systems through projects/programmes with a limited duration. Bad experiences in the past (failures of blanket-wise input promotion not suited to all conditions) have made farmers even more reluctant to take credits for agricultural investments.

The importance of soft loans is emphasized by many. The evaluation report of Irish Aid activities in Tigray mentioned access to credit as the best secondary project benefit to farmers. The Report suggests using part of the compensation in cash for community work for the creation of revolving funds for credit supply services.

Ready-made solutions to the credit/supply issue do not exist but a number of preconditions need to be considered:

- more site-specific extension messages need to be developed as to replace previous blanket approaches,
- extension and input supply systems should become more problem-oriented and demand-driven,
- both the demand and supply side should develop in line with market-oriented agricultural development,
- supply systems should be developed by the private sector and not by government,
- institutional development at grassroots level should be promoted to better represent farmers' interests (appreciation of extension messages, knowledge of the market, negotiating interest rates).

Successful examples of credit supply (e.g. by Menschen für Menschen in Merhabete, Mida and Dera weredas in Abbay basin) are based on short term inputs, like providing a starting capital, with appropriate institutional arrangements for long term application. Institutional arrangements need to be based on existing (banking) structures. Revolving funds created and managed by some NGOs within the framework of their ongoing activities are likely to collapse after phasing out of the project.

A number of overall policy issues have been identified as of considerable importance in relation to local economic development in small and intermediate urban centres[120]. These support and reinforce some of the issues previous identified. They include:

- Transport and communications infrastructure are very important although of themselves will not guarantee local economic development.
- Decentralization has great potential in terms of efficiency and accountability but there are a number of cost and other considerations. In particular there is a need to address: (i) access to adequate financial resources, (ii) a favourable climate for local institutions (e.g. land tenure systems, institutional structure of markets, a broader national development strategy that is export orientated).
- Better integration of local, regional and national planning.
- Capacity building of local institutions especially where decentralization is recent.
- Strengthening of local democracy and civil society to make it easier for poor groups to have their needs taken into consideration.

8.3.5 Towards an Alternative Approach for Achieving Sustainable Natural Resource Use in the Baro-Akobo Sub-Basin

(i) Introduction and Principles

The Baro-Akobo Sub-basin and its extension into the Pibor-Sobat-White Nile Sub-basin has a number of unique characteristics that set it apart from the Tekeze-Atbara and the Abay-Blue Nile Sub-basins. The large areas of natural Montane and Lowland High Forest, vast areas of wetlands, the extremely varied socio-cultural characteristics of the peoples of the Sub-basin, the close inter-relationships between hydrology, ecology and livelihood support systems are all important factors to be taken into consideration in developing a sustainable watershed management framework. Nevertheless, many of the concerns

[120] Satterthwaite, D & C. Tacoli (2003) “The urban part of rural development: the role of small and intermediate centres in rural and regional development and poverty reduction.”, paper prepared for DIFID by IIED, London.

expressed in connection with the Baro-Akobo Sub-basin apply equally well to the other two Sub-basins.

While the Baro-Akobo Master Plan remains the official approach of the Ethiopian government for the development of this sub-basin, and the plan has been discussed with the regional governments in the sub-basin, it has never been fully reviewed and formally accepted. Indeed, as suggested above there are a number watershed management issues concerning its approach. It seems that an alternative and more realistic approach to land use development in this sub-basin should be considered at this time. This should include recognition of the sub-basin's contribution to the Nile Basin and the importance of its watershed functions.

The alternative approach proposed suggests that it is important to recognize the needs of all the local communities living in the sub-basin, as well as the wider beneficiaries in the Nile Basin, the Ethiopian highlands and the global community. This means that a rights-based approach should be applied to the sub-basin's development, one which is both environmentally and socio-economically sensitive, as well as being economically viable and contributing to regional and national development.

Some guiding principles which this approach should include are:

- Recognition of the rights of the indigenous people living in the sub-basin, both their rights to the lands they have traditionally used and the resources therein, as well as their rights to sustainable development,

- Recognitions of the linkages within the sub-basin between environmental conditions and livelihoods and from the sub-basin to downstream communities in the Sudan and eventually Egypt, but also upwind to those parts of Ethiopia where rainfall may in part be due to the evapotranspiration of the forests of the upper sub-basin, and

- Recognition of the global significance of the biodiversity in the sub-basin because of the presence of wild coffee genetic resources in the forests which should be conserved in situ and other biodiversity which is as yet unprotected, as well as the fauna and flora in the Gambela regional park.

(ii) A Framework for Sustainable Resource Use

Any approach to watershed management requires coordination of actions at the basin and sub-basin level with appropriate institutional development, policy coordination and methods for applying the agreed approaches at different levels.

This section elaborates some of the essential aspects of this coordination at different scales.

a) Institutional Development for Coordination and Policy Coherence:

Given the inclusion within the sub-basin of land belonging to four Ethiopian regional states, it is important that a mechanism for coordination is developed. This must address upstream – downstream linkages as well as the management of trans-regional land uses, especially forests.

Coordination of sub-basin management by the four regional states will require the development of an institution which is able to influence, and where necessary control, the actions of agencies within the regional governments. This could be developed from existing experience with river basin agencies such as the Tennessee Valley Authority in the USA, but others in the developing world which will probably have more relevant experience. This institution must have a forum for discussion through which the regions can come to a consensus.

A key question is how it will have the necessary authority to ensure implementation, especially in the face of non consensual decisions. In this respect, it should be noted that there already signs of considerable divergence in policy and action by the regional states, one being the difference between SNNPRS and Oromiya RS with respect to the clearance of highland forests by investors. This body must also be able to address differences of opinion between the regional governments, and national authorities, such as the Ethiopian Electricity, Light and Power Authority (EELPA) over payments for environmental services, such as water for hydro-power generation. A key area of internal negotiation within the sub-basin which the agency must undertake is the balancing of costs and benefits across the sub-basin as the development plan is implemented. This will be especially sensitive where one regional state foregoes a development measure in order to ensure the sound functioning of the hydrological system for the benefit of downstream regions.

Clearly a substantial agency is required as it will have to coordinate the implementation of the sub-basin plan, negotiate trade-offs between the regions wishing to optimize their own gains and ensure strict and equal implementation of national EIA procedures and other guidelines.

b) Policy Coherence

While one of the key responsibilities of the sub-basin agency will be the formulation of a framework development plan for the basin and the coordination of its implementation by the regional states, this must be based on a coordinated and coherent set of policies. In Ethiopia policies are developed at the regional level based on federal government policies. However, there is some room for differing interpretations of federal policies and there are already examples of differing interpretation of investment policies and EIA procedures. Hence achieving policy coherence is not going to be easy.

There is also the need to develop additional policies or policy practice where there are gaps in the working out of the Ethiopian constitution and policies on the ground, or where key issues which are vital to river basin development in this area are not addressed. In this case areas of concern might include:

- Forest policy – on which there has been a vacuum at the national level until recently,
- Biodiversity considerations in development planning, and
- Protection of the rights of minority or neglected ethnic groups, of whom the sub-basin includes many.

c) Strategic Land Use Zoning:

A key element of any coordinated sub-basin development will be a strategic land use framework, or zoning of land use, to ensure that different land uses occur in appropriate parts of the basin for them in order to maximize overall benefits. This strategic land use zoning has to be coordinated at a sub-basin scale across the four regions concerned. This must involve a process of land evaluation to identify the suitability of the land for a range of uses, but it must also include consideration of biodiversity conservation concerns, methods to ameliorate the impact of climate change, and downstream hydrological issues, three areas which are often given little attention.

Critical land use zoning issues to be addressed at this scale include:

- protected areas for genetic resources – especially coffee and forest resources – e.g. Kontir Berhan and Yayu coffee forests, and lowland – highland forest transects - e.g. Godere and Seleseng-Mocha forests, which are two of the top three RPFAs in Oromyia in terms of area of "closed" and "dense" forests, the total number of tree species and level of endemicity.
- protected areas for wildlife – e.g. Gambela Regional Park which is the only wildlife sanctuary in the sub-basin,
- protected areas for catchment management in terms of steep terrain and need to control erosion, but also catchments for planned reservoirs, e.g. the Baro hydro-power scheme,
- sites for irrigated farming, and
- appropriate cropping systems for different areas.

Strategic land use zoning will not only assess where forest must be retained for sound functioning of the sub-basin in terms of hydrological stability and minimal sediment levels, but also where controlled expansion of agriculture can be allowed, and where sustainable logging can also be permitted.

d) Community Empowerment

One specific area where policy development is desirable and coordination within the sub-basin essential, is the role of communities in basin development. In particular, it has been noted above that the state is not very effective in managing protected areas, and the same is likely to apply to any strategic land use zoning. However, there are some NGO initiatives which are showing how community involvement can lead to forest protection and improved land use management. Hence a coordinated policy through the basin which recognizes the role of communities, and bring them into the discussions and implementation of the basin development plan would seem to be appropriate.

e) Community based Land Use Planning

At the local level sustainable watershed management should be achieved through technical measures, such as farming system development and appropriate soil and water conservation measures. However, this should be implemented within the framework of a community land use plan which ensures that land use is matched to land facets using some type of land capability assessment based planning by communities. Given that existing patterns of land rights exist and given sensitivities over redistribution of land it is clearly not possible to reallocate land holdings and relocate land uses completely. However, at the community level some involvement of rural households in planning land use across their area, especially with respect to common access grazing areas, forest resources and conservation measures should be possible with support from the development agents once they have been trained.

(iv) Technical Measures for Sustainable Resource Use and Livelihood Development

a) Forest Management for Livelihood Development.

The debate about forest use and conservation often takes place with little public participation or consideration of the needs of these communities. There are however some approaches to forest management which are now more participatory and even involve handing over responsibility for forests to local communities in order to ensure their effective protection.

It should be recognized that with forests there are two potentially conflicting scenarios based around conservation for their environmental functions and transformation to fulfill economic functions. The environmental functions of the high forests in the sub-basin include:

(i) acting as a repository of genetic resources,

(ii) providing habitats for faunal and floral species,

(iii) providing hydrological functions, including moderation of the discharge of water to streams and rivers, and minimization of sediment content,

(iv) protecting soils from erosion and ensuring slope stability, and

(v) being a sink for CO^2.

Economic functions include providing:

(i) timber,

(ii) non-timber forest products (NTFPs) (e.g. honey, coffee and spices),

(iii) agricultural land.

The development of NTFPs is seen as one way in which the value of the forests can be increased and thereby communities encouraged to develop participatory forest management groups which will protect and maintain the forests. In this way both the environmental and economic functions are supported, rather than these being in conflict.

One NGO project is already experimenting with this in the Mizan Teferi and Masha areas of the upper sub-basin in SNNPRS. To date this has involved training for forest fringe communities in NTFP production, especially modern beehives to widen community involvement in this activity, as well as increased production. Domestication of spices, especially Ethiopian cardamom, is also being undertaken along with the planting of spices in degraded forest fringe areas to increase the value of this forest. Community nurseries have been established to produce seedlings and women’s groups are involved in managing the planted areas. Improved management of wild forest coffee is also supported through training, while quality control advice is being given for picking and post-harvest handling to increase the value of this specialist coffee. Different combinations of these NTFPs are found across the project area depending on altitude and rainfall, while there are many domestically used NTFP whose sustainable management is also being supported.

Marketing is a key element in this NTFP development. Honey producers have formed marketing groups in order to be able to negotiate with traders and a contract has been established between seven of these and a specialist honey trader who can process the high water content honey from this area. As a result of this linkage honey prices have increased threefold over a three year period. Organic certification of coffee in the area has also been achieved through two cooperative unions and marketing of this coffee with a premium is being undertaken through an international network linked to the certifier.

To link NTFP production to forest management and protection, agreements are being made with government agencies for the local communities to take over the management of the forest areas, including Region Priority Forest Areas (RFPAs). Through this arrangement the communities will be responsible for the day to day management and protection of the forest, while the government will oversight their activities to ensure that forest destruction is not occurring. These Participatory Forest Management (PFM) Groups will be funded by a levy on the extraction of commercial NTFPs, such as honey, spices and coffee. This is a trial case of devolving forest management to the lowest feasible level, a case of subsidiarity which is often proposed as a way to improve natural resource management.

There are a number of pros and cons of the experience to date. On the positive side the communities have a large body of knowledge about the forests they use and they understand the importance of maintaining it. Communities have been happy to form PFM Groups and as yet these are working smoothly and will soon be registered as Associations to make them legal entities under Ethiopian law. This is important as these PFM groups sometimes feel threatened by the way grants of forest land are made by the regional government without reference to the zonal or wereda officials, let alone the communities concerned. Once they have a legal status and their forest areas are registered as community managed forest, they will also be able to enter into negotiations with other organizations, such as the regional government with respect to any land allocations to investors and with irrigation schemes and hydro-power companies with a view to obtaining payments for the environmental services they provide. The later should further encourage forest protection.

Another advantage of getting PFM groups and their forests legalized is that their claims for forest land help create clear limits within which community based participatory land use planning can take place, and so control agricultural expansion.

The types of NTFPs vary across the sub-basin and in BSGRS, outside the area where the project operates, there is the potential for the production of gums and resins. The estimated production of the gum arabic and of resins from the whole of BSG (not just in the sub-basin) are shown in Table 81.

Table 81. Potential Sustainable Production of Gums and Aromatic Resins in the BS-G Region.

ZONE	Potential production 1st grade (tons/annum)	Potential production 2nd grade (tons/annum)	Potential production grade 3 (tons/annum)	Potential production Total (tons/annum)
(i) Gum arabic				
Asossa	18	88	9	**115**
Kamashi	130	53	56	**239**
Metekel	65	181	29	**275**
REGION	**213**	**322**	**94**	**629**
(ii) Resins				
Asossa	5	87	**-**	**92**
Kamashi	1	17	**-**	**18**
Metekel	12	154	**-**	**166**
REGION	**723**	**1,352**	**-**	**2,075**

b) Farming Systems Development

The driving force to land use change, especially deforestation, in most of the sub-basin is population growth and the demands for increased farm land as the number of farm families has increased and crop yields have fallen. The way to address this has traditionally been forest clearance, and more recently the use of chemical fertilizers to maintain yields.

A major crisis for the government's Sasagawa 2000 fertilizer programme occurred in the early part of this century when many farmers faced serious debt problems in Wellega due to the bumper maize harvest and low prices which reportedly saw some farmers to have had to sell oxen in order to repay their loans. This led the government research and extension service to seek other ways to improve yields and maintain soil fertility. Initially this led to the introduction of composting technologies, while there has also been renewed attention to other biological methods, such as agroforestry and biological soil and water conservation methods. There has certainly been some positive experience with such methods with one NGO in the Metu area reporting increases of over 30% in crop yields following agronomic soil and water conservation activities alone.

This experience, along with the problems which have faced some farming systems in coping with population growth, suggests that much greater attention should be given in agricultural extension to supporting the evolution of the various farming systems in the sub-basin to cope with the population growth and ensure sustainable use of the natural resources. This will involve the use of local resources to maintain soil fertility – especially the use of organic matter and compost, cropping arrangements to reduce erosion and improve soil fertility, as well as soil and water conservation measures including agro-forestry and biological conservation techniques. However, this requires on-farm research to ensure that methods proposed are economically viable and appropriate for the labour availability and environmental conditions in the area. Further such on-farm research has to be undertaken in the different farming systems and also for households with different resource endowments in each farming system. The past problems with blanket extension messages must be avoided. Farming system development must also be linked to market development in order to encourage farmers to invest in maintaining the structure and fertility of their land.

In some part of the sub-basin, major challenges in farming system development exist. In Western Wellega action is urgently needed to address catchment degradation and the extreme pressure which is being put on wetland through their intensive cultivation. While technical measures may be developed to address specific problems, which include termite damage of biological conservation initiatives, diversification of rural incomes is also necessary.

c) Sustaining the Upper Sub-Basin Wetlands

There is no government policy about wetlands. In general they are seen as wastelands which could be used more productively if they could be transformed through drainage and water management. However, such transformation often means that their environmental functions, especially for water supply and water storage are lost, while there are difficulties in maintaining soil fertility and sustaining crop yields. The typical result is that those previously multiple benefit areas are degraded and become single benefit ones, providing only rough grazing.

Research and field development activities by a local NGO, Ethio Wetlands and Natural Resources Association (EWNRA), over a ten year period in the upper sub-basin near Metu in Illubabor Zone has shown that cultivation and some hydrological storage and water supply functions can be sustained almost indefinitely if a set of practices are followed. In one case where these were used over 80 year of wetland cultivation and use were reported. However, in most communities only some, or none, of these are practiced and so wetlands are in general prone to degradation once cultivation commences. The key practices which are recognized by the local communities as a result of their own experiments and which are now part of their local knowledge include:

- Achieving a multiple use regime with only parts of the wetland in cultivation in any year,

- Restricting the drainage period and avoiding double cropping which involves a 10 month drainage period,
- Maintaining a swamp area at the wetland outlet to prevent down-cutting and lowering of the water table,
- Maintaining a swamp area at the head of the wetland as a water reservoir,
- Avoiding drainage within 5 metres of springs around the wetland edge,
- Minimizing the depth of the drains and using ditch blocking techniques to prevent overdrainage,
- Using ditch-blocking to ensure the wetland floods in the wet season to replicate the natural flooding regime, and
- Keeping the slopes coming down to the edges of the wetlands under natural vegetation to reduce sediment deposition.

Based on this experience a model of sustainable multiple use in wetlands has been developed which is being used in extension discussions by EWNRA with wetland using communities in the area (see Figure 24).

Wetlands also benefit from sound catchment management as much of the water flow into them is at the subsoil level from the interfluves. As a result, soil and water conservation measures in these areas, as well as the maintenance of natural vegetation and coffee forest on the catchment slopes has been found to help maintain wetland water supplies. Hence sustainable wetland use will also benefit from community based participatory land use planning.

However, it is to be noted that in the most sustainably managed wetlands there tend to be locally developed, or traditional, community institutions which undertake some wetland management activities. Some are also involved with choosing wetland for cultivation, protecting swamp areas within wetlands, coordinating cultivation and the preparation of the land. However, in most cases these committees have a rather narrow focus and ignore the full range of benefits which are obtained from the wetlands. A key point is their neglect, in some cases, of the impact of drainage and cultivation on springs, and hence the workload of women when springs dry up. Another area of neglect is the limited attention they give to catchment management issues.

As part of its wetland work the local NGO has come into conflict with the efforts of the government's Wetland Task Forces which seek to expand wetland drainage rapidly and intensify it. Intensification through double cropping is an easy route to wetland degradation, while rapid expansion of wetland cultivation is often undertaken with little attention to the points outlined above as the communities selected by the Task Force usually have no such knowledge and there is no appropriate government extension advice. Where the Task Force tries to impose intensification on communities with a sound understanding of wetland management, there has been resistance to the government orders. Slowly it seems that sustainable wetland management, with a balance between economic benefits and environmental functions is not only becoming better understood by the communities, but also by the government agencies at the wereda and zonal level.

d) Wildlife Protection and Community Benefit Sharing

Among the strategic land use zoning outcomes, it is almost certain that there will be the requirement to maintain and further strengthen the Gambela Regional Park. Although there is little game remaining in this area, with time and proper management, this should become a focus for biodiversity conservation in the lowland sub-basin with wider relevance to the total Baro-Akobo basin. However, achieving effective management and control of access with the National Park will require clear and firm political action and support. This will also involve legal designation and definition of the Park boundaries, significant funding support to the Wildlife Organization, and effective protection of the wildlife.

The creation of such protected areas, as with the forests in the highland sub-basin, requires actions to ensure that neighbouring communities benefit in some way in order to encourage them to protect the resource base. This will involve the establishment of mechanisms for an equitable distribution of the financial benefits accruing from wildlife conservation between the government and the communities. Such benefit sharing measures have been piloted in Southern Africa and these would provide a basis for adaptation to the conditions in this area.

In addition, it is also necessary to recognize that in wanting to have the park protected, those who would otherwise be looking for land in these area for their livelihoods need to be supported to develop alternative livelihoods or develop their existing farming systems so they are more sustainable and do not need to encroach into the protected area.

8.4 Organisational and Institutional Issues

8.4.1 The facilitating role of government

Government still maintains a strong control of all development activities in the country. The inherent danger to this is the adoption of a top-down approach and attitude. In a more open dialogue with development partners at all levels, government would benefit more from an exchange of knowledge and experience of other organizations and institutions.

Numerous activities of government capacity building are being undertaken but these alone will not be effective if not paralleled by a change in attitude. One of the main challenges is to improve information management (exchange of information between organizations, dissemination to lower levels, and building up of a common institutional memory). This would provide the fuel for the engine of up-scaling of successful but isolated development activities.

8.4.2 Project cycle management

There is a need to address discontinuities in the government structure with regard to the overall "cycle" of project identification, planning, coordination, stakeholder consultation and participation, and implementation. Currently, it is not clear who has the responsibility for watershed management and at what level. Thus, these responsibilities need to be better demarcated. It is not necessarily a problem that various organizations take up responsibilities in watershed management (MoWR/BoWR, MoARD/BoARD/WoARD, donors, NGOs) NRM or LUP (MoARD, EPLAUA) as long as there is a workable level of harmonization. In addition, those taking the responsibility or being given a mandate should be able to build up the required capacity to fulfil their task.

Watershed management planners should not plan in isolation but, at all levels, ensure timely consultation with implementers and beneficiaries. Plans should include arrangements for implementation, and at the lower levels, these should be agreed upon by implementers. In the ideal case, planners would also be responsible for (coordination of) implementation, provided that they have the capacity to do this.

8.4.3 Awareness of the conceptual framework for watershed management

There is still a need for improved awareness of watershed management concepts, principles and their implications. Watershed management planning at watershed level is a different subject than planning at the grassroots level. At **higher levels**, planning is strategic and concerned with development pathways in selected "development units or domains" (as used in this regional assessment), planning frameworks, and identification of priority areas. At the **lower level**, planning is concerned with modus of implementation.

Watershed management, as an integrated or holistic approach, should be interpreted more pragmatically. A **holistic approach** to watershed management will need to encompass a detailed and comprehensive understanding of the underlying social, economic and policy causes behind land degradation, poverty, food insecurity and a limited range of livelihood possibilities. In more pragmatic terms, holistic means e.g. that during situation analysis it should be realized that the causes of specific problems may need to be sought in other sectors or disciplines.

Integration does not mean that implementation has to cover all possible sectors of integrated rural development. It means that development or sustainable land management interventions are put into context one with another (e.g. SWC to increase moisture availability to agricultural production; improved stoves as to reduce the need for fuelwood and depletion of forest cover). Targets of integrated approaches should not be set too ambitiously and should not exceed implementers' capacities. The level of detail and relative levels of responsibility among the various stakeholders will depend on a thorough understanding of local circumstances and various options may emerge rather than a single "blueprint" for implementation.

8.4.4 Policy issues

Development policies are formulated from a predominantly economic perspective, with the following consequences:

- Natural Resource Management and SLM related strategies and principles are discussed only very briefly,
- only few policy documents, mainly those related to water resources development, refer to watershed management,
- very few policy documents contain an in-depth analysis of lessons learnt and too easily take the assumed success of previous activities for granted

(i) Validity of the ADLI policy

Berhanu Nega (2004)[121] questions the success of the ADLI strategy and advocates a more balanced development strategy with urbanization given as important a place as agricultural development. He stresses the importance of the overall very low labour productivity in agriculture as another, or even the main, reason inhibiting development of Ethiopian agriculture. On the basis of Government production statistics, he claims that whatever the achievements of ADLI in raising productivity in some specific areas, it has not been able to raise overall productivity at the national level. Poor extension coverage is not the reason, as some 34 % of the farmer population is said to participate in the ongoing extension program. The fact that more and more marginal land with less than the national average productivity is coming into cultivation, is given as a more plausible explanation.

The ADLI strategy is also said to be too much a supply side strategy with little consideration to demand conditions. In good harvest years because of the low purchasing power of the urban population and limited opportunities of exporting surpluses to the international markets, prices fall sharply and so discourage farmers to invest in surplus production.

The author, quoting others, argues that recent history shows that the claim that agricultural development can be the engine for overall development is not correct. Rather that development of agriculture in Ethiopia is constrained by the low levels of urbanization.

Nevertheless, two points are clear:

- agricultural development should be based both on improved input supplies and on favourable market conditions,
- better linkages between the agricultural sector and others are indispensable for overall economic diversification and development.

In spite of the overall picture, small positive changes are noticeable during the last few years. Newly introduced water harvesting practices, together with small-scale and micro-irrigation development, have resulted in agricultural diversification. This can be observed in local markets, which show both a diversified supply of agricultural produce and an increasing demand (willingness to pay higher prices). Factors such as price liberalization, improved access to markets (new roads) and nutrition education are thought to be at the basis of it.

[121] Berhanu Nega (2004) "Is Agricultural Development Led Industrialization a viable strategy for Ethiopia?" - Paper prepared for a symposium to celebrate the 50th anniversary of Alemaya University, 2004.

(ii) Rural Land Policy: Institutional Issues

The national law vests primary rights in the state with the decentralised administration of land to the Regions. However, there is no federal institution responsible for land administration[122]. At the regional level institutional structures vary in each Region, each having adopted a different approach to land administration institutional structures. The current land registration programmes lack consistency, including the way land is administered and user rights granted[123]. The most noticeable differences are in their organizational structures, inheritance and the provisions of permitting sub-leases.

Currently, the land registration programmes have a narrowly technical focus. They are not taking the opportunities to link land reform and security of title with economic investment in sustainable land management, poverty reduction and improved livelihoods.

[122] ARD for USAID (2004) "Ethiopia: Land Policy and Administrative Assessment".
[123] World Bank (2005) "Rural Land Policy in Ethiopia: Aide Memoir",

9. LONG TERM CAPACITY AND MONITORING NEEDS

9.1 Capacity Needs

Ethiopia has the asset of an extensive government structure reaching down to the lowest levels. However, the weaknesses in effective operational capacities are known and improvements are hampered by frequent restructuring and high staff-turnover and frequent transfers.

The limited capacity of government organizations, in terms of means, numbers and qualifications, is one of the key constraints to development. It is noticeable in the sector of agricultural and rural development as well as in all other sectors. An in-depth stakeholder analysis with regard to Sustainable Land Management (SLM) has recently been carried out by EEFPE/IFPRI (Gete Zeleke et al., January 2006). The analysis identifies a number of opportunities and constraints to promote and upscale SLM practices.

Assets and achievements in, and constraints to, sustainable land management as identified by the study, are summarized in the table below. The overriding challenges reportedly are improved information management (horizontal as well as vertical) and capacity building at all levels.

Table 82. Sustainable Land Management: Assets, Achievements and Constraints

Assets and Achievements	Constraints
Ample existence of environmental and development policies and strategies, including land use and land administration policies and regulations	Limited awareness among political leaders of extent and impact of degradation Implementation and enforcement lagging behind Lack of easy diagnostic tools for decision makers Focus of support to low potential areas is considered an outdated concept Lack of differentiation in policy implementation within weredas (weredas can be highly variable in conditions) Persisting land tenure insecurity
Organizational set-up of MoARD down to the Kebele level	Top-down approach to technical assistance Limited capacity at all levels Institutional instability Lack of linkage federal-regional level Sectoral extension packages Lack of extension tools Inconsistency in extension messages Limited access to knowledge and information systems
Harmonization of approaches resulting in a guideline for Community Based Participatory Watershed Development	Not yet translated in guidelines for partly illiterate farmers
Increasing numbers of development agents	Limited knowledge of socio-economic aspects

	Non-participatory attitude Act as messengers instead of as facilitators System of imposed implementation quota Obligations of activities not related to extension
National Research System at various levels; strong presence of international research organizations	Limited research capacity of national system Lack of experience of SLM researchers Lack of functional linkages between organizations Lack of cooperation and communication Lack of awareness of SLM issues among scholars Lack of dissemination of research data to extension
Highly variable agro-ecological environment allows testing wide range of SLM practices	Technological gaps in SLM
Availability of both indigenous and scientific knowledge	Lack of integrated institutional memory Limited dissemination of information Remaining knowledge and information gaps
Availability of successful technology	Implementation only pocket-wise
Existence of donor support	Procedures and requirements demanding and not harmonized
Opportunities for carbon sequestration	No projects formulated in this field
Broad knowledge of SWC structures Some information available on effect of measures	Blanket recommendations, lack of site specific application Lack of integration of SWC with SLM Only recent focus on vegetative measures Delayed diversification of measures Lack of research data on efficiency of implementation Limited knowledge on appreciation by farmers and "farmers strategy" towards SLM activities

Government is aware of these shortcomings and is trying to improve overall capacity of government organizations. The establishment of the new Capacity Building Ministry is one testimony for the government's commitment to further deepen the decentralization process. Recently, donors have tended to shift their focus in development assistance, from projects and programs to budget support and capacity building for recipient partners:

- the Italian funded SRPT (Strengthening Regional Planning in Tigray) project is providing support to BOFED-Tigray. A GIS Department will be created (emanating from the present Department of Physical Planning) providing the cartographic basis for planning. BOFED's database comprises all map data of the Woody Biomass project and the Tekeze River Basin Master Plan study,

- CIDA is supporting capacity building in the BoWR in all aspects of water resources development and water harvesting, both in Amhara Region (SWHISA project) and Tigray (WHIST project),

- GTZ provides capacity building at various levels as one of the four main components in the GTZ-SUN (Sustainable use of Natural Resources) programme, in Amhara, Oromiya and Tigray region,

- USAID is supporting the BoARD in Amhara Region in integrated watershed management policy, planning and implementation capacity,
- the upcoming CIBAS project is also aiming at capacity building in the agricultural sector.

Under PASDEP, a program of intensified training for extension agents and farmers, and establishment of a network of farmer training centres, has been launched. The 2004 Millennium Development Goals document reports an enrolment of 45,000 students of who about 10,000 have completed their apprenticeship programme. The December 2005 PASDEP document reports that 55,000 DAs are being trained, 23,000 of who have graduated.

Improved ratios of DAs per number of farmers are explicit issues in the SPM (Strategic Planning and Management) documents of various government agencies. SPM objectives of the Oromiya Regional Government include e.g. an increase of the ratio of DA/farmer from 1/956 to 1/274, over the current SPM period.

Efforts are being undertaken and ideas are being developed to improve communication between government organizations (e.g. wereda net, video conferencing). Modern communication facilities (internet/e-mail) are used between federal and regional level, but are still very limited or lacking at wereda level.

Opportunities of knowledge management and dissemination, to all levels in society, are not used to the full extent, and are hampered at the lower levels by limited communication facilities. Complementary alternatives in the private sector are not sufficiently encouraged.

Efforts of capacity building in government agencies are numerous (among others, by GTZ, CIDA), and have become high priority on the development aid agenda. But efforts are not as effective as they should be. The capacity to improve technical knowledge simultaneously has its limits, and a large part of the learning capacity is taken by the governmental decentralization process.

Full decentralization has been achieved in only one year, but government agencies, especially the newly created ones (like EPLAUA) and those at lower levels (weredas), are still learning to cope with new tasks and responsibilities. The Ministry of Capacity Building (MCB) has launched a District Level Decentralization Capacity Building Programme (DLDP), but this is said to be concerned mainly with aspects of governance (according to the MCB's Public Relations Office) to guide the overall decentralization process.

Major challenges remain in relation to watershed management, both of technical and institutional capacity at grassroots level and technical capacity at government level. In contacting farmer communities in multi-sectoral technical matters, the extensive government apparatus still has to make use of the rather narrow “channel” of Development Agents. This channel may be “widening” as the outputs of DA training centres are being increased considerably. However, also the level of these DA needs to be improved and their approach to be changed from messenger/supplier to mediator/facilitator. This will require an intensive on-the-job guidance as well as a re-tuning of the TVET curriculum. On the recipient side, institutional development in local communities is seriously lagging behind. At present, although some forms of traditional self-help groups exist, no institutions are available to represent interests of local communities, and full dependency remains on political leadership (Kebele leaders).

Within the framework of community-based participatory watershed management (CBPWM), the formation of local planning committees is now encouraged and at watershed level, watershed development committees are created. Some projects also work with user groups or interest groups (e.g. gully protection working group), and examples exist where Kebeles have formulated by-laws for certain forms of resource management (e.g. for hillside closure). Building on experiences with such low levels of organization, and within the context of sustainable land management and market-oriented agricultural development, more attention should also be paid to formation of producer groups as to improve access to markets, credit and input supplies (refer also to following section).

At all government levels, awareness of the need for integrated watershed management can be observed. Guidelines have been developed for local level watershed management, but at the level of larger watersheds, conceptual, strategic planning and implementation capacities still need to be strengthened.

In Amhara Region, the BoWR is preparing watershed development plans as a component of irrigation development. The plan is mainly technical, and preparation follows a top-down approach. Communities are used as a source of information only. The plan is passed to the wereda (WoA) for implementation, at least three years prior to irrigation implementation. These plans are rarely implemented and are failing for obvious reasons (no consultation with communities and responsible agencies).

Progress is reported with regard to fragmented and isolated activities of various actors. There is harmonization now in overall approaches, supported by generally adopted guidelines. At national level, a platform for donor coordination has been created. In Amhara Region, BoARD has taken initiatives to harmonize activities at the regional level, based on a “Round table Discussion on Watershed Management, 2006”. In this same event, EPLAUA emphasized the lack of coordination between planning agencies and advocated a clear framework for integration, with a better linkage between planning and implementation agencies.

9.2 Monitoring Needs

9.2.1 Data Gaps

During the preparation of this Report it has become apparent that there is a vast amount of data appropriate for watershed management planning available in Ethiopia. The work of the Soil Conservation Research Project laid the foundations of research into soil erosion. Work at the University of Makelle under the joint programme with the KU Leuven, Belgium is continuing this pioneering work. In the MWR the River Basin Master Plan Studies of the Abay, Tekezi and Baro-Akobo River Basins are a mine of data and information for watershed management. From the MARD the GIS and socio-economic database of the WBISSP also provide a substantial set of data.

However much of this data are quickly becoming out of date or the data which is available is fragmentary in time and place. Two main areas of data that require to be filled are (i) detailed landcover mapping, and (ii) long-term and consistent sedimentation data at various scales. These are considered in more detail below.

A third area that requires more research (rather than monitoring) is in the field of poverty and livelihood strategies, and relationships between sustainable land management and determinants of farmers' investment decisions. The substantial work undertaken by Ethiopian Research organizations and the CGIAR group over the past decade is to be continued and will provide much relevant data that will effectively inform policy and strategy development in sustainable watershed management.

9.2.2 Land Use and land Cover

The objective of establishing a land use /land cover monitoring system is to capture the dynamics of landcover and land use in terms of location. Knowledge of the rates of conversion of forest, woodland and shrubland to agriculture and on the specific locations and extents of these conversions would also be a great value in evaluating and reformulating policies and plans on watershed management. In addition the results could be used for monitoring:

- agricultural and rural development;
- domestic bio-energy supply;
- forestry and woodland management and conservation:
- resettlement planning, implementation and monitoring;

- disaster preparedness planning and monitoring;
- water development;
- many other facets of natural resources management and conservation.

For this reason, and given the scarce resources and expenses required to undertake mapping landcover changes, consideration should be given for a wider role for mapping landcover changes (i.e. not only landcover monitoring for watershed management).

Two alternative (though not necessarily mutually exclusive) approaches to monitoring landcover are possible.

The first alternative is to attempt to monitor changes in land cover over the whole country. Any monitoring system must have information on the baseline situation at one point in time (whether past or present) from which changes in the future can be measured. Ethiopia covers some 113million hectares and monitoring landcover changes across the whole country at relatively frequent intervals (say five years) would be extremely demanding in resources. If the whole country is to be monitored then some form of sampling may have to be considered as an alternative to complete re-mapping with all the implications for obtaining statistically reliable data that sampling entails.

Rather than whole-country monitoring a reduction in the resources required could be achieved if a more focused assessment was made of landcover changes in key thematic and geographical priority areas. These might include but be not limited to:

- Assessing landcover changes in the upper catchments of key river basins (e.g. the lake Tana Sub-basin) as an input to analyzing household energy supply changes, sedimentation rates and changes in flood frequency and the need for developing catchment management plans and activities;
- Assessing changes in forest cover in the forest and woodland areas on the frontiers of agricultural expansion;
- Assessing landcover and woody biomass changes in reception areas where voluntary resettlement is being undertaken;

- Assessing woody biomass changes in areas of high-intensity agriculture to monitor on and off farm tree and shrub cover;

- Assessing landcover and woody biomass changes in areas of active expansion of Commercial agriculture (e.g. the western Lowlands of Gondar Zone in Amhara region and Western Zone in Tigray Region).

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- Assessing landcover changes in valley bottom swamp areas in Southwest Ethiopia and impacts on food security, woody biomass, biodiversity and hydrology.

9.2.3 Erosion and Sedimentation Control

The MWR has an extensive network of gauging stations a substantial proportion of which are capable of obtaining data on sediment load. A three years project “Assessment and monitoring of erosion and sedimentation problems in Ethiopia” came to an end in June 2002. The main activities of the project aimed at establishment of “an operational erosion/sediment monitoring network”. The project could not address all monitoring issues. The project had two main components: 1) the upgrading of the network of stations for monitoring rivers in the main basins, with special emphasis on sediment monitoring, and 2) assessment and monitoring of erosion in a selected number of micro-watersheds.

During the project, the emphasis within the first component was on monitoring of priority basins in the Ethiopian Highlands and the establishment of a network of bench mark stations for long term comprehensive measurement of runoff and sediment. Special emphasis was put on collection of sediment data.

The importance of the second component (micro-watersheds) was based on:

- the lack of quantitative information on erosion in, and sediment transport from, small watersheds,
- the lack of facilities to monitor the effect of watershed treatment, mainly in the form of soil and water conservation activities,
- the fact that degradation in small watersheds ultimately causes the high sediment loads in main rivers.

The combination of the two above components (large river network and micro-watersheds) in one project was seen as a first step towards a monitoring system for the entire hierarchy of river basins, from the main river basins down to the micro-watershed. It should be realised however, that runoff and sediment measurement in large rivers relate to sediment volumes only, not to extents of upstream areas eroded. Also, it does not explain the extent and causes of siltation of small dams for irrigation. Although the selected micro-watersheds are representative of large areas in the Ethiopian Highlands, it is not possible to correlate monitoring data in micro-watersheds with data for large basins. Future additional monitoring activities should be designed at several levels in between.

As part of the project, existing data on suspended sediment load in Ethiopian rivers was collated[124]. The database for sediment and run-off data comprises 230 stations over 7 main river basins. Some 110 stations are located in the Abay basin, 16 in the Tekezi and 7 in the Baro-Akobo Basin. However, the data result from a large number of single samples taken for different purposes. The majority of the data consists of only a few observations made over years or even decades. The project finally selected 34 stations for which sufficient data was available to undertake regression analysis to make estimates of annual sediment yield. Of these 15 were in the Abay basin, 1 in the Baro-Akobo Basin and none in the Tekezi basin.

The following evaluation report of the first phase made a number of recommendations:

- consolidation and quality control will be required with regard to appropriate functioning of the installed network of bench mark stations in river basins,
- appropriate monitoring in micro-watersheds still requires substantial, and partly specialised, inputs,
- monitoring should preferably cover the period before, during and after watershed treatment and dam construction,
- substantial capacity building is still required to allow MoWR to become a leading agency in guiding watershed management activities, and
- that a second phase of the project was recommended to respond to these requirements.

The objectives of such a long-term monitoring programme would be to:

- to improved the national monitoring network to produce continuous and reliable data

[124] RODEC (2002) "Estimation of Suspended Sediment Transport of Selected Rivers in Ethiopia – Application of a regression Model", MWR, Addis Ababa.

- To develop and test a monitoring methodology for micro-watersheds to provide information on erosion and sedimentation
- To improve MoWR's capacity in monitoring and in guiding watershed management, and
- to elaborate guidelines for monitoring, sustainable watershed management, and impact assessment;

In order to achieve these objectives a number of activities were proposed.

1. Develop a long-term monitoring strategy including
   - consolidation of hydro-sedimentological network operation
   - rational extension of network of benchmark station in large basins
   - integration of project data into national hydrological database
2. Select, procure and supervise installation of equipment for modest network extension or intensification
3. Assist in preparation of Hydrological Yearbooks
4. Design monitoring devices, e.g. flumes, at the outlet of micro-watersheds/ inlet of reservoirs
5. Define related monitoring requirements such as basic meteorological stations, bathymetric surveys
6. Select and procure monitoring equipment for micro-watersheds
7. Supervise the installation of monitoring devices in pilot micro-watersheds
8. Identify qualified partners for monitoring activities in micro-watersheds
9. Develop and support the first phase of a monitoring programme using verifiable impact indicators
10. Assist in the formulation and execution of a balanced pilot implementation programme in pilot watershed(s), including
    - selection and training of an implementation partner
    - implementation of <u>priority sites</u>/areas for watershed treatment
    - formulation and initial implementation of a <u>sustainable watershed management programme</u>
11. Identify possibilities for linking up monitoring of large basins with smaller watersheds (this would be most relevant within the framework of river basin development, and not necessarily at the national level of river basin monitoring)
12. Train and coach staff at federal, regional and local level in network operation (tools and operation procedures), data collection and data dissemination
13. Propose/ carry out a training programme aiming at
    - general WSM capacity building in MoWR (internal workshops, seminars with other agencies, formal training, on-the-job training, field work training)

- . transfer of know-how in all activities carried out in micro-watersheds

14. Develop guidelines for national network operation, based on lessons learned
15. Develop procedures for dissemination of monitoring data
16. Assist in the development of guidelines for planning of WSM activities
17. Prepare guidelines for monitoring the impact of watershed protection activities

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ANNEX 1.

METHODOLOGY USED BY WBISPP TO DERIVED LAND COVER DATA AND TO UNDERTAKE POTENTIAL SOIL LOSS RATES

1. Land Cover Data

1.1 Data source and classification

The Landsat-TM images with 7 spectral bands, a nominal ground resolution (pixel size) of 30 x 30 metres and a nominal scene size of 185 x 185 km was used. Landsat-TM was used to define the different classes of land cover types. Both visual and digital classification techniques were used to identify the nine major classes and fifty-six sub-classes.

A two-step hybrid classification system was used before the final land cover map is prepared. The first step involves visual classification of relatively larger visually homogeneous polygons, while the second step is digital classification of the above large polygons in to different sub classes.

1.2 TM hardcopy image interpretation

A false colour composite of bands 4-7-1 (Fig. 1) was used as opposed to the conventional false colour composite of 4-3-2. As the project land cover type classification is aimed at capturing two-biomass types in different land cover classes, the bands, which can enhance and help to distinguish vegetation were selected. The delineation of vegetation patterns on the TM hardcopy images was carried out using standard visual classification techniques. These involve:

- Delineation of assumed vegetation type boundaries from the Landsat TM hardcopy on the transparent sheet.
- Identification of vegetation patterns with changes in color tones and texture. Polygons with similar color, tone and texture were grouped in to similar land cover class.

1.3 Digital image classification

The digital classification of images was carried out for the whole of each Regional state.

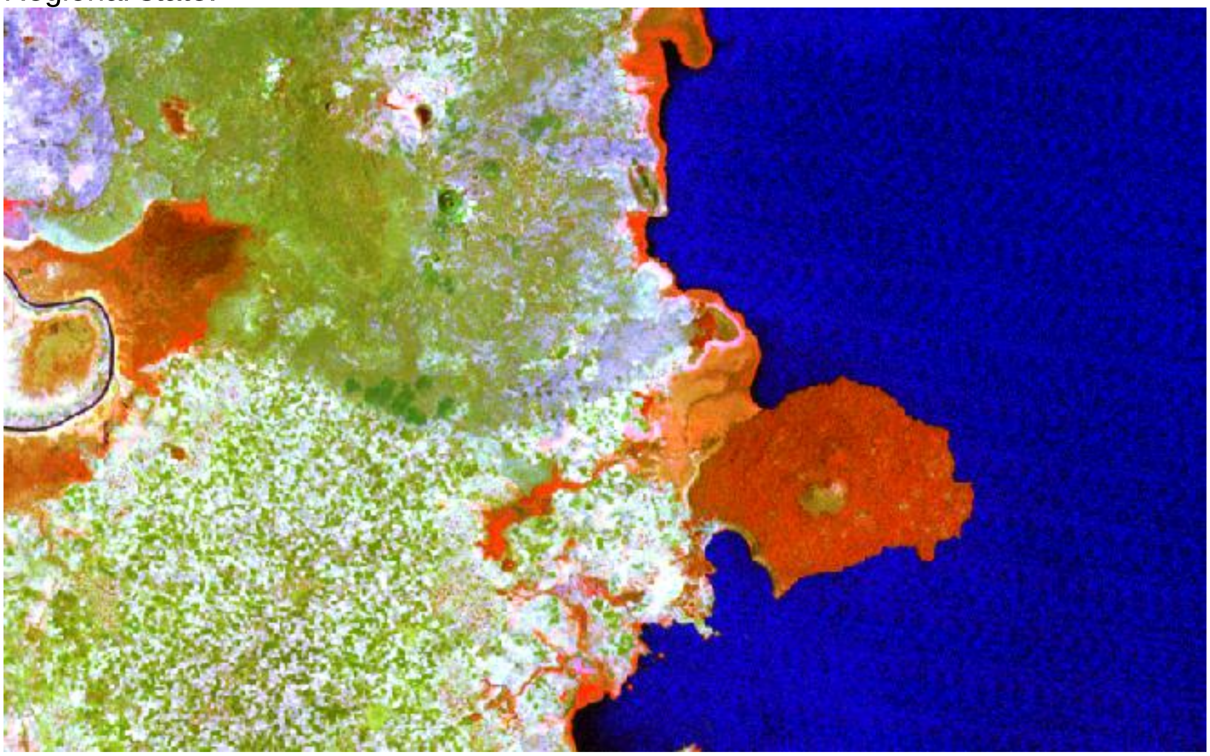


Fig.1. False colour composite of Landsat TM: 4-7-1.

1.4 Bands selection

A Landsat-TM image has 3 visible, 3 infrared and 1 thermal bands. Not all the seven bands were used. In order to reduce computer time and to treat only the most pertinent data, band correlation tests were conducted. In addition to the correlation tests, each band was graphically compared with the others. Tests revealed that there is a high level of correlation between the TM1 and TM2 and between the TM5 and TM7. High band correlation indicates that one of the two correlated bands can be excluded, as its inclusion will not contribute much in terms of adding more information when the other is already considered.

Considering the sensitivity of the TM1 band to atmospheric effects, the TM2 band was selected. According to the band characteristics of the Thematic Mapper, TM5 is more appropriate than the TM7 for vegetation applications. As band 6 is a thermal band, it is not used for land cover mapping. It is only used to map a surface temperature. Finally, four bands, namely, band 2 (green), band 3 (red), band 4 (near infrared) and band 5 (mid infrared), were selected for the digital classification.

1.5 Using digital data

As the Digital Numbers (DN) are calibrated by suppliers in order to allow their immediate use. The DN were transferred from the entire images and were used as they are. None of the images have deteriorations such as bad lines, which result from defects of the detectors. Fortunately, almost all images except the one covering Mt. Choke are free of cloud cover. Even the one covering Mt. Choke has less than 5% cloud cover. In most cases the 5% cloud cover is acceptable if it is distributed all over the image.

1.6 Image geo-referencing

All thematic information is stored in a GIS system and is related to topographic maps of Ethiopia at 1:250 000 scale. Because thematic information from digital images are stored in the GIS, and because some digital information was imported from the GIS during the land cover map preparation, the images must be geo-referenced. All the four bands selected were geo-referenced in relation to the UTM projection (Universal Transverse Mercator). Transparent topographic maps at the 1:250 000 scale were used as a reference to correct the images. The regression model used to fit the image to the maps was a first order polynomial, which allows rotation, scaling and translation. The nearest neighbour resampling method was used in order to avoid changing the original input pixel values.

The geo-referencing technique applied in the WBISPP has some particularities. Due to the age of the maps, features observed on the images are not always present on the maps. Also, some areas showed a reduced number of features, which could be used as control points during the geo-reference process. To overcome these problems, the reference maps, in this case, the topographic maps were used conjointly with the enhanced hard copy images at the 1:250 000 scale. A regression model was created based on the selected control points and was applied to the four bands.

In most cases, between 20 and 30 control points are necessary for developing the regression model. When x and y residual errors are less than one pixel the collection of control points are stopped. The residual is expressed in the number of pixels and gives an overall of the accuracy of the geometric correction process

1.7 Hard Copy Interpretation

Each hard copy image was interpreted using standard image analysing techniques based on tone, infra red reflectance and pattern coupled with the experience of the interpreter of the area being interpreted. These provisional land cover interpretations were transferred to the 1:250,000 topographic sheets and digitized into the GIS.

The image interpretations were then extensively field checked and land cover observations made every 1 to 2 kms and the position recorded with a GPS instrument.

On return from the field GPS readings were downloaded into the computer and super-imposed onto the digital Landsat TM images for revision and re-interpretation. These were then re-digitized where necessary and the land cover legend constructed.

This provided the 1st stage polygon land cover map. The next stage was to refine the land cover within each of the polygons using an unsupervised classification and a next stage interpretation.

1.8 Digital image classification

The land cover variability of Ethiopia and the lack of available ground knowledge are such that the definition of pure training sites necessary for a supervised classification is extremely difficult. The project instead used an unsupervised classification, which does not require prior knowledge of the existence or the type of the land cover classes.

1.8.1 Classification principles

Unsupervised classification uses clustering algorithms that examine a large number of unknown pixels and divides them into a number of classes, spectral classes, based on a natural grouping present in the image values. Within the clustering approach, an image was segmented into an earlier determined number of classes. The premise behind clustering is that features with spectral similarities should be close in the spectral space whereas features from different classes should be well separated. Thus, pixels belonging to a particular cluster are more or less spectrally uniform.

For an unsupervised classification, one of the most common approaches to determine the natural grouping of a data set is the migrating means algorithm.

1.8.2 The migrating means algorithm approach

The migrating means, also called the k-means algorithm, involves many steps. The information that must be provided for its execution is the number of clusters. For the other parameters, the default value can be used. The k-means procedure of EASI/PACE was tested using different number of clusters; typically 10, 16, 20 and 24 clusters. The outputs, the classified maps, were visually compared with an enhanced image of the same area. Results showed that the classification map using 20 clusters was the closest to the enhanced image and was thus selected. From these 20 clusters, 16 were generally retained for the final map prior to field verifications; the remaining four classes representing very small proportion of the image were merged with the cluster closest to it in spectral space. Even using 16 classes appeared excessive and merging some the classes is always expected and considered as a better solution than redoing the clustering.

The k-means algorithm steps are as follows:

1. Due to the amount of data involved, image data sampling was done in multi spectral space to determine candidate clusters centres.

2. The location of each pixel in the multi spectral space was examined and the pixel was assigned to the nearest candidate clusters. The assignment was done on the basis of Euclidian distance.

3. The new sets of means that result from the grouping produced in step (2) were computed.

4. The procedure continues until there is no significant change in the location of class mean vector between successive iterations. In the EASI/PACE software, the default number of iterations was set to 20 and the minimal Euclidian distance corresponds to .01%. The means vector calculation will then stop when one of these two conditions is met.

5. The result of the k-means clustering approach is a thematic map where each cluster is represented by a unique number. Cluster statistics were also produced indicating the mean DN values for each band selected for the classification process.

1.8.3 Classification outputs

The result of the classification is a thematic map where each cluster is represented by a unique number and where pixels falling in the same class during the clustering process have the same number. At 1:250 000 scale, since there is no need to access information pixel by pixel, the classified image was filtered with a Mode filter, using a window size of 5 by 5 pixels. This removes noise pixels and replaces them with the dominant cluster. Arbitrary colours are given to the different classes and if necessary, a grouping was done based on the statistics of each cluster. Finally the classification map was printed with a legend indicating which colour represents each cluster. At this stage, the term "preliminary classification" seems more adequate to define the classification (Fig. 2).

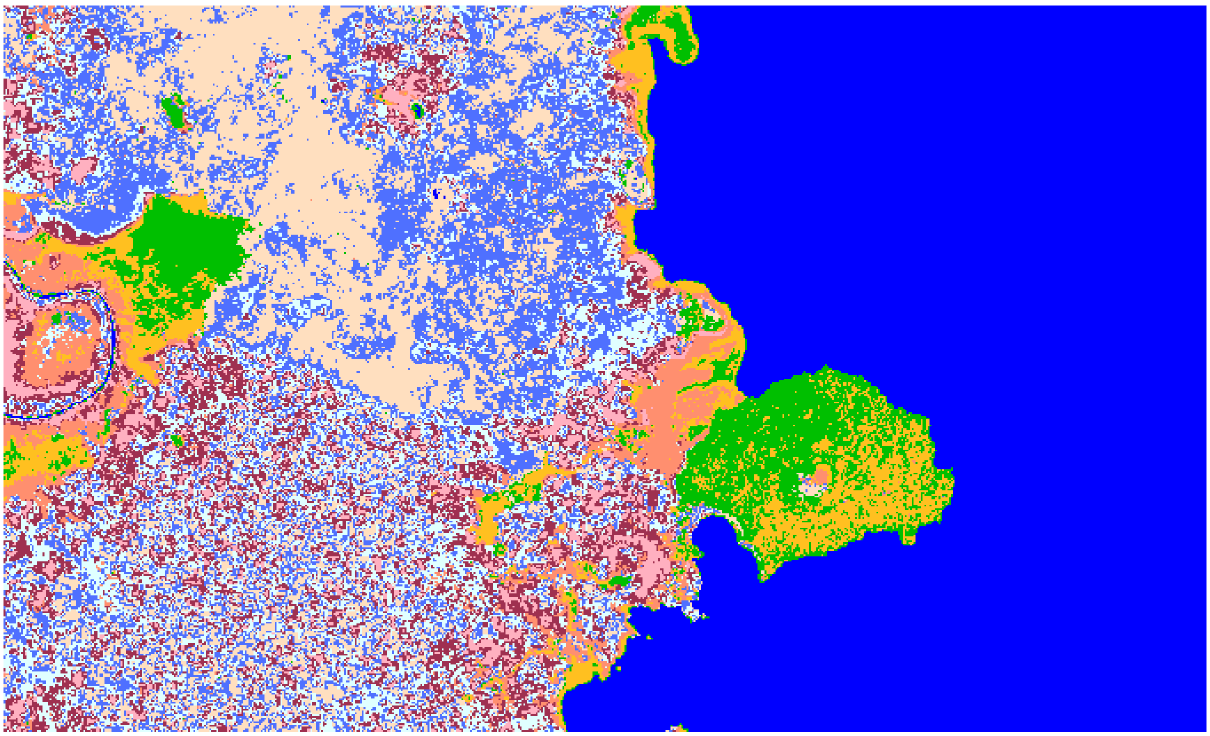


Fig. 2. Clusters (spectral classes) of unsupervised classification.

The next stage was to compare the 1st stage land cover polygons with the cluster patterns on the unsupervised classification map. This was done by overlaying the transparent sheet on the classification map. If necessary, additional subunits can be drawn, but because of the need to generalize, this is generally not necessary.

The visual and unsupervised classifications are carefully compared with information collected during the field phase. The land cover value of each cluster within a polygon identified by visual interpretation was thoroughly examined and a spreadsheet table was produced showing their land cover values.

Then result of visual classification, polygon, were digitized in GIS system and the resulting GIS polygon coverage was exported to Image Analysis System. The two classifications are combined in to one with help of “Model” function in PCI Geomatics (Image Analysis System) (refer to figure 4).

The ultimate step consists of producing final land cover maps. At this stage, field observations are used as the basic information from which it is possible to associate land cover types to each cluster defined during the clustering process.

To produce the final land cover maps for each area, the preliminary classification maps are corrected in order to fit as much as possible with the ground reality observed during the field surveys. The correction of the preliminary classification in order to produce land cover maps, demands that the following steps be undertaken:

1. The polygons delineated visually and verified during field observation, are digitized into the GIS. Later, the vector format is transformed to a raster format and transferred to the IAS.

1. In the IAS, the modelling procedure is used to produce the final land cover map by comparing the visual interpretation polygon with unsupervised classification based on spread sheet table prepared after field verification.

2. The output map, generated during the modelling process, was thematic map. Where a new set of values, arbitrarily defined, are assigned to each land cover type.

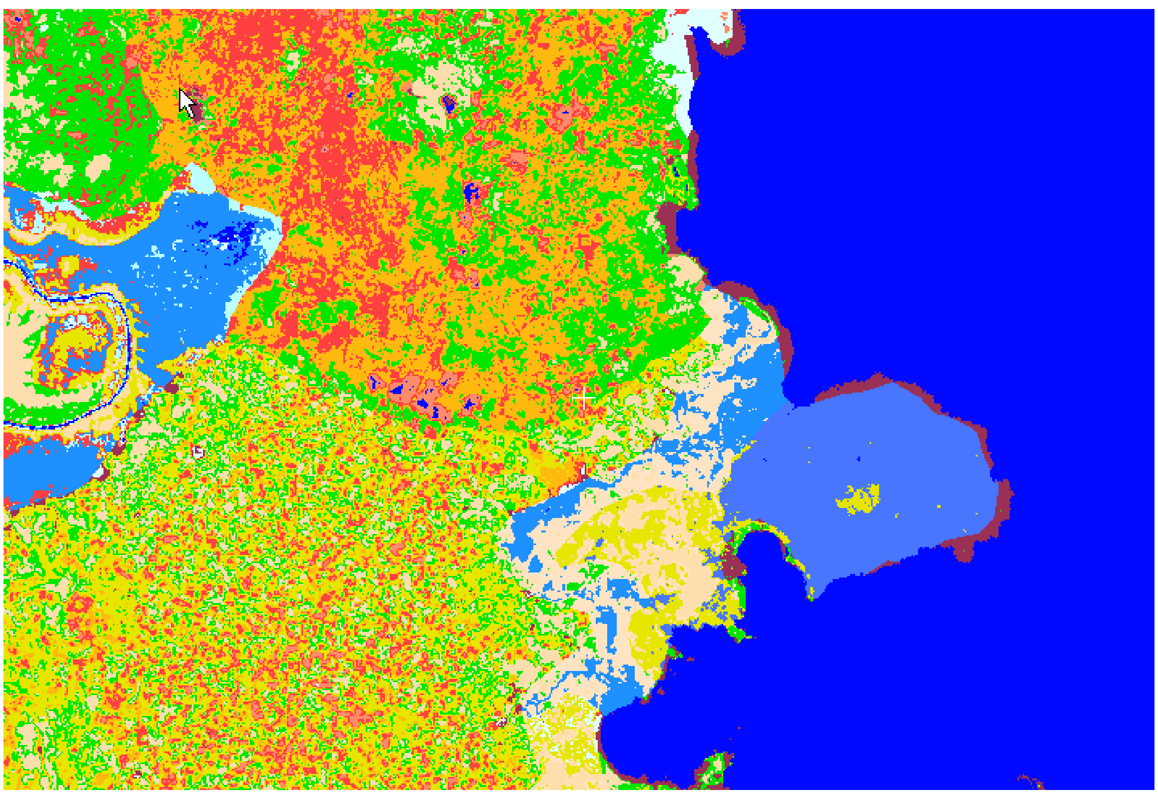


Fig. 3 Land use /land cover classes (information classes)

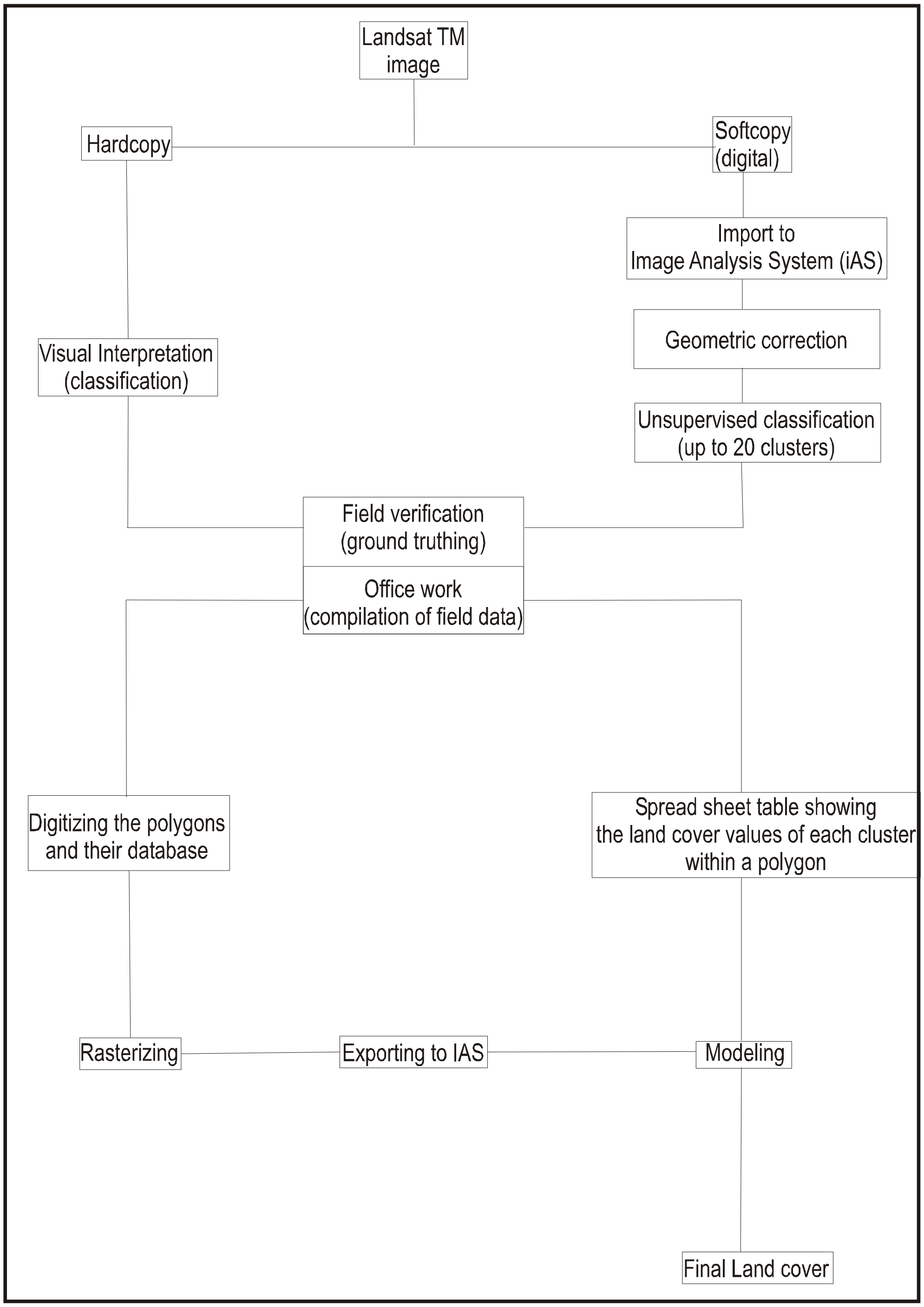


Figure 4. Steps followed in Landsat TM classification.

2. Soil Erosion Analysis

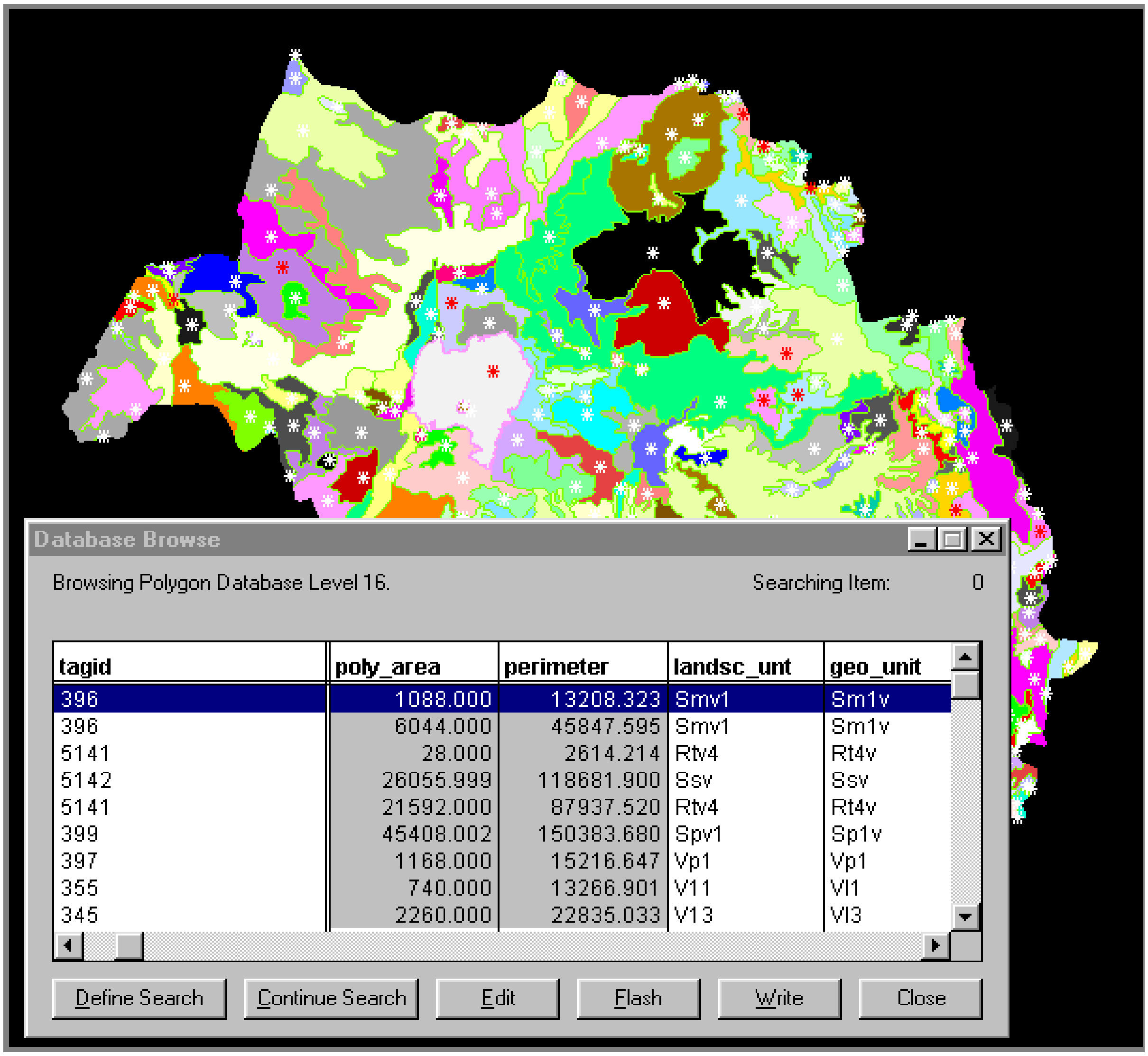
The analysis was carried out internally and externally. Internally means within PAMAP-GIS. Externally means analysis carried out by an external database (Dbase/MS Access). Even though, a number of functions were used in internal data analysis, the major ones such as Polygon formation, Overlay Analysis, Digital Train Model and Modeling modules will only be discussed.

2.1 Polygon and Grid Formation

The first step of analysis for all polygon features digitized from both primary and secondary sources is linking polygons with their associated database with the help of polygons formation module. To do this the program needs two sets of data i.e. a closed vector (polygon) and a database. The program first lays a regular series of equally sized user-defined pixels over the map; second determines which polygon each pixels belongs to; third links all pixels in each polygon to that polygon's database tag or a database record and finally reports on the correctness of the newly created polygon cover. (figure 5).This process is the springboard for the raster analysis that follows. Some of the themes which had undergone polygon formation are the Land cover, Rainfall erosivity and soil erosivity maps.

These vector maps are then converted to raster files for the subsequent analysis.

Fig. 5 An output of a polygon formation.



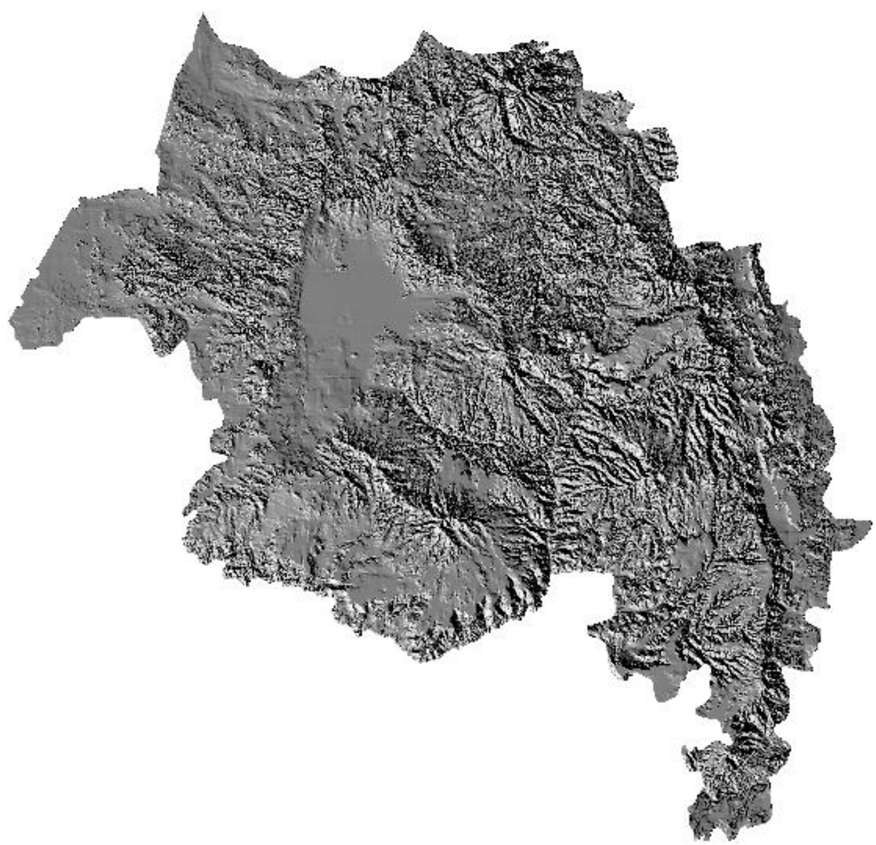
2.2 Digital Elevation Model/Digital Terrain Model

A Digital Elevation Model (DEM) is a surface cover whose Z values represent the elevation (or any other attribute being mapped) of each pixel. The input for the DEM comes from map sheets of 1:250,000 topographic map series produced by EMA with 100 meters contour interval.

The finite difference algorithm was used to interpolate for those pixels with no contour lines. The finite Difference algorithm is a repeated smoothing technique, using a series of iteration over a surface. It can be visualized by the analogy of taking a pegboard filled with pegs of different heights and stretching a rubber sheet taut over all the peg-tops. The pixel values at known data points (i.e., the peg-tops) are not modified, but the values of all other pixels are. The " constant "grooming" of the data results in a DEM surface cover with accurate values for all pixels.

Once the DEM is created altitude, slope, shaded relief and many other maps can be derived (Fig. 6).

Fig. 6. Shaded relief



2.3 Modeling

A modeling module mainly overlays surface covers according to a simple arithmetic or a user-defined mathematical formulae. The mathematical formula can range from a simple arithmetic to complex database models, which uses a wide range of mathematical functions. There are four alternatives to modeling in PAMAP:

Linear database modeling: analyzes polygon, vector or point databases at a time by combing up to 16 database attributes and exporting the result to another database attribute;

Linear surface modeling: uses a simple algorithm to combine up to 16 surface covers into a single surface cover;

Formula surface modeling: applies a formula to combine up to 16 surface covers in to a single resultant cover model;

Formula database modeling: is used to create a model combining up to 16 database attributes on the basis of a user-defined combination formula, then update another attribute with the new calculated value.

The third alternative was mainly used to model a Potential Soil Erosion Hazard (Fig. 8 and 9) using a formula:

A = R*K*L*S*C*P; where

A = Total soil loss (t/ha/yr)
R = Rainfall Erosivity factor, is a surface level derived from Digital Rainfall Model
K = Soil Erodibility Factor, a classified soil surface cover according to a pre-defined norms for each soil type.
L = Slope length factor, is a classified raw slope surface level according to a pre-defined norms for different slope classes.
S = Slope gradient, is a classified raw slope surface level according to a pre defines norms for different slope classes
C = Land cover factor, is a surface level converted from a land cover polygon based on each land cover’s erosion factor
P = Management factor

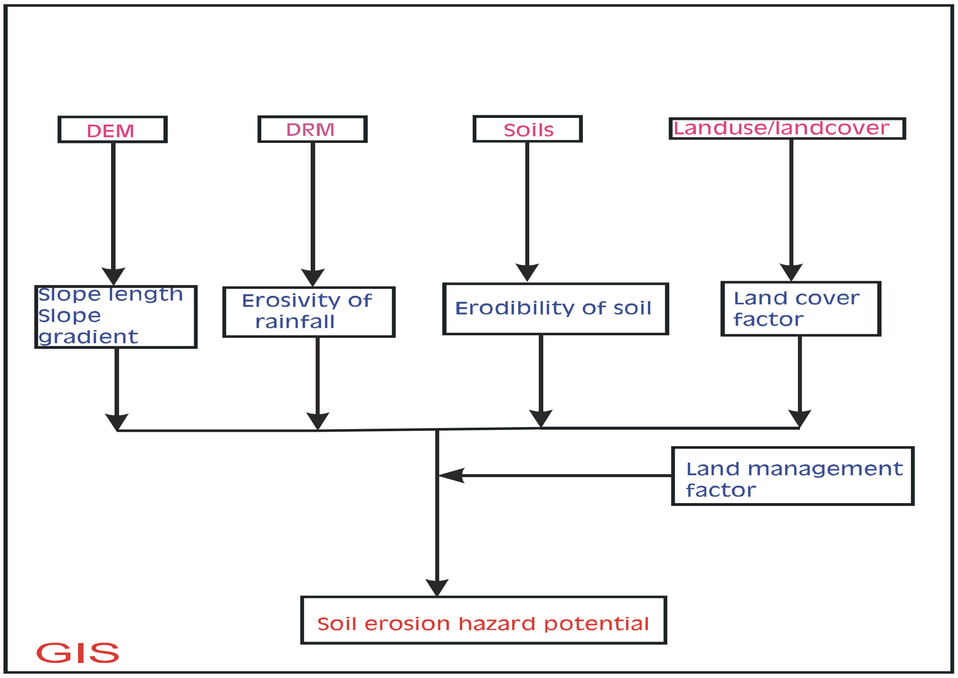


Fig. 7 Potential Soil Erosion Model

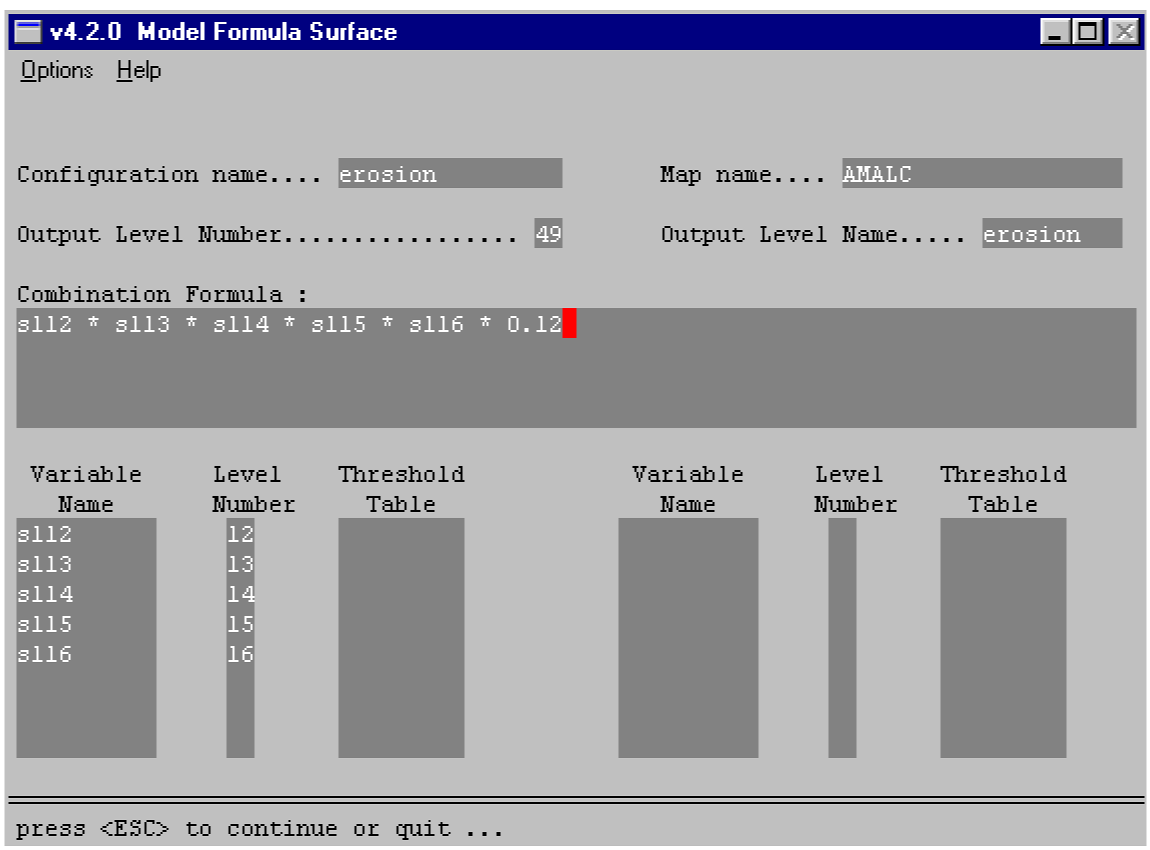


Fig. 8. An example of a surface modelling (Potential Soil Erosion)

ANNEX 2

METHODOLOGY TO DETERMINE CROP PRODUCTION FORGONE FROM SOIL EROSION

SOIL LIFE MODEL

1. Rationale

The "soil life" model derives from work by Stocking[1/] and followed a comprehensive review of the literature of studies on soil loss and its impact on crop production conduced throughout the world. The main conclusion from this and other work is that "erosion reduces productivity first and foremost through the loss of plant available soil water capacity"[3/] by reducing soil depth.

The EHRS estimated nutrient loss due to erosion (at 100 mt or 8 mm per hectare) on croplands as about 5 kg equivalent of DAP per ha (30,000 mts DAP/6 million ha). Most Ethiopian Highland volcanic derived soils have a relatively constant nutrient status down the soil profile, with clay dependant cation exchange capacity (CEC), moderately low to neutral pH, and low aluminium levels. Other than a deficiency in phosphorous they are generally considered to be moderately fertile. The EHRS estimated that nutrient removal is almost totally replaced by soil weathering.

There are three possible exceptions to this generalization. The first concerns soils derived from the basement complex granites and metamorphic rocks found in north Tigray, northwest Wello, west Gojam, west Welega, west Illubabor, south Sidama and the southern parts of the Harege highlands. Termed "Acrisols" they often have high aluminum levels and a pH below 5.5. However as natural soil fertility is very low[4/] soil erosion itself is not likely to lead to a more rapid depletion of nutrients than on volcanic derived soils.

The second exception concerns soils derived from basalts (also termed "acrisols") but which because of the high rainfall are seriously leached of mineral nutrients. These soils are located in highland Keffa and Illubabor. Much of the CEC and most nutrients are present as organic complexes, and are located in the topsoil. Erosion of the topsoil on these soils thus will lead to a rapid decline in productivity.

The final exception relates to soils derived from basalts but located above 2600masl. A farming systems study of Shewa[5/] demonstrated the increasing incidence of following above 2600masl. Similar trends have been observed in Gojam, south Wello and Shewa by LUPRD[6/]. The reason for the rapid decline in soil fertility after one or two seasons of cropping is unclear. It may be related to leaching of nutrients (although the few soil chemical analyses available do not indicate this).

A second cause might be the slow release of organic nitrogen caused by low temperatures and thus slow activity of micro-organisms. In western Europe a nitrogen flush occurs in October after the high summer temperatures have warmed the soils and is thus temperature dependant, whilst in tropical climates the nitrogen flush occurs at the onset of the rains and is thus moisture dependant. In Ethiopia above 2,600 masl it may be a combination of the two factors: with cold temperatures either delaying the flush until late into the rainy season or seriously inhibiting it completely.

A third and related problem may be that the presence of the clay mineral allophane which increases with increasing altitude because the clay colloids are not weathered into kaolinite or illite. Allophane is known[7/] to block the mineralisation of organic matter as well as fix phosphorous. Whatever the reason it is not likely that topsoil soil removal will have any more detrimental effect than on volcanic derived soils at lower altitudes.

The conclusion is therefore that except for the humic Acrisols in the high rainfall areas of Keffa and Illubabor the main impact of soil removal on crop productivity will result from reduced soil depth and thus reduced soil water holding capacity.

2. Methodology

The model uses the following factors in calculating the impact of declining soil depth on crop yield:

-rainfall (by month)
-potential evapotranspiration (PET) (by month)
-actual evapotranspiration(AT)(by month)
-crop coefficients (by month)
-crop water requirements (by month)
-soil water reserves
-excess/deficit

Rainfall: Rainfall data was obtained for Hosaina at 2310 masl in southwest Shewa with a mean annual rainfall of 1192 mm. To avoid "masking" of the start, end and the mid season break of the rains which result when average monthly values are calculated, an actual year's rainfall data (1984) was used, that year being judged as representative of most "normal" years.

Potential Evapotranspiration*:* Potential evapotranspiration was derived from monthly constants and negative regression coefficients multiplied by altitude. Constants and coefficients were derived from work by Wolde Gabriel[8/].

Crop Coefficients*:* are estimated for each crop based on crop growing periods in Hosaina. The growing periods were derived from crop calendars in LUPRD farming system studies[9/] conducted in the areas. Coefficients for defined stages of crop growth were obtain from FAO publications[10/] and assigned to the relevant months. For months outside the crop growing period a coefficient of 0.2 was estimated for weed and stubble cover.

Actual Evapotranspiration: is the PET multiplied by the crop coefficient.

Crop Water Requirements: are the AT values during the crop growing period.

Soil Water Reserves: are the previous month's reserves plus the current month's rainfall less actual evapotranspiration. To allow for losses in the previous month's reserves caused by the percolation of excess water to ground water, a factor of 0.75 was applied. Surplus water above the water holding capacity of the soil is assumed to be lost to overland flow. The potential water holding capacity of the soil was assumed to be as follows:

Acrisols	80mm/meter
Nitosols/Cambisols	100mm/meter
Planosols/Vertic Cambisols	125mm/meter
Vertisols	150mm/meter

Actual holding capacity was effective rooting depth multiplied by potential water holding capacity.

Excess/Deficits**:** were calculated as the difference between soil reserves (factored as above) and crop water requirements.

Water Requirements Satisfaction index *11/*: was calculated as follows. In the month prior to planting the index was set at 100. Subsequent deficits as a fraction of total crop water requirements (multiplied by 100) were deducted from the previous month's index. The index of the last month of the crop growing period represented the cumulative water deficit. The index was correlated with decline in crop yields as follows:

Index	**% of average yield**
95-99	80-100
80-94	50-79
60-79	20-49
<60	crop failure

The correspondence between the index and crop yield have been calculated by FAO from information from many test sites and projects. As far as is known no empirical work has been conducted in Ethiopia.

3. OPERATION OF THE MODEL AND RESULTS

The model was formatted in Lotus 123 and run using Hosaina's 1984 rainfall for six crops and four soil types. Soil depth was progressively lowered and the depth at which crop yield was affected recorded. The results are shown in Table A1-1

Table A1-1

Critical Maximum and Minimum Soil Depths for Four Major Soils (cm)

(a) Acrisols (awc = 80 mm/m)

	Maize	Wheat	Pulses	Sorghum	Teff	Millet
Maximum	123	118	109	100	107	107
Minimum	54	53	46	45	41	34

(b) Nitosols (awc = 100 mm/m)

	Maize	Wheat	pulses	sorghum	Teff	Millet
Maximum	98	95	87	80	86	86
Minimum	43	43	37	36	33	27

(c) Planosols (awc = 25 mm/m)

	Maize	Wheat	pulses	sorghum	Teff	Millet
Maximum	78	76	70	64	69	69
Minimum	33	32	29	29	26	22

(d) Vertisols (awc = 160 mm/m)

	Maize	Wheat	pulses	sorghum	Teff	Millet
Maximum	61	59	54	50	53	53
Minimum	27	26	23	22	20	17

The crops fall into two groups: maize and wheat are the most vulnerable to decreasing soil depth, with relatively high maximum and minimum critical soil depths. Maize is a long season crop that suffers from the drop in rainfall between the belg and main rains and from its high water demands in the main growing period. Wheat although a main season crop continues to have high Water demands after the main rains in October.

The second group comprises sorghum, teff, pulses and finger millet. These crops demonstrate a greater resilience to declining soil depth. Sorghum, which is a long season crop, exhibits the greatest resilience to declining soil depth. Finger millet appears to be best able to withstand the shallower depths with teff following millet.

The results are consistent with published accounts of drought tolerance in crops. Ex-post analysis of research station and test plot data and rainfall would be useful to test the validity of the WRSI/yield relationships. Current work by the SCRP on the impact of soil depth and yield relationship would also assist in calibrating the model for Ethiopia.

The difference in the soils potential water holding capacity and its impact on soil depth/yield relation ships are clearly indicated in Table A1-1. The greatest difference occurs between the maximum critical depths, with the minimum critical depths exhibiting least differences. Similarly between crop differences are greatest for soils with low water holding capacities (eg. Acrisols) and least with soils with high capacities(eg. Vertisols).

The model does not take account of excess water and surface ponding of water on poorly drained soils (eg. Vertisols). Application of the model in Senegal for groundnuts suggested a 3% reduction in the WRSI whenever a 10 day period had an excess of 100mm. Clearly more work is required in Ethiopia before such relationships can be established, although some of the EARO/ILRI work on broad beds could be relevant.

SOIL LOSS-CROP PRODUCTION MODEL

A. Annual Soil Loss Rates

These were derived from the GIS estimates and calculated for each wereda.

B. Critical Depths

Maximum depths at which crops are affected by moisture stress are 95 cm (Maize/Wheat), 80 cm (sorghum/pulses), and 85 cm (teff). Minimum critical depths at which crop yields are reduced to <20% are 45 cm (for maze/wheat). 35 cm (for sorghum/pulses),and 30 cm for teff. These estimates derived from the soil life model for Nitosols.

C. Years to Reach Minimum Depth

This was calculated by dividing the difference between the maximum and minimum depth by the annual soil loss rate.

D. Annual Decline in Crop Yield

Decline in yield was assumed to linear and was calculated by dividing 100 percentage units by the number of years taken to reach the minimum depth. The following annual yield declines for a number of soil loss rates were obtained:

% Annual decline in yield	mm of soil lost per annum					
	0.3	1.5	2.9	4.1	8.0	10.0
Maize/wheat	0.06%	0.3%	0.58%	0.82%	1.60%	2.00%
Sorghum/pulses	0.07%	0.33%	0.64%	0.91%	1.78%	2.28%
Teff	0.05%	0.27%	0.53%	0.75%	1.45%	1.82%

Preliminary work has been published by Hurni (1983) describes the relationship between barley yields on a Nitisol in north Shewa and soil depth by the equation:

Y = 0.38 + 0.032* tons per hectare (R=0.7=66)
where * = soil depth in cm.

Thus yields decline at 3.2% per 1 cm decrease in soil depth which is a slightly higher than the soil life model predictions of between 1.82 and 2.28%.

E. Percentage of Land Entering, Within, and Leaving Critical Soil Depth Range

These calculations determine the % area of each depth class, which is within the critical soil depth ranges for each of the three crop groups in any one year over time. In the absence of any data on the frequency distribution of actual soil depths within each class, it was assumed that actual soil depths were equally distributed in each depth class. Soil removal each year would therefore result in reductions from one class with corresponding additions into the class below. The calculations for each soil class are explained below using maize/ wheat and an annual soil loss of 3.5mm.

100-150 cm: Removal of 3.5mm of soil in one year would bring 0.7% of the area into soil depth class 50-100 cm (3.5mm/500 mm). With a maximum critical depth of 95 cm a further 14 years of soil loss (50 mm/3.5mm) would bring 0.7% of the area of class 100-150 cm into the critical range. An additional 0.7% of the class 100-150 cm would enter the critical range (95-45 cm) every year thereafter.

50-100 cm*:* Using the critical maximum depths for each crop group then 90% of the area is in the critical range for maize/Wheat ((max-50 cm)/50 cm), 60% for wheat/pulses, and 70% for teff. Removal of 3.5 mm of soil would bring in an additional 0.7% of the land area into the critical range. At the same time. 0.7% of the area would leave to enter soil depth class 25-50 cm. Additions would match losses until soil above the maximum critical depth had been completely removed, thereafter the area in this soil depth class would decline at 0.7% per annum. For the three crop groups: maize/wheat, Sorghum/pulses, and teff this would occur after 14, 57, and 43 years respectively.

25-50 cm*:* The assumption regarding equal distribution of cropland within the whole of the soil depth range was changed to take account of the minimum critical soil depth. Logically all the maize/wheat has to be within the range 45-50 cm: any area less than 45 cm has already been abandoned for Maize/Wheat cultivation. Thus the model commences with 100% of the area of each crop group under that crop. Removal of 3.5 mm of soil would lead to the annual abandonment of 7% of the Maize/sorghum area, 2.3% of the sorghum/pulse area, and 1.75% of the teff area. Abandonment of all the area of the depth class would occur in 14, 43, and 57 years respectively.

However additions would also be arriving from soil depth class 50-100 cm at the rate of 0.7% of the area of that depth class each year.

F. Crop production parameters

Percentage crop mix and average crop yields for soils >90 cm were obtained from the WBISPP Socio-economic Surveys. Under the assumption that soil depths are equally distributed within each soil depth classes it follows that within the three critical depth ranges crop yields would be similarly distributed between 100% yield (at maximum critical depth) and 20% (at minimum critical depth). Crop yields for the 50-100 cm and the 25-50 cm depth classes were therefore reduced as follows:

50-100 cm: to the midpoint between 50 cm and the maximum critical depth of each crop group.

25-50 cm: to the midpoint between 50 cm and the minimum critical depth of each crop group.

The % of maximum yields for each crop group for the two soil depth class were as follows:

	maize/wheat	**sorghum/pulses**	**teff**
50-100 cm	60%	82%	75%
25-50 cm	24%	33%	35%

G. Cropland by Depth Class by AEZ/Altitude Range

Cropland is defined as land under annual field crops on peasant smallholder land. Areas of cropland by wereda were obtained from the WBISPP Land Cover Maps.

H. Crop Losses Due to Soil Erosion by wereda

Crop losses were calculated year by year for 25 years. No allowance was made for any expansion in cropped area although with some adaptation the model could provide for this. The formula for calculation crop losses in each soil depth class for each wereda:

% decline in yield (D)* % area in critical soil depth class (E)* % area in the crop group (F)* cropland area (Km^2)in soil depth class (G).

Crop losses were cumulated annually until the area of cropland in a soil depth class began to decline, after which allowance was made for the decline in area.

J Value of Crops Lost

Weighted averages of gross margins using open market prices (low price immediate post harvest) were used for the financial analysis. Farm labour and draught power were not costed. No fertilizer or improved need was assumed to be used. Only seed was therefore costed. For the economic analysis CIF Asseb World market prices were used. Because of the recent devaluation no foreign exchange premium was applied. Transport 800 kms from Djibouti was added. Prices were retained in US$.

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12/ Hurni, H(1983) Erosion-Productivity-Conservation Systems in Ethiopia.