Policies for sustainable land management in the highlands of Tigray, northern Ethiopia

Summary of papers and proceedings of a workshop held at Axum Hotel, Mekelle, Ethiopia, 28–29 March 2002

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Our special thanks go to the many farmers who patiently responded to our numerous questions.

Welcoming address

Simeon Ehui

Co-ordinator, Livestock Policy Analysis Programme
International Livestock Research Institute (ILRI)

Dear workshop participants
Ladies and Gentlemen

On behalf of the International Livestock Research Institute (ILRI), I welcome all the participants to this workshop. ILRI is pleased to co-host this workshop with Mekelle University (MU) and the International Food Policy Research Institute (IFPRI). After we signed an agreement in 1999 between ILRI, IFPRI and MU to launch the project, we assigned Dr Berhanu Gebremedhin to oversee the implementation of the project in the region. Soon after that, the war with Eritrea broke out. But we continued working in areas even close to the war area. This is impressive because without the determination of the project leader, Dr Berhanu Gebremedhin, and the full support of Mekelle University, and particularly Dr Mitiku Haile, the work could not have been completed on time. I would like to express my appreciation for their commitment to the project.

The Livestock Policy Analysis Programme (LPAP) of ILRI works on different projects to fulfil its objectives. The objective of the programme is to increase returns to investments in animal agriculture by smallholders by providing information on the impact and consequences of government policies that affect the livestock sector. It is also to develop appropriate policy and institutional options that will improve the livestock systems productivity, market access and asset accumulation, and the sustainable use of natural resources in developing countries by increasing capacity for policy analysis.

In general the scope of policy research varies from macro-economic level to system level work of constraint analysis. Macro policy deals with aggregate issues such as inflation, interest rate, exchange rate issues, government expenditures, tax structures etc. System level issues involve micro issues such as participatory technology evaluation, productivity measurement, system characterisation, constraint analysis etc. Our comparative advantage lies in policy research at system level. Example of policy research at the system level includes research related to technology policy, marketing and market access policy, credit and pricing policies, land tenure policies, nutrition policies, and natural resource management policy.

In addressing these policy issues we have a number of projects to carry out, which include:

- Projects and institutions for improving sustainable livelihoods
- Projects for improving the competitiveness of dairy systems
- Projects for improving the competitiveness of smallholder livestock systems, market access and trade
- Projects related to property rights, risk and livestock development
- Projects for the sustainable delivery of animal health services.

We have a small core staff for implementing the above projects and we work in partnership with many institutions both in the developing and the developed world. Our linkage with MU is an example of such partnerships. We are pleased to have developed this linkage, which has enabled us to address problems of significant importance to the region. More importantly, the linkage has enabled us to build the capacity of MU staff members who have been involved in

the project. Through this project many have been able to obtain scholarships to study overseas particularly at the Agricultural University of Norway which is also one of our key partners in this project.

Dear participants
Ladies and Gentlemen

Reducing poverty is a real challenge. Impacts of programmes and policies can be maximised if we are able to identify through research the conditions under which particular sets of programmes and policies have been successful or not. It is our hope that through this project we can help realise the following objectives for the region of Tigray:

- Enhance awareness about land degradation and its causes
- Identify major pathways of development
- Identify and assess policies and strategies to facilitate more productive, sustainable, and poverty-reducing pathways of development
- Increase awareness about land degradation problems and strategies to promote more productive and sustainable land management
- Strengthen the capacity to conduct socio-economic and policy research related to sustainable land management in the region.

I wish all the participants successful deliberations during the workshop.

Thank you.

Welcoming address

J. Pender
Senior Research Fellow
Environment and Production Technology Division
International Food Policy Research Institute (IFPRI)

On behalf of the International Food Policy Research Institute (IFPRI), it is a great honour and pleasure to welcome you to this conference on 'Policies for sustainable land management in the highlands of Tigray, northern Ethiopia'.

IFPRI is one of sixteen Future Harvest Centres of the Consultative Group for International Agricultural Research (CGIAR). Established in 1975, IFPRI has the mission to help developing countries identify and implement policies and strategies to reduce poverty and ensure food security for all people, while ensuring sustainable use of natural resources.

In partnership with the International Livestock Research Institute (ILRI) and Mekelle University (MU), we have been working to plan and implement policy research on sustainable land management in the highlands of Ethiopia since 1996. In late 1996, we held a national workshop on sustainable land management issues at ILRI, attended by representatives of the Federal Government of Ethiopia, regional states and other stakeholders, to identify key problems and priorities for policy research on this issue. That workshop was followed by an East African regional research planning workshop at ILRI in February 1997, and a planning workshop for research activities in Tigray at Mekelle University in March 1997. The research project 'Policies for sustainable land management in the highlands of Tigray, northern Ethiopia' began in January 1998, and preliminary results have been presented at an interim workshop held in Mekelle in January 1999, and at national workshops held in Addis Ababa in May 2000 and January 2001.

This workshop will review and discuss findings from this research project, and from other related research being conducted in the highlands of Tigray by Mekelle University and its collaborators.

As most of you know, land degradation, low agricultural productivity, food insecurity and poverty are severe problems in the highlands of Tigray. These problems are interrelated, and in some areas are leading to a downward spiral of land degradation and impoverishment. The main objective of our research has been to identify pathways out of this downward spiral, considering potential technology, policy and institutional interventions. As a result of this research, we have learned a great deal about the extent and causes of these problems and the potential ways for overcoming them.

I will not try to anticipate all of the findings and discussions to come over the next two days. However, I expect that among the main themes that will emerge will be the following:

There are profitable opportunities for more sustainable development and land management in the highlands of Tigray.

1. Exploiting these opportunities will require investments in an appropriate portfolio of physical, human, natural and social capital.
2. The appropriate strategy for investments, policies and institutions must be suited to local comparative advantages; there is no one-size-fits-all strategy that will work in all circumstances of the highlands of Tigray.

I want to extend my sincere thanks to:

- The Swiss Agency for Development and Cooperation for providing financial support to this research
- The International Livestock Research Institute and Mekelle University for their partnership in all aspects of research planning, implementation and dissemination
- The Tigray Bureau of Agriculture and Natural Resources and the Tigray Bureau of Planning and Economic Development, for providing crucial institutional support, participation in the research, and access to secondary data
- Many other organisations, including the Commission for Sustainable Agriculture and Environmental Rehabilitation in Tigray, the Relief Society of Tigray, Mekelle Research Center, and other organisations and their representatives who provided valuable information to this research
- The many zonal and *woreda* level officials who provided information and logistical support to the project and
- Particular appreciation is due to the many community leaders and farmers who so graciously and patiently participated in the research.

Without the active interest and participation of leaders and farmers from the region, this research would not have been possible. I hope that the research and this workshop will help regional and national policy makers to develop strategies to better serve these leaders and farmers in their quest to eliminate poverty and land degradation in the Ethiopian highlands. I wish us all success in this effort.

Thank you.

Opening speech

Mitiku Haile

President, Mekelle University

Dear workshop participants
Ladies and Gentlemen

It is my pleasure to make an opening speech at this very important workshop on 'Policies for sustainable land management in the highlands of Tigray, northern Ethiopia'. The workshop aims at reviewing research findings of the project conducted in the region since 1997. It also aims at discussing the results of the research project with policy makers here, researchers in different disciplines, development practitioners at grass root levels and other stakeholders both in government and non-government organisations. The workshop will be having implications for these different stakeholders because they are partners in implementing land management policies in the region. The workshop will also aim at identifying and discussing key policy issues and options for sustained land management and priorities for policy action.

The project is a triangular collaboration between Mekelle University (MU), the International Livestock Research Institute (ILRI) and the International Food Policy Research Institute (IFPRI) with strong support from the Bureau of Agriculture and Natural Resources (BoANR) and the Bureau of Planning and Economic Development (BoPED). The two partners, BoANR and BoPED, have been instrumental in giving us all access to secondary information and in linking to farming communities.

I regret not including farmers in this meeting, who have benefited us very much with their interaction and I believe we could open opportunities for our farmers to have access to this information through translations into Tigrigna.

The research again was aiming at characterising the problem of land management in the highlands of Tigray and developing and testing hypothesis supporting government policy. Some hypotheses have been proved and a lot of data collected; and hopefully with the presentations we will be able to see how other hypotheses have been tested.

The workshop also aims at identifying proper pathways of development in the region. It is a timely and important workshop as we are implementing the new Rural Development Strategy in the region. Past experiences and interactions of various practices in improving agricultural productivity, reducing poverty and bringing sustained land management will also be reviewed.

The project also aims at strengthening the capacity of collaborating organisations in Tigray to conduct policy research and analysis related to land management. The project also helps to facilitate the adoption and implementation of policy strategies to improve land management in the highlands of Tigray.

The study was conducted in 50 *tabias* representing diverse villages, households and plots operated by these households. A comprehensive database was created through careful collection and computerisation. Dr Berhanu Gebremedhin will present the database.

Household, community and plot surveys have been conducted within the community and a special database of soil samples on about 2170 plots of land has been collected to verify soil fertility that will serve in formulating strategic land management issues. The database will help

understand the resource base of the region that will be availing itself for updating. It is my belief that other researchers will enrich the database in their studies. The utility of the database could be realised through the envisaged household targeted studies in the coming cropping season for formulating different technology packages in pilot areas in Tigray.

The workshop will also facilitate the implementation of the rural development strategy drawn by the government, which anticipates rapid and sustained economic development. The spin-offs of the research will also strengthen the capacity of researchers to undertake different studies. Publications from the research will increase the economy of thought by improving the teaching and learning process.

The workshop is organised in such away that various researchers involved in land management will be sharing experiences. Issues regarding environment, energy and indigenous knowledge will be discussed. Resource persons involved in the implementation, monitoring and evaluation of land management activities will present past efforts in land management and extension in Tigray.

The participants are drawn from relevant institutions related to management of resources that will vitalise the discussion and the output. I expect candid and positive interaction from participants. I realise that all of you have come sacrificing time and energy. This is an encouragement to all of us since we all feel the urgency to address issues of land management and seek solutions for increasing productivity in the region. I wish you all the best in your presentations and declare the workshop open.

Thank you very much.

Policies for sustainable land management in the highlands of Tigray: Project objectives, activities, organisation and database

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Berhanu Gebremedhin
International Livestock Research Institute (ILRI)

Background

Land degradation, especially soil erosion, nutrient depletion and soil moisture stress are severe problems in the highlands of Tigray. Land management is therefore a key problem area in addressing land degradation in the region. The proximate causes of land degradation are relatively well known. These factors include cultivation of steep slopes and erodible soils, low vegetation cover of the soil, burning of dung and crop residues, declining fallow periods, low and uncertain rainfall, and limited application of organic or inorganic fertilisers. Little is known, however, of the underlying causes of land degradation, which are thought to include population pressure; poverty; high cost or limited access of farmers to fertiliser, fuel and animal feed; limited farmer knowledge of integrated soil and water management measures; lack of access to credit; and other factors.

Government policies and programmes can play an important role in farmers' land management decisions by influencing the underlying factors. The policies and programmes include macro-economic and sectoral policies, land tenure policies, agricultural research and extension policies, credit programmes, infrastructure development programmes etc. Due to the complex array of factors affecting land management and diverse agro-ecological and socio-economic conditions in the highlands of Tigray, a one-size-fits-all set of policies is unlikely to work effectively across the region.

To mitigate the problems of land degradation in the highlands of Tigray, International Food Policy Research Institute (IFPRI), International Livestock Research Institute (ILRI) and Mekelle University (MU) have been conducting collaborative research in order to identify policies, institutions and programmes to facilitate improved land management in the highlands of Tigray.

Goal and purpose of the project

The long-term goal of the project is to contribute to improved land management in the

highlands of Tigray in order to increase agricultural productivity, reduce poverty and ensure sustainable land use. The immediate purpose of the project is to develop and assess policy and institutional options for sustainable land management and help policy makers in Tigray implement the policy and institutional strategies to improve land management in the highlands of Tigray.

Project objectives

The specific objectives of the project are to:

1. characterise the problems of land management in the highlands of Tigray and develop hypotheses about the key causes, emphasising government policies and programmes
2. identify dominant 'pathways of development' in the region, and their causes
3. determine the past and current impacts of different factors (especially policies and programmes) on land management in the different 'development pathways' and their implications for agricultural productivity, poverty and sustainable land use
4. strengthen the capacity of collaborating organisations in Tigray to conduct policy research and analysis related to land management
5. help facilitate adoption and implementation of policy and institutional strategies to improve land management in the highlands of Tigray.

Project activities

The project activities include:

1. problem characterisation and hypotheses development based on literature reviews, key informant and farmer surveys, and analysis of secondary data
2. community (50) and village (100) surveys and analysis of ensuing data
3. household (500) and plot (2117) surveys and analysis of ensuing data
4. strengthening capacity of collaborating institutions through:

- involvement of collaborators in the design and implementation of surveys and analysis of data
- PhD training
- short-term trainings
- in-service training
- transfer of database, geographic information systems (GIS) equipment and computers, and other project equipment

5. increasing awareness about problems of land degradation in Tigray and strategies to address the problems, through policy seminars, workshops and conferences, advisory committee meetings, and papers and publications
6. facilitating adoption and implementation of policy and institutional strategies to improve land management.

Database

The project conducted surveys on 50 communities, 100 villages, 500 households and 2117 plots operated by the sampled households. Most of the information collected pertains to changes in agricultural and natural resource conditions between 1991 and 1998. Soil samples were collected from each surveyed plot, of which 300 samples were analysed for nitrogen, phosphorus, potassium, pH, soil texture and organic carbon.

A summary of the database collected through the project is given below:

1. Community (*tabia*) level

- Access to *woreda* town and roads
- Number of villages per community, number of households per village and average size of household (1991, 1998).
- Local organisations, programmes and irrigation development
- Local prices (crop, livestock and livestock products, tree and tree products)
- Community natural resource management (enclosures, woodlots and forest lands)
- Land use and land tenure (land tenure, land rights and access, land distribution, land markets and land tenure security)

2. Village level
    - Livelihood strategies (major livelihood activities of men and women)
    - Infrastructure (access to roads, markets and services; access to irrigation; local organisations)
    - Agricultural production and markets (crop production and yields, livestock ownership, use of purchased inputs, crop production practices, land investments, technology adoption)
    - Community natural resource management (enclosures, woodlots and forests, energy sources for cooking)
    - Factors of production and factor markets (labour, draft animals, farm implements, credit and savings)
    - Human welfare and natural resource outcomes (human welfare, changes in natural resources conditions)
3. Household level
    - Household composition, occupations and education
    - Household assets (land, buildings, livestock, farm equipment, valuable trees, access to infrastructure and services)
    - Factor acquisition and disposition (land, labour, oxen, credit access and savings)
    - Income and expenditures (crop income, livestock income, other income, crop and livestock production expenses, consumption expenses)
    - Agricultural technology and practices (crop technologies, livestock technologies, fodder)
    - Participation in collective action (mass mobilisation, food-for-work)
    - Household energy sources and use (sources for cooking, heating, and lighting)
4. Plot level
    - Inventory of plots (owned, operated, plot quality, access of plot)
    - Land use, tenure and land rights (tenure security, terms of land acquisition and disposition)
    - Land investment (short and long term investments)
    - Crop production (land management practices, use of purchased inputs, labour inputs, draft power inputs)
    - Other products from plot (poles, branches, leaves, roots, fruits)
    - Conditions of soil/land on plot (gullies, erosion, soil depth, soil texture, soil fertility etc.).

Executive summary

Berhanu Gebremedhin,[a] Solomon Tesfay[a] and Dereje Assefa[b]*
a. International Livestock Research Institute (ILRI)
b. Mekelle University (MU)

Overview of papers

The papers presented at the workshop dealt with a wide array of topics related to land management in the highlands of Tigray. Presentations on the objectives, activities and database of the project, and on the performance of the first regional Five-year Development Plan (1995–99) and the stipulations of the second Five-year Development Plan (2000–2005) set the stage for careful scrutiny of and deliberations on the findings of the subsequent presentations. The subsequent papers reported results on the causes and implications of agricultural change and land management; the status and determinants of soil fertility; land use, land transactions and impact of tenure security on land investment; policies and institutions for livestock development and sustainable land use; community woodlot and grazing land management; comparative analysis of community and private tree plantations; the economic return to and impacts of policies affecting land management; and the role of extension in sustainable land management in the region.

Soil erosion, nutrient depletion and soil moisture stress are severe interrelated problems of land degradation in the highlands of Tigray. Land management is, therefore, a key problem area in achieving sustainable agricultural development in the region. While the effect of proximate causes of land degradation (e.g. cultivation of steep slopes, low vegetation cover, erodible soils, burning of dung and crop residues, declining fallow periods) is relatively well understood, the effect of underlying causes (e.g. population pressure, poverty, limited farmer knowledge of integrated soil and water management measures) is not well known. Government policies and programmes can influence farmers' land management decisions through their effect on the underlying causes of land degradation.

Policy makers face the challenge of identifying and implementing appropriate policies and programmes to mitigate the problem of land degradation and help achieve sustainable agricultural development. Due to the diverse agricultural and natural resource conditions that exist in the highlands of Tigray, it is unlikely that a one-size-fits-all set of policies will work under all circumstances. Policies may not be developed to suit every possible situation. However, it may be important to identify appropriate policies and programmes for different `development pathways' (common patterns of change in livelihood strategies), which may have different comparative advantages as determined by their agricultural potential, market access and population density. For example, in areas with high agricultural potential (high rainfall or irrigation, and good soils) and high market access, intensification of cereal crop production using high levels of external inputs and expansion of perishable cash crops may be the two development pathways of greatest potential. In less-favoured areas with low agricultural potential and further away from markets, a development pathway based on

improved livestock productivity through improved management of grazing lands and integrated natural resource management may be more beneficial. The policy options for different development pathways may be different. The purpose of the project was, therefore, to identify and assess alternative policy, programmes and institutional options for sustainable land management and help policy makers in the region to implement the appropriate options.

Based on an evaluation of the performance of the first Five-year Development Plan (1995–99) of the region, Haile Yohannes[1] reported that the regional economy has achieved an average annual growth rate of 6.7 percent during the planning period. The second Five-year Development Plan (2000–05) envisages an average annual growth rate of 7.1 percent, with an estimated aggregate investment of Ethiopian Birr (ETB)[2] 2.01 billion, which is about 27.4 percent of the regional GDP (compared to ETB 1.05 billion during the first Five-year Development Plan, which was about 22.8 percent of GDP). Agricultural production is expected to rise to 1.076 million tonnes in 2005 from its current level of 0.775 million tonnes. Overall, the second Five-year Development Plan emphasises building implementation capacity at lower administrative levels, especially at the *woreda* (district) level. Belete Taffere contended that agricultural and natural resource programmes and projects during the last decade in Tigray were based on extended soil and water conservation, full and minimum package agricultural extension, and the Sustainable Agricultural and Environmental Rehabilitation in Tigray (SAERT) programmes.

1. Throughout this overview, author references are to papers presented in the workshop and summarised in this Working Paper.

2. In 2002, US$ 1 = ETB 8.50.

Pender et al. (a) investigated the impacts of community level factors such as population pressure, development of irrigation and roads, and institutional interventions such as agricultural extension and credit on agricultural and land management practices, and their implications for productivity, natural resource conditions and human welfare, based on analysis of the community and village level surveys. Substantial investments in roads, irrigation and other infrastructure, improved access to education, health care, water supply and other public services have resulted in improvements in many aspects of life in the region between 1991 and 1998. Improvements in access to infrastructure and services have been higher in areas that were less favoured in 1991. Agricultural extension services are associated with more intensive land management and conservation practices, thus potentially contributing to increased crop yields, wealth and access to food, but was associated with worsening conditions of grazing lands. Although irrigation resulted in intensified land use and changes in crop choice, it was associated with less adoption of fertiliser and improved seeds than expected. Returns to investment in irrigation have so far been low, suggesting the need for further study to improve returns from irrigation. Population pressure was associated with increased labour and capital intensity, but not with significant increases in yields, suggesting that population pressure reduces cropland productivity due to land degradation. Education appears to have substantial positive effect on resource conditions and human welfare in the region. Non-farm development, accompanied by agricultural development, appears to be a more productive and sustainable development pathway for the region. In areas with less potential for non-farm development, livestock production appears to offer a better development strategy.

Some of the results of the community level analysis of the impact of community level factors on agricultural and land management practices have been confirmed with results of household and plot level analysis of factors influencing crop production and income, livestock income and investment, and other sources of income (Pender et al. (b)). Land management practices such as stone terraces, reduced burning, reduced tillage, and application of manure and

compost increased crop production substantially. The productivity impact of modern inputs such as fertiliser and improved seeds is low. However, opportunities to exploit complementarities between modern crop inputs and stone terraces exist. Improvements in livestock production can raise household income from livestock as well as from crop production significantly. Improved literacy also increases per capita income significantly, especially through its effect on livestock productivity. Membership in marketing co-operatives is associated with higher household income. Households involved in non-farm income generating activities such as off-farm salary employment, trading, food-for-work and other non-farm activities have higher total income than households specialising in crop production. Female-headed households earn substantially lower crop income and total income than male-headed households. Larger households earn significantly lower per capita income although they receive comparable total income with smaller households. Land tenure does not appear to be a major determinant of total crop production and household income. However, tenants (especially sharecroppers) were found to use fewer inputs and obtain lower yield at the plot level than owner operators. These results imply that the comparative advantage of farmers in the highlands of Tigray is not in high-external input intensive cereal crop production but more in such activities as improvement of crop production using low-external input investments and practices such as terraces, manuring, reduced tillage and reduced burning; improved livestock management; and diversification of livelihood strategies to non-farm activities and small-scale livestock such as poultry and beekeeping.

Berhanu Gebremedhin et al. (a) found that due to increasing population and limited supply of cultivable land in the highlands of Tigray, landlessness is increasing in the region. However, the fledgling and informal land markets such as sharecropping, fixed rental and borrowing or gifts are performing the important function of providing land access to land poor farmers. The rental price of land depends on the quality of land, while sharecropping arrangements appear to be independent of land quality. Farmers perceive that tenure security is an important determinant of farmers' willingness to invest in land improvements and use improved farming practices, suggesting that improved tenure security is important for sustainable land management in the region.

Livestock production is an integral part of the rural economy in Tigray, with oxen supplying the only traction power for crop production. Between 1991 and 1998, oxen ownership improved in Tigray (Berhanu Gebremedhin et al. (b)). The biggest improvement was found in households who had no ox, acquiring one ox or more. Community members attributed the improvements in oxen ownership to better availability of credit. However, ownership of cows, sheep and goats declined, mainly due to shortage of feed, and losses due to drought and diseases. Communities perceived improvements in conditions of grazing lands but deterioration in their availability. Econometric analysis showed that credit access, road development, literacy, and access to transportation services are important for livestock development in the region. Population pressure was associated with worsening conditions of grazing lands.

Community natural resources management (grazing land and woodlots) appears to function well in Tigray (Berhanu Gebremedhin et al. (c)). Investigation of the determinants of collective action for grazing land management showed that there is substantial local initiative for collective management of grazing lands in the region, with almost 90% of villages in the highlands having rules and regulations for communal management of grazing lands. Collective action for grazing land management appears to be higher at intermediate population and in communities with higher social capital, and lower with proximity to markets and heterogeneity in oxen ownership. Similar to restricted grazing lands, collective action for woodlot management is higher at intermediate population density and in areas further from markets. Benefits are higher and problems lower with community woodlots managed at village level than at higher municipality (*tabia*) level, suggesting that community natural resource management may be more effective and beneficial if conducted at the most local level.

Involvement of external organisations and programmes in promoting the establishment of community woodlots detracted from collective action for woodlot management, suggesting that the role of external organisations and programmes in community natural resource management may need to be demand driven and complementary to local efforts.

A comparative analysis of community and private tree plantations showed that community woodlots managed at sub-village level (compared to *tabia* or village managed) undertook more frequent weeding and watering activities that are important for tree survival (Jagger et al.). Labour investment per hectare for woodlots is higher in woodlots managed at *tabia* level than those managed at village or sub-village levels. However, tree survival rates are lowest at woodlots managed at the *tabia* level, indicating that labour is used less effectively on *tabia*-managed woodlots. Both communities and households required permission to harvest woodlot products. Net present value (NPV) calculations for the period 1997–2000 showed that *tabia*-managed woodlots have the lowest NPV while household managed woodlots have the highest NPV. Communities overwhelmingly reported that woodlots have positive environmental benefits. These results reinforce the findings from the analysis of collective action for woodlot management that devolution of woodlot management to the village, sub-village and household level may lead to more effective management and higher returns on investment.

Land degradation may result in increasing shortage of fuel for cooking, heating and lighting in rural areas. Northern Ethiopia in general, and the Tigray region in particular, is facing a severe woody biomass shortage. An investigation of the fuel supply and demand behaviour of farm households in rural Tigray showed that biomass fuels, especially woody biomass and dung, are the primary sources of fuel in Tigray, covering about 96 percent of the total fuel consumption in the region (Zenebe Gebregziabiher). A higher proportion of woody biomass, charcoal and kerosene is consumed during the wet season, while a higher proportion of dung and crop residues is used during the dry season. No significant substitution was found between private tree growing and use of dung or crop residues for fuel, suggesting that private tree planting for fuel is still very low and that households depend on community resources for fuel wood.

Farmer innovations in soil and water management can play an important role in sustainable land management. An inventory of farmer innovations in soil and water management showed that farmers in the highlands of Tigray innovated in such practices as trapping silts and water to create farm land, planting local fodder grasses to reinforce terraces, spreading manure through irrigation water, and diverting water into riverside terraces (Fetien Abay et al.). Farmer innovations can be disseminated to other farmers for experimentation and adoption, to development agents (DA) for diffusion to other farmers, to scientists to support scientific research and adaptive technology development, and to policy makers for possible enabling policy, programme and institutional support.

Genetic diversity or variation is important for current output levels and future crop improvements. The level of crop genetic diversity can be influenced by farmer land management practices. Conservation of crop genetic diversity can be done *in situ* (on farmers' fields) or *ex situ* (away from farmers' fields). Understanding the factors influencing farmer choice of crop varieties can provide useful information to enhance *in situ* conservation of crop genetic diversity. Farmers select crop varieties based on their differential responses to environmental variability (Fetien Abay and Smale). Farmers' knowledge of genetic resources and traditional selection techniques, if combined with scientific knowledge on special breeding techniques, could lead to identification of cultivars that can have a wide potential for use in the semi-arid areas of Tigray and other parts of Ethiopia.

Overview of discussions

About 85 participants from various governmental and non-governmental organisations in

Ethiopia, universities and international research organisations attended the workshop (Appendix 2). Participants were drawn from the Tigray Bureau of Agriculture and Natural Resources (BoANR), 26 *Woreda* (district) Bureaux of Agriculture and Natural Resources, the Tigray Food Security Desk, the Commission for Sustainable Agriculture and Environmental Rehabilitation in Tigray (CoSAERT), the Relief Society of Tigray (REST), Mekelle Research Center, the Tigray Bureau of Planning and Economic Development, six zonal administrative councils in Tigray, junior agricultural training colleges, the Ethiopian Agricultural Research Organization (EARO), Oromia and Amhara Bureaux of Agriculture and Natural Resources, Mekelle University (MU), International Livestock Research Institute (ILRI) and International Food Policy Research Institute (IFPRI).

The diversity of expertise and experience that the participants brought to the workshop provided several useful insights and comments through careful evaluation of the presentations from various perspectives. Policy formulation starts from creating awareness about alternative policy options. The constellation of people from the various administrative levels in the region provided a good opportunity to create awareness about possible policy options and issues identified by the study. Participants raised issues ranging from survey implementation to interpretation of findings. In this section, we present the key issues raised during the discussions.

Since the survey collected information about changes in agricultural and natural resource conditions between 1991 and 1998, the reliability of farmer recall data needs to be confirmed. There are several techniques that can be used to ensure the reliability of survey data. After careful design of survey instruments based on knowledge of the farming system and secondary information, pre-testing of the survey instruments followed to ensure relevance (questions are pertinent to the objective of the research), validity (questions can be answered correctly by respondents), and reliability (questions are stated clearly and specifically). Data checking included consistency checks to ensure that various responses are consistent with each other. Enumerators were trained carefully in techniques of developing rapport with the communities.

The project has developed a huge database that can be very useful to policy makers, development practitioners, researchers and academicians. The database is joint property of IFPRI, ILRI and MU. The database will be made available to local collaborators in the region. Other users can have access to the data by making proper arrangements with the institutions and ensuring acknowledgement of the efforts of the institutions involved in collecting the data and the financial support of the funding agencies.

Perceptions of local people about agricultural and natural resource conditions and priorities for investment can be important inputs for local planning purposes. This is even more critical given the process of decentralising decision making to the lower, especially the *woreda* (district) level. Involvement of farmers in programme development and implementation is essential for successful development efforts. Real participation of farmers in decision-making can also ensure that programmes and projects address the felt needs of farmers and are demand driven. For example, farmers' perceptions of soil fertility can be much more comprehensive than scientific explanations of soil fertility. Farmers' perceptions of soil fertility may be based on several indicators such as soil moisture, soil depth, and biomass production. Farmers in the highlands of Tigray perceived generally that cropland conditions and soil fertility in the highlands showed an improvement between 1991 and 1998. However, laboratory soil analysis showed that soils in the highlands of Tigray are deficient in soil nutrients, especially in total nitrogen, suggesting that despite the perceived improvements, the fertility status of the soils in the highlands remains very low.

Land transactions (sharecropping, fixed rental and borrowing/gifting) are widespread in the highlands of Tigray. Improving land transaction systems in the region can improve access to

land and raise efficiency of land use. It could be expected that land quality and expected yield of grains and straw may affect the terms of sharecropping arrangements. However, if sharecropping serves as a balance between incentive problems in wage contracts and risk pooling (as argued in the theoretical literature on sharecropping), then land quality may not be an important determinant of sharecropping arrangements. Land quality and expected yields do not appear to affect sharecropping arrangements in Tigray. Although there are variations in sharecropping arrangements across the region, the tendency appears to be towards equal share between the owner and the tenant. Farmers operate smaller plots in irrigated areas mainly because of the high labour requirements of irrigated agriculture. The land transaction practices (especially sharecropping and renting) in irrigated areas may be different from those in rainfed areas. This issue needs further study, as the survey did not capture it well enough. Landlessness was found to be high in low population density areas, perhaps because cultivable land may be less available in low-density areas or due to migration to low-density areas in search of land. Some policy issues regarding land tenure were raised: how and whether to institutionalise land transactions, whether all household members should have the right to own land, and steps to reduce population growth.

Livestock being an integral part of the rural economy in Tigray, identification of the factors associated with the development of livestock and its relationship with sustainable land management is important for policy purposes. Oxen ownership in Tigray increased between 1991 and 1998 and this is mainly attributed to availability of formal credit. However, there has been a drop in oxen price during the same period, perhaps because of the closing of the Eritrean market due to the war with Ethiopia. While formal credit from REST proved to be very important for livestock development in the region, the role of informal credit was not investigated. Future studies may need to consider the role of informal credit for livestock development. Ownership of cows decreased with better access to market. Future studies are needed to consider why this is the case. The extension programme in the region is biased towards crop production. Participants agreed that future extension programmes need to give greater emphasis to livestock production, especially in light of the significant economic returns to livestock production reported during the workshop.

The free and uncontrolled grazing system is considered as a major cause of grazing land degradation in Tigray. Private or communal management of grazing lands could replace free grazing. A comparative analysis of the two grazing land management systems may reveal their relative effectiveness in terms of sustainable use of the resource. The degradation of grazing lands and other natural resource is also severe in the lowlands of Tigray, which could warrant a similar study.

Despite their contributions in facilitating the establishment of community woodlots, external organisations and programmes reduced the effectiveness of collective action for community woodlot management. The reason may be because *Woreda* Bureau of Agriculture experts and development agents attempt to dictate management decisions to the communities. The regional Bureau of Agriculture also has a similar assessment and steps are being taken to redress the problem. Proximity to market may encourage community members to break rules of community woodlot management in order to fetch fuel wood to town for sale, in addition to the effect on higher opportunity cost of labour used for collective action. Regarding community management of grazing lands, it would be useful to study in detail the process of collective decision-making and documentation of rules, methods of conflict resolution, and arrangements for benefit sharing.

The comparative analysis of community and private tree plantations revealed that although extension service and labour inputs are higher at *tabia* and village levels, survival rate of trees is higher at household level. This could be because households water seedlings more frequently, which can make a lot of difference in tree survival. Participants raised the issue of private woodlots being planted more with eucalyptus, which may have negative environmental

effects such as competition for ground water. Whether or not the negative environmental effects of eucalyptus are as real as perceived by ecologists was debated at length and participants agreed on the need for careful evaluation of the environmental effects. The issue of requiring permission to harvest woodlot products was also discussed at length. Although it was not clear whether there was uniform rule across the region for harvesting woodlot benefits, participants reached at a consensus that decisions on use of community woodlots should be left to the communities themselves, with technical input from the bureaux of agriculture and other government and non-government organisations.

Most of the fuel wood used by rural households in Tigray comes from communal areas, such as woodlots, forests and bushes. The long-term strategy in the region is however to develop private woodlots. Sometimes conflicts arise among communities on the right to collect fuel wood from communal areas. Participants indicated that studies be conducted to identify the causes of the conflict and traditional means of settling the conflict in order to provide information for better management of communal resources. Private tree planting did not turn out to be a significant substitute for use of dung and crop residues, perhaps because private tree plantation is intended for other purposes than fuel or because private tree planting is still too limited to have significant impacts. Participants said there is a potential for tree growing for charcoal production in the region, provided efficient ovens would be available. Improved stoves could save energy. Efforts have been made in Tigray to introduce improved stove in rural areas. However, the fuel production and consumption study did not find use of improved stove to be an important determinant of fuel consumption in Tigray, perhaps because of technical limitations of the stoves. Understanding why improved stoves failed to have significant impact on fuel consumption can supply important information for the development and dissemination of improved stoves in the future.

In semi-arid areas such as most of the highlands of Tigray where soil moisture is an important limiting factor for agricultural production, irrigation development offers an option to alleviate the problem. However, the experience in the highlands of Tigray shows that salinity can be a serious problem of irrigation water use. Salinity is not a problem of irrigation dams only; river diversions and spring irrigation can result in salinity as well. The soluble salts are on farmlands and the problem is created by excess water on farmlands. Salinity could, therefore, be minimised through better plot management, regulated irrigation water use, and application of gypsum. Use of appropriate drainage channels is still another option, although this may not be effective on cracking soils where hydraulic conductivity is very low. Participants also mentioned the importance of looking for other water harvesting techniques that could better be suited under different climatic and topographic conditions. Further and continued research is needed to generate more information on alternative water harvesting and use techniques, and the institutional and policy strategies required to make irrigation water more effective and beneficial to farmers.

Several important issues were raised regarding the determinants of household crop production and income. Female-headed households in Tigray have lower crop production and household income than male-headed households, perhaps due to lower labour productivity of women in crop production, or cultural restrictions against women plowing. Although international factors such as food aid may be important in analysing the impact of policies on land management in Tigray, it is conceivable that such variables affect policies at the national level. Population pressure, land holding and irrigation did not have strong impact on economic returns in Tigray. Land transactions are working to equalise access to land. The insignificant effect of irrigation in the region warrants a detailed and comprehensive study. Similarly the return to fertiliser and improved seeds is low in the region, perhaps because of soil moisture stress.

Conclusions and recommendations

Significant improvements in the provision of infrastructure and public services have been achieved in Tigray since 1991, more so in areas that were less favoured in 1991. Soil fertility of the soils of the highlands of Tigray as measured by the levels of NPK appears to be very low implying that a comprehensive soil fertility management strategy would be needed to restore and maintain the fertility status of the soils. Local communities and development agents need to be well informed about the soil fertility status as well as conservation of biomass.

Land transactions are important functions for providing access to land in the region. Institutionalising these informal land markets could increase the efficiency of the land markets. Participation of local people in resource management planning is essential for sustainable use of natural resources. In this regard, for better resource management, the people at local level should be better informed and trained.

The highlands of Tigray are suited for livestock production, as shown by the relatively high returns to investment in livestock. However, credit, market access, extension services and infrastructure development appear essential for livestock development in the region. Moreover, households involved in non-farm activities have higher income than those dependent solely on crop production, implying that non-farm development has the potential to improve household income and welfare in the region significantly. Crop production using low-external input investments and practices such as terraces, manuring, composting, and reduced tillage, rather than high-external input intensification using high levels of inorganic fertilisers, appears to be a better crop production strategy in the region.

Collective action for woodlots and grazing lands management in Tigray appears to function well. However, involvement of external organisations and programmes in community resources management need to be demand driven and complementary to local efforts. Moreover, community resource management appears to be more effective and more beneficial if conducted at the most local level. Private tree planting does not appear to contribute significantly yet to fuel consumption in the region. Given the severe shortage of fuel in rural Tigray, policy and extension services need to be strengthened to encourage private tree plantation in the region.

Soil moisture stress is a critical limiting factor of agricultural production in the region. Irrigation development offers a potential option to alleviate the problem. However, the impact of irrigation on crop production and farm income has not been significant. This implies the need for further and continuous study on the technical, policy and institutional factors affecting the outcome of irrigation development. Alternative water harvesting techniques that could be applied in the diverse climatic and topographic circumstances of Tigray need to be explored.

Participants appreciated the efforts put in creating the database and the analysis that generated the findings of the research presented at the workshop, and agreed that further analysis be conducted and results be published and disseminated as soon as possible, especially within the region. Participants also agreed on the need to train representatives of local collaborators on the use of the data, and for follow up studies to address the gaps in knowledge identified during the discussions.

* Mr Solomon Tesfay passed away during the write up of this Working Paper.

Summary of papers

Overview of the Tigray National Regional State: Achievements of the first five-year development plan and future prospects

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Following the seizure of power in 1991, the EPRDF-led government had fiercely contended with a legacy of a decimated private sector, inefficient central planning and weak institutional capacity. It took overriding measures in replacing the command economy by an economic system driven by market forces. Moreover, the government adopted an Agriculture-Led Industrial Development (ALID) strategy. The centrepiece of this development strategy lies in creating strong linkage between the agriculture and industrial sectors. This linkage would create a basis to exploit the vast untapped resource in the agriculture sector to promoting a fast growth in the industrial sector thereby reducing the level of unemployment through efficient use of resources.

In light of this, during the last decade, the government in collaboration with the local communities and various non-governmental organisations has implemented different programmes/projects in pursuit of reducing chronic poverty, ensuring food security, promoting the private sector and reducing the level of unemployment. These have brought many encouraging and remarkable achievements in different fields of the economy. Moreover, during the First Five-year Development Plan (1995–99) the region's economy has achieved an annual average growth of 6.7 percent. To strengthen these achievements and attain further objectives, a Second Five-year Development Plan has been prepared for the period 2000–05, with the main objectives of reducing poverty, ensuring food security, achieving ecological improvements and environmental protection, preventing HIV/AIDS and others.

The second development plan envisages achieving a remarkable success in different sectors of the economy and an overall annual average regional economic growth rate of 7.10 percent. In the course of attaining the stated goals, the development plan indicates that aggregate investment will increase from Ethiopian Birr (ETB)[1] 1.05 billion in 2000 to 2.01 billion in 2005 (from 22.8 percent of the regional GDP in 2000 to 27.4 percent in 2005).

1. US$ 1 = ETB 8.50 in 2002.

In the agriculture sector, the average annual agricultural production is planned to rise from the existing 7.75 million quintals to 10.76 million quintals in 2005, i.e. achieving an annual average growth rate of 1.2 percent. Similarly, through wider introduction of the package of technologies (like the Sasakawa-Global, SG-2000), the productivity of crops of the traditional sector is also expected to grow.

In the education sector, the gross enrolment rate of students in primary education is planned to rise from 63.5 to 81 percent, and from 17.7 to 25.7 percent in secondary education. The health service coverage is also planned to rise from the existing 55 to 70 percent coverage at the end of the plan period. With the view of improving the road networks, the road density is also planned to reach 53 km in 1000 km^2 or 0.71 km for 1000 people at the end of the plan period.

With regard to providing adequate public services and creating an efficient civil service, the availability of skilled manpower in sufficient quantity is of paramount importance. Therefore, during the plan period, a total of 10 thousand new permanent civil servants are expected to be employed in the different government offices. This will increase the current 33.4 percent fulfilment of the required-trained manpower to 60 percent by the end of the plan period.

The second five-year plan provides a special emphasis to building implementation capacity at the lower administrative structure, especially at *woreda* and *tabia* levels. This is expected to enable and facilitate implementation of various development activities and attaining food security at household level, bring about improved socio-economic status in the region, and an overall improvement in the living standard of the society.

Efforts for sustainable land management in Tigray: The role of extension

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Background

Tigray is one of the regions most known for its serious land degradation problem. This is manifested in the form of soil erosion, deforestation, declining bio-diversity resources, and soil moisture stress. Environmental and natural resource degradation in the region has caused serious drought and famine problems. The frequency of drought is increasing from time to time. Agriculture in Tigray is the dominant economic sector of the region. However, farming practices are backward and traditional. Production increases resulted from expanding cultivated area and not from increasing yield. However, the land frontier, especially in the highlands, has shrunk. In order to bring about sustainable livelihood to the people, the regional government and the people have put significant effort in the rehabilitation and development of the region's natural resources, especially since 1991.

Objective of this paper

The paper has the following specific objectives:

1. to assess the potential and the constraints of the region's natural resources, with an overview of its socio-economic and environmental impact
2. to identify technical, policy and institutional issues that need to be addressed in natural resources management in the region
3. to come up with the possible strategic recommendations that need to be considered.

Natural resources of Tigray

Tigray is located at the northern limit of the central highlands of Ethiopia. The landform is complex composed of highlands (in the range of 2300–3200 metres above sea level (masl), lowland plains with an altitude range of (<500–1500 masl)[1], mountain peaks (as high as 3935 masl) and high to moderate relief hills (1600–2200 masl). Thus Tigray has diversified agro-ecological zones and niches each with distinct soil, geology, vegetation cover and other

natural resources. The climate is generally sub-tropical with an extended dry period of nine to ten months and a maximum effective rainy season of 50 to 60 days. The rainfall pattern is predominantly uni-modal (June to early September). Exceptions to the rainfall pattern are areas in the southern zone and the highlands of the eastern zone, where there is a little shower during the months of March to mid May. Considering rainfall, atmospheric temperature and evapotranspiration, more than 90% of the region is categorised as semi-arid. The remaining areas in the region can be categorised as dry submoist (near the central south highlands and the Wolkite highlands) and arid (the lower areas of Erob and Hintalo Wajerat *woredas*). There are also some moist zone patches in the Kisad Gudo, Mugulat and the Tsegedie highlands.

1. The least altitude (200 masl) is found at the extreme eastern edge of the Erob *woreda*.

Natural resources policies, strategies and programmes in Tigray and their impacts

Land degradation, especially soil erosion, is a serious problem in Tigray. This is commonly expressed in the severe denudation in the vegetation cover, the soil erosion and fertility depletion in the farm lands, the prevalence of wide and deep gully formations, the extinction of most important biotic resources (field crops, pulses, oil and fibre crops, the forage plants, the medicinal plants, wild life etc.), and the deterioration of the surface and groundwater potential of the region. Land degradation is the principal cause of the decline in agricultural productivity and total production (crop, livestock) in the region, rendering the region dependent on imported food (both in the form of purchased food and food aid). Similarly, much of the region's wood demand for construction and furniture is met by imports from other parts of the country and abroad. Cognisant of this situation, the agriculture development strategy of the region is designed to be based on the rehabilitation, conservation and development of natural resources, and is known as conservation-based agricultural development policy.

Following the conservation-based agricultural development strategy, during the last ten years, the regional government has identified and implemented a number of programmes and projects, including the extended soil and water conservation programme, the full package extension programme, the minimum package extension programme, and the sustainable agriculture and environmental rehabilitation in Tigray (SAERT) programme.

Conclusion

A lot of effort has been made both by the regional government and the people at large to rehabilitate, conserve and develop natural resources in the region. Based on annual evaluation meetings conducted by the Bureau of Agriculture and field observations, the efforts have shown encouraging results. Specially, increases in biomass, improvements in soil moisture conditions, flow of rivers and streams and the return of the previously lost wild life resources is quite encouraging. However, these results are minuscule compared with the scale of the problem. Hence, the challenges of rehabilitating and developing the natural resources in the region, and bringing about improvements in the socio-economic conditions of the people, is still formidable.

Agricultural change and land management in the highlands of Tigray: Causes and implications

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This study investigates changes in agriculture and land management practices between 1991 and 1998 in the highlands of Tigray, and the causes and implications of these changes, based upon a community level survey conducted in 100 villages in 50 *tabias*. We investigate the impacts of community level factors such as population pressure, investments in irrigation and roads, and the presence of the agricultural extension and credit programme on agricultural and land management practices and implications for productivity, natural resource conditions and human welfare.

Since 1991, a broad process of development has been occurring in Tigray, involving substantial investments in roads, irrigation and other infrastructure and improved access to education, health care, water, agricultural extension and other public services. These investments and services have resulted in improvements in many aspects of life in Tigray. The improvement in access to infrastructure and services has been even greater in areas that were less favoured in 1991, helping to equalise access in the region.

In addition to public investments and services, farmers have also undertaken a substantial amount of private and community investment, including accumulating livestock assets (especially oxen), planting trees (both privately and in community woodlots), and investing in various soil and water conservation structures. They have also adopted more labour and capital-intensive agricultural management practices. These private investments have also likely contributed to improvements in welfare as well as improvements in resource conditions, most of which were also perceived by farmers to be improving in general.

We have investigated the determinants of changes in agricultural and land management practices and their implications for productivity, resource conditions and human welfare, and have identified a number of important tentative findings. The agricultural extension programme appears to have effectively promoted more intensive land management and conservation practices, contributing to higher crop yields, increased wealth and access to food. However, it also appears to have contributed to worsening grazing land conditions. The Tigray Bureau of Agriculture and Natural Resources (BoANR) should investigate this problem further, and consider options to intensify and improve management of grazing lands.

Irrigation was found to be an important factor underlying different livelihood strategies. Irrigation has contributed to intensified land use and to changes in crop choice, but has been associated with less adoption of fertilisers and improved seeds and less improvement in yields than expected. As a result, it appears that the returns to modern irrigation investment so far have been relatively low. This issue should be of high priority for further study, given the large amount of resources that are being invested in this development, and options should be considered to improve the returns to irrigation investment in Tigray. Among these options may be increasing priority of extension activities in irrigated areas and increasing emphasis on promotion of high value crops in such areas. Complementary investments in roads or other infrastructure may also be important in some areas.

Road development appears to have contributed to shifts in production away from livestock (especially cows) and to greater production of some cash crops. Road development is not as strongly associated with adoption of purchased inputs as we expected, but has contributed to changes in some agricultural practices, particularly burning to prepare fields. This may be an important reason why yield improvement for barley and maize has been greater in areas with better road access, since burning is associated with declining yields. Road improvements are associated with increased food availability, improvement in the quality of grazing land (probably as a result of reduced emphasis on livestock production), and to improved availability and quality of water. Overall, road development has contributed to agricultural development and improved resource management and human welfare.

Population pressure was found to increase the labour and capital intensity of agriculture. However, this intensification did not result in significantly increased yields, suggesting that land degradation caused by population pressure is reducing cropland productivity. The quality of grazing land is also being degraded by population (and associated livestock) pressure. Despite these negative indications, differences in measures of human welfare were generally unrelated to population pressure, and in some instances, population pressure was associated with improved conditions. This is likely due to greater investments in infrastructure or public services in areas with greater population pressure, suggesting the importance of such investments in maintaining and improving welfare in the region despite the high population pressure.

Educational improvements appear to have contributed to several aspects of agricultural intensification and technology adoption, including use of fertilisers and vaccines and adoption of some intensive land management practices such as composting, planting trees and live fences. Despite this, there is a puzzling association between education and declines in soil fertility and yields of some crops. This may be related to the fact that fallowing is declining more rapidly in areas where farmers are more educated. This suggests the importance of teaching principles of sustainable land management in school curricula. Aside from this negative association of education with soil fertility, the impacts of education on many other natural resource conditions (e.g. the quality of grazing land, forest, and water) are positive and large. Education is also strongly associated with reductions in infant mortality. Thus the overall benefits of improved education for resource management and human welfare appear to be quite substantial.

Differences in livelihood strategies have also led to important differences in land management and in productivity, resource conditions, and human welfare. Areas where non-farm employment is important have performed better than other areas in several respects, including improvement in crop yields, food availability, reduced erosion, and improved availability and quality of water. Promotion of non-farm development thus appears to offer a potential as a more productive and sustainable development pathway for the region. Realisation of this potential appears to depend upon agricultural development, however, given the strong association of this strategy with irrigation investment. Development of cash crops, including perishable annual crops and perennials, is also strongly associated with irrigation investment, and also helps to reduce pressure on grazing land and cropland erosion. In many areas, however, the potential for development of cash crops or non-farm activities is much lower. Livestock will continue to be critical to the development strategy of these areas. A critical issue for these areas will be to increase the productivity and sustainability of grazing land management.

Characterising land resources problems using perceptions of local planners: A conceptual framework to improve local level planning

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Periodic monitoring of the status of natural resources is fundamental to generate adequate information for planning and policy-making for their sustainable management. In Tigray, land degradation is severe and extensive measures are being taken to reverse the situation. In addition to the mass mobilisation, decentralisation of power, and free market approaches, the region needs a good information base and good planning methodologies. The existence of a land use, management and conservation policy is important as a guideline for the proper use and development of available land resources.

One of the major drawbacks of the various land use and management planning methodologies developed so far is the fact that they are difficult to implement. Inter-institutional rivalries, for example, between agronomic and conservation interventions, hinder a co-ordinated strategy for dealing with integrated programmes. Thus the institutional framework is often lacking for integration and application of such methodologies at local levels of planning.

This study provides an overview of a new conceptual framework based on local characterisation of land resources problems in a defined area such as watersheds for designing and implementing a land use management and conservation planning system. The hypothesis used in testing the methodology proposed is that mapping of local perceptions of environmental problems and resource conditions and its representation communicate information and expand new knowledge more effectively. Spatial data and information in the form of maps are no longer traditional overviews of landscapes but images created to project the views and perspectives of their creators. With the advent of spatial information science several groups in society have been provided with the opportunity to redefine themselves and their territories with maps.

In this study, we used local experiences for two reasons. First, it is such knowledge that is currently dominating the local planning process. Second, it enables a smooth transfer of the methodology with adaptable language without involving technical jargon.

The new conceptual framework is tested with a case study in Alaje *woreda*. The design and application of the map of watersheds as natural and administrative units was evaluated for its ability to provide useful information with emphasis on the improvement of the degree of perceptions, interpretation and transfer of knowledge for practical application of decision-making for development purposes. These evaluations were undertaken through questionnaires and discussions designed to elicit the views of all those experts and *woreda* level development practitioners in the course of the two-year case study in the *woreda*.

For the map of the watershed, the appraisal emphasised the stakeholders' perception of the strengths and weaknesses of the division of the *woreda* into watersheds as an information source. This was done by drawing comparisons between the derived information from the maps of the watershed and the existing information sources for *woreda* description, such as land use, soils etc. Appraisal was then based on interviewees' reactions to the two sets of information sources.

In general, local planners believed that the information and knowledge generated by the approach led to better-informed activities because it expanded their knowledge base. Local planners developed greater insights into the intricacies of decision making for resource management planning. The information produced was also found to be useful for *woreda* authorities and council members. The format allowed them to clarify variables and to put values upon the variables that were meaningful to them. In effect, it allowed them to construct meaningful information for their own use. Once the various data and information is presented in map form, the local planners have the capacity to elucidate and easily comprehend various spatial relationships including spatial clustering of objects exhibiting various characteristics in a much better way than scientific statistical analysis techniques. It generates a powerful visual impression of spatial variation, enabling discussions to focus on problem areas, or enabling rapid visual recognition of association or covariance between different problems. The method often reveals patterns that transcend local administrative boundaries, and that would be masked by aggregating the data to a larger unit. The research has proved that provided some support is exerted to enable local planners to use spatial information, planning at local level can be improved.

One of the important conclusions of this research is that given the difficulty of acquiring and using quantitative and scientific data in the processes of development planning at local level in developing countries, the critical issues in designing targeted programmes and interventions is the appropriate employment of local knowledge and experiences. Linking this local knowledge to formal representations, as presented in this study, enables local planners to have better understanding of the realities surrounding them.

Experience in this research reveals that human capital and financial limitations of institutions at local levels of development planning will remain a major constraint on the use of improved methodologies of development planning for the foreseeable future. These limitations operate on both the decision-making bodies (local councils) and the planners at various local government institutions (government executive agencies). Before such planning methodologies can be effective tools, a process is needed to make essential investments in institutional capability throughout local governments.

The status of soil fertility in Tigray

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Soil samples taken from 300 plots stratified by altitude and soil type were analysed for organic carbon, total nitrogen, available phosphorous, available potassium, soil texture, and pH. Forty-two percent of plots had shallow soil depth (less than 75 cm), while 37% had medium soil depth (75–100 cm) and 21% were of deep soils (more than 100 cm depth).

Soils were found to be very low in total nitrogen. Employing the scientific rating of more than 1 percent N to be high, 0.5–1% medium, 0.1–0.2% very low, and less than 0.1% extremely low, we found that 76% of the plots had extremely low levels of total N, while 21% had very low, and 3% had low total nitrogen content. The level of available phosphorous is even worse in the study area. Using the Olsen method and rating of more than 15% available phosphorus as high, 5–15% as medium and less than 5% as low, we found that 98% of the plots had low available phosphorous.

The level of available potassium content of plots was found to be relatively better: 30% of the plots had high available potassium, 37% had medium level, while only 33% of the plots had low available potassium content. The reported results had been derived based on the assumption that available potassium of more than 0.6 meg/100 g soil represent high content, 0.2–0.6 meg/100 g soil represent medium content and less than 0.2 meg/ 100 g represents low content of available potassium.

The results of pH tests revealed that 1% of plots had alkaline soils (pH >8.5), 51% of plots had medium alkaline soils (pH of 7–8.5), 1% had acidic soils (pH <5.5) and 47% had medium acidic (pH of 5.5–7.0) soils. The level of organic carbon in the sample plots was also very low. Employing a rating percent organic carbon content of 20% to be very high, 10–20% high, 4–10% medium, 2–4% low and less than 2% very low, we found that 94% of the plots showed very low organic carbon content, while only 6% of the plots had low level of organic carbon. Clay, silt and sand contents varied much among the plots. Sand content varied from 18.28 to 94.16% and silt from 0.7 to 60%. Clay content also ranged from 3.28 to 58.72%. Table 1 gives summary statistics of the soil analysis results.

The soil analyses results showed that the plots of Tigray have very low soil fertility status, especially with regard to total nitrogen and available phosphorus. A comprehensive soil fertility replenishment and maintenance effort is required to raise the low soil fertility status of the soils in Tigray.

Table 1. *Summary of the descriptive statistics of soil analysis results.*

Soil property	Minimum	Maximum	Mean	SD	CV (%)
Organic carbon (%)	0.019	3.08	1.12	0.6	0.36
Organic matter (%)	0.03	5.31	1.93	1.04	1.08
Total nitrogen (%)	0.01	0.28	0.08	0.049	0.0024
P (PPM)	0.016	6.54	0.92	1.04	1.08
pH	5.24	9.9	7.05	0.68	0.46

Clay content (%)	3.28	58.72	22.21	12.45	155.001
Silt content (%)	0.7	60.0	23.4	11.66	136.11
Sand content (%)	18.28	94.16	54.37	18.46	340.78

Land use, land tenure and sustainable land management in Tigray

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Increasing population results in land scarcity and, when alternative employment opportunities outside of agriculture are limited, may eventually lead to landlessness. Under this situation, well functioning land markets may result in welfare gain by allocating the land resource to more efficient users and by permitting land consolidation to achieve economies of size. However, for land markets to function efficiently, low transaction costs and tenure security are essential. Land tenure security is important not only for the development of efficient land markets, but also for investment in land improvements.

In Ethiopia, after almost two decades of socialist oriented economic policy under the military regime, the new Ethiopian government has been taking measures to liberalise the economy since 1991. In the agricultural sector, measures to liberalise the input and output markets and increase institutional support for agriculture, such as agricultural research and extension services, have been taken. In the regions of Tigray and Amhara, land registration aimed at improving farmers' land tenure security has also been implemented. However, the long-term impact of these measures will depend on their effect on the structure and stability of economic incentives available to farmers. Whether or not government policies are conducive to investment in agriculture, and whether the incentive structure translates into a more sustainable use of the natural resource base is an empirical question.

This paper assesses the land use, land tenure and land access situation in the northern Ethiopian region of Tigray since 1991 and investigates the effect of land tenure security on land management. Descriptive analysis and econometric analysis of data collected from 50 *tabia*s[1] (communities) and 100 villages in 1998 are used.

1. *Tabia* is the lowest administrative unit in Tigray usually comprising of four to five villages.

According to survey respondents, landlessness is increasing in the Tigray region. Between 1991 and 1998, the number of landless households per *tabia* grew by more than 140%. Informal land transactions are operating in the region, including share-cropping, fixed lease paid in cash or in kind and borrowing. The use of fixed lease as a means of land acquisition, although very low, appears to be increasing, and sharecropping arrangements seem to be shifting towards equal share between the landholder and the leaseholder. While the rental price of land seems to be dependent on the quality of land, sharecropping ratios appear to be independent of the quality of land.

While landowners cover part of labour, seed and fertiliser costs in sharecropping arrangements, traction and equipment costs are entirely covered by the shareholders. The average terms of sharecropping and fixed lease is about two years, and is not influenced by the type of crop planted. The likelihood of renewal of sharecropping or lease contracts is not affected by the type of crop planted or land investment by the tenant. Farmers reported that while tenure security is highly likely to affect farmer incentives to invest in land, farmers own land investment is unlikely to affect tenure security. Irrigated land appears to be concentrated

in high population density areas.

Econometric analysis of the effect of tenure security on land investments and use of improved farming practices show that tenure security is an important determinant of farmers incentives to invest in land and use improved farming practices. Stability of tenure encourages investment in stone terraces, while landlessness detracts from it. Perceived tenure security was associated with investment in tree plantation and soil bunds.

Our results imply that improving tenure security is important for improved land management in the region. The land titling that took place in Tigray, coupled with the regional legislation that prohibits further land redistribution, is an important step in this direction. However, legal support for farmers' use rights in perpetuity, their right for compensation of land investment in case of special-circumstance land re-distributions, and the right to bequeath land to children could strengthen tenure security.

Our results also imply that the potential roles of public policy to facilitate the development of the fledgling land market needs to be explored. Moreover, restrictions on land exchange may need to be revisited. The wishes and preferences of farmers regarding land tenure arrangements and land administration should be considered as an important and crucial input into the design of future tenure arrangements in the region.

Policies and institutions for livestock development in the highlands of Ethiopia: Results of a community survey in Tigray, northern Ethiopia

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The Agricultural Development Led Industrialization (ADLI) development strategy of the Ethiopian Government stipulates that the productivity of the livestock sub-sector would be enhanced through improvements in the quality and availability of feed, veterinary services, and genetic improvement through crossbreeding. According to the 1998 livestock census, the Tigray region has about 3.04 million cattle, 0.94 million sheep, 1.47 million goats, 0.41 million equines, and 0.013 million camels. As in other highlands of Ethiopia, livestock in Tigray are integral part of the rural economy supplying draft power for traction and transportation, cash income from sale of livestock and livestock products, food such as milk for household consumption, manure to maintain soil fertility and dung for fuel.

In this paper we investigate policy and institutional factors associated with changes in livestock ownership between 1991 and 1998, changes in the availability and quality of grazing lands, and changes in use of purchased feed and livestock vaccines in the highlands of Tigray. The research is based upon a community survey conducted in 50 *tabias*[1] (communities) and 100 villages in 1998/99. A stratified random sample of 50 *tabias* was drawn, and two villages within each *tabia* were drawn randomly. Analysis of descriptive information from the survey was used to examine the changes in livestock ownership, availability and quality of grazing lands and use of livestock vaccines and purchased feed, and the associated reasons. Econometric analysis was used to identify the determinants of the changes.

1. *Tabia* is the lowest adminstratiive unit in Tigray usually comprising of four to five villages.

We find that there has been improvement in oxen ownership in Tigray between 1991 and 1998. Communities attribute increased ownership of oxen to improvement in access to credit. The highest improvement was observed in households who had no ox at all acquiring an ox or more. However, there has been decline in ownership of cows, sheep and goats. Communities reported losses due to drought, diseases and feed shortage as the major cause for the decline in ownership. Some improvements have also been observed in conditions of grazing lands while availability decreased. No change has been observed in the importance of various sources of feed between 1991 and 1998.

Econometric analysis results showed that credit access, road development, access to transportation services and literacy are important for livestock development. In a credit-constrained rural economy, credit institutions that are suited to the needs of rural households are important for agricultural development. Our results show that households who have access to credit are more likely to own livestock, especially cows and oxen. Access to credit also increases household's use of purchased feed. Moreover, an improvement in access to credit was associated with higher donkey ownership. In the Ethiopian highlands donkeys are

important for transportation of goods.

Road development and improvements in access to transportation services stand out as important for improved ownership of oxen and cows. Infrastructural development such as roads and improved access to transportation services may improve the profitability of crop and livestock production by reducing transportation costs and improving access to market. Literacy is positively associated with livestock ownership. Literacy in rural settings may be important for access to written information, which may improve the efficiency of agricultural activities.

Households' use of purchased feed appears to be determined by factors that affect both the availability of feed (such as annual precipitation and population pressure) and demand for feed (such as access to credit and transportation services). Use of purchased feed is low in highly populated areas, perhaps because population pressure reduces the availability of feed. Annual rainfall increases use of purchased feed since feed availability is higher with high rainfall.

We also find that population pressure has a negative effect on grazing land conditions, supporting the Malthusian perspective of the effect of population pressure on natural resource conditions. Annual precipitation and crop intensification appear to improve the conditions of grazing lands, perhaps by improving the availability of feed, implying that the grazing lands may be supporting livestock beyond their carrying capacity. Road development is associated with worsening conditions of grazing lands, suggesting that infrastructure development may have negative effects on natural resource conditions.

There has been substantial increase in the use of animal vaccines in Tigray. However, use of animal vaccines is higher at higher elevation (than at lower elevation), and lower in areas with higher transportation access.

Community resource management in Tigray: Woodlots and grazing lands

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Common property resources (resources that are owned and managed by a given community) are important sources of fuel wood, timber, grazing land and irrigation water in many developing countries. However, these resources tend to be overexploited due to the absence of use rules and regulations or ineffectiveness of existing use rules and regulations. Several alternative solutions have been proposed to redress the problem of resource degradation of common property resources in developing countries. These include privatisation, state ownership, imposition and enforcement of use rules and regulations by an external force such as governments at different levels, or collective management by communities

This paper evaluates the nature and determinants of community management (collective action) of woodlots and grazing lands in the northern Ethiopian highlands of Tigray. Common property resource degradation in Tigray is severe. Concerted effort to redress the degradation of the natural resources is also underway, especially since 1991. Major strategies for environmental rehabilitation in Tigray include construction of stone terraces, soil bunds and micro dams; establishment and development of area enclosures (areas closed to human and animal interference in order to promote natural regeneration) and community woodlots (enclosures with enrichment plantations or areas of new plantations); and enforcement of use rules and regulations for grazing lands.

Results are based on data collected from 50 communities and 100 villages in Tigray through group interviews. Information was sought about changes in agricultural and natural resource conditions between 1991 and 1998, and their causes and effects. Analysis of descriptive information was used to identify the nature of management of woodlots and grazing lands, the roles of different organisations (local and external) in managing them, and the benefits and problems encountered. Econometric analysis was used to investigate the determinants of collective action and its effectiveness in managing the resources.

Woodlots

Community woodlots are widespread in the highlands of Tigray, with almost nine out of ten communities having at least one community woodlot. Most of these woodlots have been established since the downfall of the military government in 1991. External organisations, especially the regional Bureau of Agriculture, have been instrumental in facilitating the establishment of the woodlots. The most common and allowed use of woodlots is to cut and collect grass for animal feed, roof materials or other purposes. Most woodlots are managed at

village level, while some are managed at the higher community (*tabia*) level. We find that community-managed woodlots tend to be larger than village-managed ones, perceived benefits from woodlots are greater in village-managed than community managed woodlots, and violations are more common in community-managed than village-managed ones. The average return per person-day invested in 1998 was higher for village woodlots than community woodlots. Villages are pursuing a more intensive management strategy than larger communities. Woodlots are in most cases protected by a guard paid in cash or in kind.

Woodlots are most commonly planted with eucalyptus trees (especially globulus and camaldulensis). We find that a woodlot of average-sized eucalyptus trees would be worth more than Ethiopian Birr (ETB)[1] 80 thousand per hectare. Thus, despite the limited current benefits that communities receive from community woodlots in Tigray, community woodlots are contributing substantially to community wealth. Communities see few problems as a result of the establishment of woodlots.

1. US$ 1 = ETB 8.50 in 2002.

We find evidence for an inverted U-shaped relationship between collective action for woodlot management and population density, where collective action is high at intermediate population density and low at both low and very high densities. Market access detracts from collective action for woodlot management, perhaps by increasing the opportunity cost of labour or increasing exit options. The involvement of external organisations (mainly the Bureau of Agriculture) in promoting woodlot establishment has a negative effect on tree survival, suggesting that external organisations may not be achieving full participation of local communities in promoting woodlots.

Grazing lands

As with woodlots, grazing areas with use rules and regulations (restricted grazing areas) are widespread in the highlands of Tigray. Almost 90% of villages have one or more restricted grazing areas. However, unlike woodlots, all restricted grazing areas are managed at the village level. More than half of the restricted grazing areas are used solely for grazing by oxen. In about 42% of the cases, restricted grazing areas are used only during September to December. In addition to grazing animals, other allowed uses include cutting grass for feed or construction, fuel wood collection from dead trees, and bee keeping. All villages reported that the grazing lands have regenerated significantly due to the use restrictions.

Unlike woodlots, most of which were promoted by external organisations, most restricted grazing lands were promoted by local communities themselves, indicating the prevalence of local initiative for collective action in managing grazing lands. Most restricted grazing lands were established prior to 1991, contrary to the case with woodlots. However, similar to woodlots, restricted grazing lands are usually protected by a hired guard. Most frequent violations reported in 1998 were letting animals graze while grazing is not allowed, and cutting grass for feed and construction without permission. Most violations are penalised.

Similar to community woodlots, we find that collective action for grazing land management is higher at intermediate population than at low or very high population levels. Communities with higher social capital (as measured by the number of local organisations operating in the community) are more likely to contribute for collective action for grazing land management. Market access detracted from collective action for grazing land management, similar to the effect of market access on community woodlot management. Community heterogeneity in oxen ownership increases the likelihood of violations of use restrictions and regulations.

Conclusions and implications

Collective action for woodlot and grazing land management generally functions well in the highlands of Tigray. Thus, community natural resource management can be an effective means of redressing natural resource degradation and increasing community wealth. However, community natural resource management may be more effective and more beneficial if conducted at the most local level, and if involvement of external organisations is demand driven and complementary to local initiatives. Collective action for natural resource management may be more effective in areas with intermediate population that are far from markets and have higher social capital. In areas of greater market access, high population or high wealth heterogeneity, and private-oriented approaches to resource management may be more effective.

Rural fuel production and demand in Tigray

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Using a sample of 200 households from rural Tigray an attempt was made to examine fuel production and consumption behaviour of rural households in the region. A non-separable farm household model was used in the empirical analysis. Qualitative and quantitative descriptions indicate that biomass fuels, particularly woody biomass and dung constitute the prominent fuel sources in the study area. These two fuel types were found to account for over 96 percent of the total fuel consumption. Some indication of changing pattern of fuel consumption towards increased use of dung and reduced use of woody biomass has been observed. Seasonal variations were observed in the consumption of the different fuels. Greater proportions of woody biomass, charcoal and kerosene were consumed during the wet season and greater proportions of dung and crop residues were consumed during the dry season.

Estimation of fuel collection functions was one aspect of the empirical analysis. In this respect, collection functions were estimated for woody biomass, dung and crop residues. The woody biomass collection function was estimated under three different conditions: dry season, wet season and total woody biomass collection. A separate consideration was made for woody biomass collection from common areas. Separate regressions were carried out for total dung collection and dung collection from commons. In the woody biomass collection functions, the time spent collecting fuel had a significant and positive effect in all cases. Number of female youths was more important (significant and positive) in dry season woody biomass collection. But, both the number of male youths and number of female youths were found to be equally important in the wet season woody biomass collection, perhaps due to the desire to spread wet season labour burden among household members. However, on the whole the number of female youths was found to be more important in the case of total woody biomass collection. But, number of female adults was significant and negative.

The total dung collection function was found to be statistically insignificant. The time spent collecting dung influenced significantly and positively dung collection from commons. The number of female youths and number of male youths were significant and negative. Number of cattle was highly significant and negative, as expected, implying that there will be little incentive to collect dung from commons as the number of cattle owned by household increases. The agro-ecological variables of middle highland and upper highland were found to be significant and positive suggesting that significantly greater quantities of dung are collected from commons as one goes from the lower to the upper highlands.

In the crop residue collection function, age of head was significant and negative implying an inverse relationship between age of head and crop residue collection. The time spent collecting residues had a significant and positive effect. The number of cattle was significant and negative, as expected, implying that the quantity of residue collected for fuel decreases as the number of cattle owned increases, since cattle compete with fuel for crop residues. Residue collection is less in the middle highlands than the lower highlands. Among the crop pattern variables, maize increased crop residue collection while millet reduced it. Growing sorghum did not have significant effect on crop residue collection.

Demand functions were estimated for woody biomass, dung, crop residues, kerosene and charcoal use in rural Tigray. The woody biomass demand function was estimated under three scenarios: dry season, wet season and total woody biomass demand. Because of the non-

separablity of production and consumption decisions due to market failures for fuel as well as labour used for fuel collection, virtual (shadow) prices and shadow wages were used as explanatory variables instead of market prices in the woody biomass, dung and crop residues demand estimations. Fuel specific marginal product of labour (or shadow wage) was computed from the respective fuel collection functions. Then shadow fuel prices were drawn as a product of shadow wage and time spent to collect a unit of that fuel type. Unexpectedly, own-price elasticities of woody biomass demand were significant but positive. But, all cross-price elasticities turned out to be insignificant, which implies that the different fuel types are independent. All own-wage elasticities were found to have negative signs. But, only the own-wage elasticity for wet season was significant. This suggests that farm households are more sensitive to wet season increased shadow wages and respond by cutting fuel consumption.

In the dung demand function, own-price elasticity was negative as expected but insignificant and cross-price elasticity was negative but insignificant. Both own- and cross-wage elasticities were insignificant but with different signs. Number of cattle, food habit and the agro-ecology variables of middle highland and upper highland were found to have significant influence in the demand for dung. In the case of crop residues demand, own-price elasticity was significant but positive. Cross-price elasticity and all other variables considered turned out to be insignificant. The variables upper highland, food habit, and improved stove were found to have more influence on charcoal demand. Although the variable improved stove was found to have the expected negative sign, in both the woody biomass and dung demand functions, it was insignificant. Its negative sign indicates the tendency towards fuel saving.

Considerable variations in the stove dimensions in general and stove height in particular were observed. Most of the improved stoves built were found to be larger than the recommended dimensions. These problems contribute to the ineffectiveness of the improved stove. The technical limitations in the stove dimensions must have arisen from inadequate training, inappropriate grasp of the technicalities in stove construction, and lack of appropriate supervision and follow up by extension agents during stove construction, which emanates from a very dispersed and massive but weakly conceived stove extension programme.

Seasonal factors play an important role in the fuel consumption pattern and in the labour allocation decisions of farm households. Households were found to be more sensitive to wet season labour scarcities. Among the household composition variables, number of female youth was more important in total woody biomass consumption. This implies that energy and forestry policies should take into account seasonal factors and the intra-household labour patterns, if meaningful results are to be achieved. Empowerment of women should also be considered. Moreover, dung collection from commons was found to constitute a significant proportion of dung consumed in the study sites. The fuel consumption pattern of households was found to vary depending on agro-ecological conditions. Households in the lower highlands depend more on woody biomass, whereas households in the middle and upper highlands were found to depend more on animal dung. Households producing maize were found to consume more crop residues but households producing millet were found to use less crop residues. This implies the need for agro-ecology based interventions to alleviate the fuel scarcity problem.

The number of trees was found to have insignificant impacts on fuel consumption in most cases, and no indication of substitution was observed between private tree planting and burning of dung or crop residues. There are no indications of privately grown trees being used for fuel. This suggests that the supply-side oriented measures of tree planting are inadequate. The community woodlots, communal grazing lands with woody biomass resources and natural forests, which constitute important sources of woody biomass collection for most of the rural households, suffer from absence of utilisation guidelines and lack of a clear legal/institutional framework as regards to their ownership and utilisation. Hence, an appropriate management regime or institutional arrangement needs to be established to manage and control the

common resources.

The high price of pole-sized trees in the construction market, perhaps as a result of the recent drive in reconstruction efforts, must also have discouraged substitution between private tree plantation and fuel consumption from other sources. Improvements in stove diffusion and/or design is among the feasible alternatives to alleviate the fuel crisis in the region. However, the improved stove that was so far being promoted was found to be ineffective. Considerable variations were observed from one household to the other in the stove dimensions, contributing to its ineffectiveness. This calls for further technology refinement. In addition, the limitations in the stove dimensions are largely outcomes of the inefficiencies in the extension system that promoted adoption of the stove. As it is not possible to provide conclusive evidence of the problem of fuel collection and consumption in rural Tigray with such a one period study, further studies on the topic are recommended.

Community and private tree planting for sustainable land management and improved livelihoods in Tigray—Understanding the tradeoffs

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Northern Ethiopia is experiencing severe woody biomass shortages that contribute to land degradation. The clearing of indigenous forest and woodland affects important environmental services that forests provide with respect to maintaining soil fertility and water resources within watersheds, as well as biodiversity. In addition, in the absence of adequate fuelwood supply, smallholders burn dung for cooking and heating that could otherwise be used for fertilising cropping fields. Declining soil fertility is a major factor contributing to low yields for cereals and other important crops, particularly in less-favoured areas. Improving access to the virtually untouched resources in community woodlots could significantly relieve pressure on indigenous woodland as well as provide fuelwood, freeing up dung for use as fertiliser. In addition, allowing communities and smallholders to harvest poles, fuelwood and other products from these woodlots offers alternative sources of income in a region where there are few non-farm income generation opportunities.

Devolution of forest resources is a possible mechanism for improving community and smallholder access to resources in woodlots, which include poles, fuelwood, tree fodder, grass, and non-timber forest products such as honey and incense. Over the past decade the regional government of Tigray has been devolving woodlots from community (*tabia*) level management to village (*kushet*) level management, sub-village (sub-*kushet*) level management, and has also been allocating community wasteland for private tree planting. Thus, we have a unique opportunity to compare the experience of these varying levels of woodlot management. Information about the potential benefits and costs, as well as other characteristics of the various institutional approaches to woodlot management can inform forest policy, which is currently under review in the region.

Two targeted woodlot surveys were conducted in Tigray between late 2000 and mid 2001. The surveys focused on investments that were made between 1997 and 2000, their costs and the benefits received. Three community woodlots per *tabia* were randomly selected for surveying. Of the 120 community groups surveyed about their woodlots—34 were *tabia* managed, 75 were *kushet* managed and 11 woodlots were managed at the sub—*kushet* level. Wherever possible respondents included a representative from the *tabia* or *kushet baito*, a member of the agricultural cadre, the woodlot guard, one woman and a community member with no office. To investigate management of private woodlots, three households were randomly selected from *tabias* that had redistributed community land for private tree planting (66 households were surveyed in total).

Managers of all *kushet* and sub-*kushet* woodlots received extension training on woodlot management between 1997 and 2000, while only about 25% of households received such extension advice. Since many households lack access to forestry extension and advice there is likely a role for non-government organisations (NGOs) and the regional Bureau of Agriculture (BOA) to increase extension to these households. The most common types of extension advice received were on the topics of general woodlot management, soil and water

conservation, and seedling planting and tree tending.

Several types of woodlot investments were undertaken in woodlots between 1997 and 2000. The most common types of investment were paying a guard to oversee the woodlot, and labour investments in planting trees, weeding/cultivating, removing stones or building soil and water conservation structures. Community woodlots managed at the sub-*kushet* level more commonly undertook important management activities including weeding and watering that were most likely to improve tree survival rates. Labour investments per hectare in woodlot management activities were much higher in *tabia*-managed woodlots where mass mobilisation and compensated labour (through food-for-work or cash-for-work programmes) are employed. For example, the amount of labour used for removing stones and building soil and water conservation structures in *tabia*-managed woodlots is over 100 person-days per hectare per year, compared to *kushet* and sub-*kushet* managed woodlots that average approximately 40 person-days per hectare per year. These data are particularly interesting when compared with average survival rates for trees planted. *Tabia*-managed woodlots have the lowest survival rates (approximately 45%), whereas household managed woodlots, with the lowest labour inputs, have much higher survival rates of approximately 65%. The comparison of labour investments and survival rates raises the question of whether *tabia*-managed woodlots over-invest in labour-intensive activities that are unlikely to improve the biophysical productivity of the woodlot.

With respect to benefits received by communities and households, thatching grass and fodder grass were the most common products harvested from woodlots. No communities or households reported harvesting fuelwood or tree fodder, and there was very little harvesting of poles, non-timber forest products or grass used for handicrafts. The highest yields of thatching grass were observed in *tabia*-managed woodlots (almost 15 headloads per hectare per year), whereas the highest yields of fodder grass were observed in *kushet* and household managed woodlots (approximately 11 and 9 headloads per hectare per year, respectively). For the few cases where poles were harvested, eucalyptus poles were most commonly cut (84% of poles harvested). The average age of harvested poles was approximately 10 years, and the average pole price was approximately Ethiopian Birr (ETB)[1] 11.

1. In 2002, US$ 1 = ETB 8.50.

Information on the institutional barriers to harvesting was collected. For most woodlot products, communities require permission from the Bureau of Agriculture (BoA) to harvest. Interestingly approximately half of the households that managed private plantings on community wasteland also reported that they required permission to harvest poles and fuelwood. Most of the communities and households that required permission to harvest woodlot products faced penalties if they harvest without permission from the BOA. Communities managing woodlots overwhelmingly stated that they would harvest more from the woodlots if permission was not required. Households did not express the same desire to harvest more if permission was not required, but given the very young age of most of these woodlots (i.e. 1 year), it is likely that many households have not been faced with the question of whether or not to harvest products from their woodlots.

Using average wage rates and prices, and a discount rate of 30%, net present value (NPV) estimates indicate that for the years 1997–2000 all types of woodlots had negative returns. *Tabia* woodlots have the lowest NPV/hectare and household managed woodlots had the highest NPV/hectare. Considering the future, and assuming a 10% harvest of the standing stock of trees in each woodlot in the 2002 and another 10% in 2007, improved NPV/hectare per year estimates—though they are still predicted to be negative for all community managed woodlots, but positive for household woodlots. Harvest of a larger portion of the tree stock or harvesting more often would lead to positive NPV in most cases.

In general communities and households perceived that woodlots had positive environmental benefits. There was a general perception that soil, water and biodiversity conditions were improving in woodlot sites. In addition, communities and households perceived that soil depth and moisture in the areas surrounding the woodlot were improving, while run-off and flooding and the width of gullies decreased, particularly downhill from woodlots. Perceptions of these types of positive externalities were the same for woodlots where greater than 75% of the trees planted were eucalyptus, indicating that farmers perceive no discernable difference between the benefits of eucalyptus and other tree species. This finding suggests that limitations should not be put on planting eucalyptus in woodlots. However, maintaining some level of species diversity in woodlots is advisable.

Several policy recommendations emerge out of this research. Information on labour investments, actual and potential returns indicate that the large labour inputs associated with mass-mobilisation and voluntary compensated labour—particularly in *tabia* woodlots—are not efficient. Donors and local agencies that organise food-for-work and cash-for-work programmes should rethink activities undertaken as mass-mobilisation and voluntary compensated labour. Our findings indicate that devolution of woodlot management to the *kushet*, sub-*kushet* and household levels leads to more effective management and higher potential returns on investment. This is evidence of the success of devolution and this policy should be further pursued. In addition, communities and households need greater control over the harvest of the resources in woodlots. Devolution and increased decision-making power over woodlot resources should be accompanied by extension training that promotes the sustainable management of woodlots. Harvesting cycles for various woodlot products that ensure communities and households have constant stream of benefits should be promoted. In addition, while revising land use policy with respect to woodlots, stakeholders and policy makers should adopt a companion policy that promotes the effective protection/sustainable use of indigenous forest resources.

Local innovation in water and soil management: Its implications for local policy and action

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Past approaches to soil and water conservation involved transfer of technology. Interventions in Ethiopia depended mainly on mass mobilisation and food-for-work programmes. In contrast the ISWC II (Indigenous Soil and Water Conservation Phase II) Ethiopia project started out by discovering local soil and water conservation innovations. From the start, the research involved as many actors as possible from research, extension, teaching and policy making areas, aiming to encourage them to support farmer led improvement of land husbandry. ISWC II-Ethiopia is implemented in the semi-arid, mountainous Tigray region by Mekelle University (MU), in collaboration with the Tigray Bureau of Agriculture and Natural Resources (BoANR), Mekelle Research Center (MRC) and non-governmental organisations (NGOs) operating in Tigray.

The programme initially focused its efforts on promoting local innovation in land husbandry, enhancing local experimentation and on influencing relevant policy in Tigray. The entry point was the discovery of local innovators: farmers who, without direct support from formal research and extension services, have developed new ways of using locally available resources for agriculture and natural resource management in order to improve their livelihoods in a sustainable way. A methodological problem arose in trying to distinguish innovators from non-innovators. Some site-specific modification of a technique may always be needed. Moreover, because conditions are constantly changing, farmers have to modify their farming techniques over time. Also in the Tigray region, the ISWC II-Ethiopia programme found that every farmer innovates to some degree. In this area of extreme landforms, with high plateaux (2500 metres above sea level, masl) and lowlands (below 1500 masl) separated by steep slopes and escarpments, farmers must deal with diverse agro-ecological conditions. In order to cope with these complex and changing conditions, the farmers are constantly obliged to experiment and to adapt their methods and techniques. They actively seek information and new ways of doing things that could improve their livelihoods. In distinguishing innovators, ISWC II-Ethiopia focuses on the most striking activities that the local communities perceive to be important and new relative to their experience according to their criteria.

Inventory results on local innovations for soil and water conservation showed that farmers innovate in such practices as trapping silt and water to create land, planting local fodder grasses to reinforce terraces, diverting water into riverside terraces, using water infiltration furrows shaded by planted grass, spreading manure through irrigation water, collecting hyrax dung to fertilise plots and revegetating slopes with indigenous trees.

Enhancing farmer experimentation helps develop site appropriate technology and strengthens local capacity to adapt to new conditions. The ISWC-II programme assumes that farmer innovation is based largely on informal experimentation. The role of outsiders is to recognise these experiments and reflect on farmers' assessment of local problems and possibilities, and to help farmers build on these ideas. By providing new ideas and linkages with sources of information (other farmers or formal researchers), ISWC-II Ethiopia stimulates farmers to innovate further. The development agents (DAs) play a key role in encouraging farmers to experiment with new ideas. They can help farmers find options for testing and help evaluate

the results together with farmers, rather than trying to transfer ready-made technologies that may not suit the local preferences or agro-ecological conditions. The knowledge generated through the farmers' experiments leads not only to the creation of site-appropriate technologies. It also increases farmers' capacity to adapt to changing conditions.

Interested scientists are joining the participatory technology development (PTD), farmer led experimentation which includes designing experiments with groups of farmers with common interests. ISWC-II Ethiopia does not attempt to impose PTD. Rather, scientists are challenged to engage in open dialogue with farmers at every possible opportunity, and at different stages in the experimentation process. Emphasis is placed on forging a functional link between scientists, DAs, baito (local administration) members and farmers.

Workshops were organised for scientists and included a day in the field, discussing farmer innovations with various local stakeholders. These raised the interest of additional scientists to take a closer look at farmer-developed technologies. In those cases where further studies of certain innovations were made, the new findings were added to the original entries in the database. Ten researchers from both the technical and the social sciences at MU and MRC have been involved in a variety of studies (e.g. indigenous practices of managing soil fertility and crop pests, community-based irrigation systems, interactions between farmers' soil and water conservation practices and their cropping strategies, farmer management of agro-biodiversity and farmers' views on land use policies). These researchers have met periodically to compare methods and results. Part of their agreement with ISWC-II Ethiopia is that they feed back their findings to the farmers for discussion, farmer validation or correction of the results, and deepening the analysis, so that the discussions can lead into planning of joint experiments by farmers and scientists.

Village level workshops were organised by the programme and the Bureau of Agriculture, during which the farming communities and *baito* members assessed both local innovations and introduced technologies with regard to their relevance and potential for wider diffusion. The workshops helped make the *baito* members aware of the importance of farmer innovators and their innovations for soil and water management.

The ideas generated by farmers were disseminated in various ways and other farmers were encouraged to experiment with them. Indigenous practices and innovations in land husbandry were made more widely known to other farmers, DAs, scientists, policy-makers and the general public.

Meetings were organised in villages to honour local farmers who have developed outstanding innovations in integrated land management leading to significant yield improvements. The top innovators at district level, selected from those identified in each village, were awarded prizes. As part of the ceremony, local people visited the winners' farms and saw their innovations. A similar ceremony was held to honour the three top innovators in each of the four zones of Tigray. At a regional ceremony in Mekelle, the zonal winners were invited to describe their innovations, and to explain what they had done and how they disseminate their new ideas to others. Regional policy-makers, agricultural researchers, and ISCW-II researchers attended this meeting. The prizes provided by ISWC-II Ethiopia consisted of a certificate of merit as outstanding innovator plus a sum of money sufficient to buy an ox.

Additional prizes were awarded to women innovators. In this case, the Steering Committee stressed that innovators could include also women who improved their livelihoods by going against social norms and doing their own plowing instead of share-cropping their land. Animal traction is an indigenous practice in Ethiopia, but has always been the domain of men. The awards are meant to encourage and give public recognition to women who innovate by challenging this tradition, in addition to recognising other agricultural innovations by women.

The extension approach and packages are becoming more open to considering farmers' knowledge and capacities to innovate. DAs are recognising and some are even documenting farmers' informal experimentation on soil and water management. Issues and concerns raised by farmer innovators are no longer hushed up but are brought to higher levels by DAs and by the innovators themselves, for example, at regional, national and international levels, including an international conference held in Mekelle in February 2000.

Water harvesting in micro dams: Its impact on the socio-economic condition of the community and the salinity of the irrigated fields in Tigray

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In an effort to address the problem of recurrent drought, famine and food insecurity, attempts have been made to harvest run-off water in micro dams for use in small-scale irrigation schemes. It is recognised that construction of micro dams for use in small-scale irrigation and agronomic services and vital support for proper watershed management will result in micro climatic and environmental changes with positive impacts on sustained productivity. Notwithstanding the importance of these positive impacts on increased agricultural productivity and improved community welfare, the potential negative impacts of water sources development requires constant assessment, monitoring and evaluation of the environmental changes.

A study was carried out on 14 micro dams in different ecological zones in Tigray to monitor the changes in socio-economic condition and in salinity of the harvested water and irrigated soils. Farmers living in the vicinity of the micro dams are aware about the problem of land degradation, understanding the effect of sedimentation on the reduced capacity of the dams to store water to be used for irrigation and were willing to invest in sustainable land management systems. Dams at lower altitudes in general exhibited statistically significant higher salinity levels as compared to dams situated at higher altitudes. Salinity of the harvested water varied with seasons. During the dry season when the water volume is low, salinity levels increased.

The salt content of the irrigated fields nearer to water outlets was significantly higher than the one on fields at the tail end of the schemes. However, no significant yield reduction was observed on onion and maize planted on soils with different salinity classes. The major causes for the increase in salinity of the land include mismanagement of the distribution of water and the absence of drainage to reclaim excess water from irrigated fields. Health studies conducted on 7000 children indicated that villages near to micro dams have increased risk of malaria. Community participation in draining excess water and bed nets has reduced this risk.

Economic returns and impacts of policies and programmes affecting land management in Tigray

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c. Mekelle University (MU)

This paper investigates the livelihood strategies and land management practices used in the highlands of Tigray, the factors influencing them, and their implications for crop production and income, livestock income and investment, other sources of income, and farmers' perceptions of land degradation. Several factors commonly hypothesised to have a major impact on land management, incomes and land degradation—including population pressure, small landholdings, access to roads and irrigation, and extension and credit programmes—are found to have limited direct impact on total crop production and incomes.

However, some of these factors do have a substantial impact on livelihood strategies (e.g. population pressure and access to roads and transportation), and thus can have a significant indirect effect on incomes via their impacts on livelihoods. The net effect of these indirect impacts is difficult to tell, however, since some of the livelihoods promoted by population pressure or improved access earn relatively low incomes while others earn high incomes. As population continues to grow and access to roads and transportation improves, increasing inequality of income may thus occur as a result of livelihood diversification.

Most of these factors do affect the intensity of agricultural production and adoption of various land management practices. Population pressure and smaller landholdings are associated with greater use of labour and other inputs and adoption of labour-intensive practices as predicted by Boserup. Access to an all-weather road increases use of labour and fertiliser, while irrigation increases use of labour and improved seeds, as one would expect. Formal credit is not surprisingly associated with use of improved seeds and fertiliser. However, these impacts on intensity do not add up to much impact on total crop production, due to the low marginal product of labour in crop production, the limited productivity impact of inputs such as fertiliser and seed in the moisture-stressed environment of Tigray, and limited adoption of such inputs.

Some land management practices were found to substantially increase crop production, including construction of stone terraces, reduced burning, reduced tillage, and application of manure or compost. The rate of return to investment in stone terraces was estimated to be about 25%, and terraces were found to increase use of fertiliser. Reduced burning, reduced tillage, and application of manure and compost have even larger estimated impacts on production. These practices apparently contribute to productivity by helping to conserve soil moisture and organic matter, which are critical constraints in the soils of Tigray. Manure and compost are also found to contribute to perceived improvement in soil fertility. Greater ownership of cattle is strongly associated with increased crop productivity, probably as a result of increased manure availability (whether or not intentionally applied). Promotion of such conservation practices and exploitation of complementary livestock production show more promise to boost crop production than large application of modern inputs such as inorganic fertiliser and improved seeds. However, there are opportunities to exploit complementarities between use of such inputs (especially fertiliser) and investment in stone terraces.

Improved livestock production can contribute to significantly increase household income, both directly through income earned from livestock, and by contributing to increased crop production. The marginal rate of return of livestock in terms of livestock income was estimated to be about 11%, but was significantly higher for cattle, chickens and beekeeping. Considering the impacts on crop production as well as livestock income, we estimate that the rate of return in 1998/99 was about 16% for all livestock, and 36% for cows. The rate of return to chickens and beehives were also above 30%. Thus, there appear to be promising opportunities to increase household income through improved livestock management. This is supported by the fact that households whose livelihoods are cereals–livestock or cereals–beekeeping earned substantially higher returns from livestock than other households, controlling for the value of stock that they own and other factors. Members of agricultural cadres and households who have participated in a literacy campaign also earn substantially higher livestock incomes than other households. These types of households apparently have greater skill in attaining high returns from livestock than other households. It could be valuable to study further how such farmers are able to achieve higher returns, and to incorporate lessons learned into the agricultural extension programme and development projects.

Improved literacy contributes to significantly higher per capita incomes, largely through the positive impact on livestock productivity mentioned above. Another factor found to be strongly associated with higher household incomes is membership in a marketing co-operative, which is believed to increase household income by more than Ethiopian Birr (ETB)[1] 1000, mostly through higher value of crop production. How such organisations are able to boost incomes so substantially should be studied in more detail, and lessons drawn about how and where such beneficial impacts can be replicated.

1. In 2002, US$ 1 = ETB 8.50.

Households pursuing livelihood strategies that generate non-farm income, such as off-farm salary employment, trading, food-for-work and other non-farm activities were found to earn substantially higher total income than households specialising only in crop production. Promotion of such non-farm activities, through development of roads, vocational training, and other programmes, could thus help to boost incomes in the Tigray region. Surprisingly, formal education was not found to be associated with greater adoption of non-farm activities, though this may be due to data limitations (limited number of formally educated households in the data). Further study of this issue is needed.

Households that depend on food aid or other assistance as a secondary source of income have significantly higher total and per capita incomes (not counting the value of assistance received) on average than households that depend solely on cereal crop production. This suggests that there may be a lack of targeting of food or other aid to the poorest households. Given the relatively small number of aid dependent households in our sample, this result could be a statistical anomaly (though the result was statistically significant with 95% confidence). Further study of the targeting of food aid and other assistance appears to be warranted.

Two categories of households that face greater poverty than others are female-headed households and larger households. Female-headed households earn substantially lower crop income and total income than male-headed households. While larger households earn comparable or larger total household income than other households, their income per capita is significantly lower. Increased efforts to address these problems through improved education of girls and women, family planning, and other targeted interventions appear to be needed. The fact that households with members of a women's association earn substantially higher non-farm income suggests that such associations can help by promoting income diversification.

Land tenure was not found to be a major factor affecting total crop production and household income. However, our evidence does show that tenants (mainly sharecroppers) use fewer

inputs and obtain lower yields at the plot level than owner-operators. This may be because restrictions on the duration of land lease contracts (no more than two years unless 'modern technologies' are used by the tenant) prevent landowners from leasing land to tenants that they know well, so that the incentive problems involved in sharecropping (i.e. tenants' incentive to use less inputs because they receive only a fraction of the output resulting) can lead to reduced farming intensity and yields. This problem was not observed in several villages in the Oromiya region, where the average duration of sharecropping arrangements was much longer than two years. Thus, the restrictions on land leasing in Tigray may be inhibiting productivity on sharecropped land. The regional government should consider whether such restrictions are really necessary and helpful, or perhaps prolong the allowable duration of tenancy contracts regardless of the technology used by the tenant.

Overall, the findings of this study show that profitable opportunities exist to increase agricultural production, household incomes and achieve more sustainable land management in the highlands of Tigray. These opportunities include improvement of crop production using low-external input investments and practices such as terraces, manuring, reduced tillage and reduced burning; improved livestock management; and diversification of livelihoods towards non-farm activities and small-scale livestock such as poultry and beekeeping. The comparative advantage of people in the Tigray highlands is not in intensive cereal crop production but more in such alternative activities. As a result, greater emphasis on developing these alternatives in agricultural extension and other development programmes may be fruitful. Food crop production should not be ignored in the development strategy, but less promotion of purchased inputs such as fertiliser and improved seed and greater emphasis on non-farm opportunities, livestock and sustainable land management practices may be helpful.

Farmers' management of wheat diversity in Tigray: Implications for land management

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Genetic diversity, or genetic variation is essential to both the level of current crop output and the future crop improvements on which societies will depend. In recent years, recognising that seed collections preserved in gene banks evolve differently from crop populations grown in farmers' fields, there has been increased scientific and policy interest in the strategy of conserving materials in situ (in their place). Although it is relatively straightforward to argue the importance of dynamic, farmer-led conservation of crop genetic resources from the perspective of plant genetics, related scientific and social questions are complex.

Objective of the paper

This paper discusses farmers' initiatives in genetic resource management in the highlands of Tigray, northern Ethiopia. A study was conducted in order to gain a better understanding of the diversity of wheat varieties, identify source of variability and document the extent of diversity. This study will advance the application of scientific methods to analyse on-farm conservation of crop genetic resources, and will be linked in subsequent work to the analysis of farmer and community decision-making based on econometric methods.

Framework for research

Previous applied research has identified several factors that influence the probability that farmers will continue to choose to grow landraces. The first set of factors is associated with agro-ecology. In extreme, heterogeneous and highland growing environments, farmers' traditional varieties are still more likely to be grown than modern varieties since the germplasm developed by centralised breeding programmes may not be well adapted to these areas and their microclimates. Population genetics also suggests that special forms of genetic variation will occur when crop populations of small species are isolated in geographical niches. The second factor is the ratio of labour to land, which includes agricultural intensification, or technical change that increases output per unit of land. Modern varieties are one form of agricultural intensification, and they are likely to be adopted where population densities are high. A third is market access, which affects farmers' incentives from crop commercialisation.

Sites in Tigray vary according to these underlying generic factors.

To understand how farmers' decisions about the varieties they grow affect diversity it is essential to characterise that diversity. The relationship between wheat variety names and genotype diversity has not been established conclusively in Tigray. Some researchers maintain that a variety is not named unless farmers recognise its distinctive phenological or agronomic features. Others argue that different names may be given to varieties with the same genotypes, reflecting farmers' use preferences. Furthermore, varieties that are variable in genotype may be given the same name. Resolving this problem requires a two-way characterisation. Moreover, the frequency of desirable genes has to be estimated because the morphotype variability may not be related to the genetic variability of the germplasm in stressed environments. Detecting sites of high allelic diversity will be relevant for exploring the genetic base of the varieties and in situ conservation.

Method

Seven *woredas*, and two *tabias* within each *woreda* were selected from the Southern, Eastern and Central zones of Tigray based on hypothesised levels of wheat diversity and their representativeness of the social and physical environment of the crop. History of use of improved seed, and the sampling design of the International Food Policy Research Institute/International Livestock Research Institute/Mekelle University (IFPRI/ILRI/ MU) survey were also considered, since the data of wheat diversity will later be linked to selected variables included in the survey. *Tabia* administrators, development agents and agricultural experts were involved in selecting the *woredas*. Focus group discussions were conducted with elders, seed selectors, development agents and *tabia* administrators in order to understand community perceptions of wheat diversity and management. A community diversity fair was organised to enhance the awareness of popular, extinct and endangered varieties. International wheat descriptors received from the International Plant Genetic Resources Institute (IPGRI) library were used to characterise the displayed varieties.

A total of 420 households (30 from each *tabia*) were then randomly selected. A survey was conducted to elicit farmers' knowledge of wheat varieties, preferences, and information about management of varieties. Both women and men were interviewed.

Results

We find that farmers deliberately enhance the existing diversity of their wheat cultivars, by selecting and adapting variable genotypes. They select different types of plants based on their differential response to environmental stresses. This selection process has contributed to great genetic variability and stability. Some are experimenting with local varieties based on both pureline and mass selection methods.

Three practices of selecting and developing wheat varieties were observed. First, farmers from Endamehoni *woreda*, Neksege *tabia*, were able to select and develop two varieties of wheat, using single plant selection and mass selection methods. Sinday Abraha, a variety named after the person who developed it (Abraha) is popular in some areas of Neksege *tabia*. Second, a few farmers in Wukro, Hagereselam, and Enderta *woredas* were maintaining and experimenting with endangered varieties known as Shemelmalo and Felasito. One of the farmers in Enderta *woreda*, Aragure site, had increased the seed of the extinct variety Shemelmalo and tested it for three years. On the fourth year he and his wife jointly experimented with the consumption quality of the variety. Two popular varieties (one local and one improved variety) and the Shemelmalo variety were ground separately and baked to test their bread quality. Family members expressed a preference for Shemelmalo over the other varieties.

A third practice encountered was the adaptation or 'rustication' of improved varieties. Farmers selected improved varieties which had been introduced 10 years earlier to adapt them to the changing environment of Tigray, giving them a local name based on their spike morphology. Varities known as Gombel and Gomad are examples of such an adaptation strategy.

Based on farmer perceptions, the status of wheat varieties in Tigray can be grouped into three, as currently popularly grown (e.g. Shehan, Tselim Sirnay), those on the verge of extinction (e.g. Gombel, Guande, Desalegn) and those that are extinct (Dekotsa, Lilay, Aykurtem). Changes in climatic conditions, especially rainfall, are the principal causes for the changes in wheat diversity.

Implications for further research

Focus group and detailed farm interviews in Tigray reveal that farmers' knowledge of genetic resources and their traditional selection techniques have diversified the germplasm base. Their knowledge, combined with scientists' knowledge on special breeding techniques, could lead to the identification and development of valuable cultivars that have a wide potential for use in semi-arid areas, within and beyond Tigray. The named wheat varieties grown in the highlands of Tigray include not only a large number of local types and a representative range of modern types, but also varieties selected by farmers from local germplasm and those they have adapted from modern varieties.

This understanding of farmers' practices needs to be placed within the general context of economic development in Ethiopia and factors influencing farmers' choices regarding which varieties to grow and how to manage them. Further analysis to identify the determinants of wheat diversity is therefore essential.

Closing speech

Belete Taffere
Tigray Bureau of Agriculture and Natural Resources (BoANR)

Dear Dr Mititku Haile, President of Mekelle University
Dear Dr John Pender, Senior Research Fellow, IFPRI
Dear Dr Simeon Ehui, Co-ordinator of Livestock Policy Analysis Programme, ILRI
Dear Workshop Participants
Ladies and Gentlemen

It gives me a great pleasure to make this closing speech at this important and historic workshop, which deliberated on 'Policies for sustainable land management in the highlands of Tigray' for the last two days.

As you very well know, our region is characterised by high rates of land degradation, especially soil erosion, nutrient depletion and soil moisture stress. There are several issues that should be addressed in the areas of land use, land tenure and sustainable land management in Tigray. As an integral part of the rural economy, it is also important to formulate policies and institutions for developing the livestock sector. As the role of forest resources could not be overlooked in improving living standards of local people in Tigray, it is very important to review the experience of community and private tree planting for sustainable land management and improving the livelihood of rural people in the region. Furthermore, evaluating economic returns and impacts of policies and programmes affecting land management in general is important in order to inform policy makers about the effectiveness of alternative policy options for sustainable agricultural development in the region.

It was with this general background that the International Food Policy Research Institute (IFPRI), the International Livestock Research Institute (ILRI) and Mekelle University (MU) have been conducting this collaborative research in our region for over four years now. It is my belief that the outputs of the research as well as the deliberation conducted with all your patience and dedication will undoubtedly contribute to improved land management in the highlands of Tigray in order to increase agricultural productivity, reduce poverty and ensure sustainable land use. I also believe that the study will provide basic input to develop and assess policy and institutional options and help policy makers in implementing those options in order to improve land management in the highlands of Tigray.

I believe this workshop has been very fruitful and provided new and useful information, especially to our experts and development practitioners working in the agricultural sector. I am very grateful to ILRI, IFPRI and Mekelle University for undertaking such valuable research in our region. It will be most appreciated if such collaborative research undertakings among the institutions would continue in our region. Especially, I would like to invite IFPRI and ILRI to consider doing further research in the region by building on what have been accomplished by the current project. I am also grateful to all the participants here for their valuable comments and contributions to the success of this workshop.

I thank you.

Appendix I Workshop programme

Agenda

28 March 2002

8:30–9:00	Registration
Session 1:	**Opening**
Chairperson:	Ato Haile Yohannes
Rapporteurs:	Dereje Assefa, MU and Solomon Tesfay, ILRI
9:00–9:10	Welcome and introduction *(Dr Melaku Tefera, MU)*
9:10–9:20	Welcome address *(Dr John Pender, IFPRI)*
9:20–9:30	Welcome address *(Dr Simeon Ehui, ILRI)*
9:30–9:40	Opening of workshop *(Dr Mitiku Haile, President, MU)*
9:40–10:20	Project objectives, activities, organisation and database *(Dr Berhanu Gebremedhin, ILRI)*
10:20–10:30	Questions/clarification
10:30–10:45	Coffee/photograph
Session 2:	**Land management and socio-economic development in Tigray**
Chairperson:	Dr Simeon Ehui, ILRI
Rapporteurs:	Solomon Tesfay, ILRI and Dereje Assefa, MU
10:45–11:15	Overview of the Tigray National Regional State: Achievements of the Five-year Development Plan and future prospects *(Haile Yohannes, Tigray Bureau of Planning and Economic Development)*
11:15–11:25	Questions/clarification
11:25–11:55	Agricultural change and land management in the highlands of Tigray: Causes and implications *(John Pender, Pamela Jagger, Berhanu*

Gebremedhin	*and Mitiku Haile)*
11:55–12:05	Questions/clarification
12:05–12:35	Perceptions of environmental problems and their severity in rural areas of Tigray: The case of Alage *woreda (Fikru Yifter/Mitiku Haile, MU)*
12:35–12:45	Questions/clarification
12:45–14:00	Lunch
Session 3:	**Land management and soil fertility in Tigray**
Chairperson:	Dr John Pender, IFPRI
Rapporteurs:	Dereje Assefa, MU and Solomon Tesfay, ILRI
14:00–14:30	Status and determinants of soil fertility in Tigray *(Mitiku Haile/Berhanu Gebremedhin/Amare Belay)*
14:30–14:40	Questions/clarification
14:40–15:10	Land use, land tenure and sustainable land management in Tigray *(Berhanu Gebremedhin/John Pender/Simeon Ehui/ Mitiku Haile)*
15:10–15:20	Questions/clarification
15:20–15:40	Coffee
15:40–16:10	Policies and institutions for livestock development in the highlands of Ethiopia: Results of a community survey in Tigray, northern Ethiopia *(Berhanu Gebremedhin/Simeon Ehui/John Pender/ Solomon Tesfay/Mitiku Haile)*
16:10–17:00	General discussion
17:00	End of Day 1
19:00	Dinner and reception
29 March 2002	
Session 4:	**Community resource management**
Chairperson:	Dr Melaku Tefera
Rapporteurs:	Solomon Tesfay, ILRI and Dereje Assefa, MU

8:30–9:00	Community resource management in Tigray: Woodlots and grazing lands *(Berhanu Gebremedhin/John Pender/Girmay Tesfaye)*
9:00–9:15	Questions/clarification
9:15–9:45	Rural fuel production and demand in Tigray *(Zenebe Gebregziabiher, Tigray Bureau of Agriculture and Natural Resources)*
9:45–10:00	Questions/clarification
10:00–10:15	Coffee
10:15–10:45	Community and private tree planting for sustainable land management and improving rural livelihood in Tigray, Ethiopia—Understanding the tradeoffs *(Pamela Jagger/Berhanu Gebremedhin/John Pender)*
10:45–11:00	Questions/clarification
11:00–11:30	The role of indigenous knowledge in sustainable land management *(Fetien Abay/Mitiku Haile/Ann Waters Bayer)*
11:30–11:40	Questions/clarification
11:40–12:10	Environmental and social impacts of earth dams in semi-arid areas of Tigray *(Mitiku Haile et al.)*
12:10–12:20	Questions/clarification
12:20–13:30	Lunch
Session 5:	**Determinants and impacts of household land management**
Chairperson:	Ato Kinfe Abraham
Rapporteurs:	Dereje Assefa, MU and Solomon Tesfay, ILRI
13:30–14:00	Economic returns and impacts of policies and programmes affecting land management in Tigray *(John Pender/Berhanu Gebremedhin/Mitiku Haile)*
14:00–14:10	Questions/clarification

14:10–14:40	Efforts for sustainable land management in Tigray: The role of extension *(Belete Taffere, Tigray Bureau of Agriculture and Natural Resources)*
14:40–14:50	Questions/clarification
14:50–15:10	Coffee
Session 6:	**General discussion**
Chairperson:	Dr Mitiku Haile
Rapporteurs:	Dereje Assefa, MU and Solomon Tesfay, ILRI
15:10–15:30	Synthesis of key findings *(Simeon Ehui)*
15:30–17:00	Discussion
17:00–17:15	Closing remarks *(Belete Taffere)*
17:15–17:30	Closing remarks *(Simeon Ehui)*

Appendix II List of participants

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