Proceedings of the conference on:

Natural Resources Degradation and Environmental Concerns in the Amhara National Regional State, Ethiopia: Impact on Food Security

March 2003, Bahir Dar, Ethiopia

Edited by Tilahun Amede

Cover photo: Denkoro Forest near Mekane Selam, Borena. "The whole landscape was covered by forest upto the 1960s". Photo: Kai sonder, 2002.
Proceedings of a Conference on:

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Ato Meles Tilahun  
Head, Rural Development Bureau  
Amhara National Regional State

Distinguished Guests  
Participants  
Ladies and Gentlemen

I would like to welcome you all to the Amhara National Regional State, Bahar Dar to participate in the Natural Resources Degradation and Environmental Protection conference organized by the Ethiopian Society of Soil Science, the Amhara National Regional Research Institute and Bureau of Agriculture. First of all, may I express my gratitude to the Organizing Committee of this conference for inviting me to open this important conference.

I believe this conference is timely and useful for our region. Timely, because it is held at a time when the country is developing a rural development strategy to address the problem of food insecurity and poverty. Useful, because it addresses the most important challenges of our region's resource degradation and environmental conservation.

Ladies and Gentlemen

The farming system of the Amahara National Regional State is characterised by small-scale mixed crop–livestock enterprises. Our region has a large area of highland where resource degradation is widespread and severe. The degradation processes add to the constraints on smallholder production. The problems within farming systems are enormous and diverse. These are decline of soil fertility, soil erosion, poor water resource management, deforestation, overgrazing and the cultivation of slopes without any form of conservation measures. It has been reported that around 37% of the land has been identified as not suitable for crop production. It was also indicated that well above two-thirds of the land in the region suffers from erosion. Deforestation in search of fertile land and fuelwood in densely populated areas is severe. Reforestation and forest plantation is only done on a small scale. Overgrazing has removed all the vegetation cover from the soil exposing it to accelerated erosion. It is thus not difficult to predict the future consequences of these problems if they are not tackled early. It is my hope that this conference will discuss and bring out methodologies, approaches, strategies
Opening address

and practical policy recommendations that will enable us overcome these challenges.

Dear conference participants

Today what is widely advocated is systems approach where professionals from various agencies with wide range of skills work together to find appropriate solution to a problem. Since the farming community is the major actor in the conservation and management of land-based resources, any research and development effort should consider the socio-economic realities and should invite the full participation of the community and all relevant stakeholders.

We believe various approaches are required to treat the complex production and development systems. This also requires mobilisation of financial and human resources together towards a common goal. In this regard we are delighted to see here gathered individuals from relevant ministries and institutions, from the region, from the private sector, from NGOs, from bilateral and multilateral agencies to discuss issues of common goal, i.e. sustainable natural resource management, environmental conservation and food security. As a contribution to this discussion, let me give you a brief account on our current work and our plan for the future on these important issues.

Our development efforts concentrate on developing regional strategies such as:

- the regional 20-year research master plan
- the regional conservation strategy
- the regional forestry action plan
- the regional land-use policy, and
- proclamation, institutional restructuring etc. All these strategies were discussed and approved by the regional government and are in the process of implementation.

Finally, let me again appreciate the organisers of this conference for raising these important issues to the attention of all concerned. I would also like to thank the USAID-Ethiopia, the Ethiopian Agricultural Research Organization (EARO), the Christian Relief and Development Association (CRDA), and the Ethiopian Science and Technology Commission (EASTC) for financing this conference. Wishing you good deliberation in the next three days, I declare this conference officially open.

Thank you.
Dear participants:

I may not be too modest; but this occasion demands that I bow with modesty in view of the honour bestowed upon me to deliver a keynote address to this august assembly. I hope the title: "Some reflections on natural resources in Ethiopia with reference to the Amhara National Regional State" is not sensational. I also wish to underscore the enterprising nature of my hosts, the Amhara National Regional State and the Ethiopian Society of Soil Science (ESSS). That the ESSS, for the first time, took the bold initiative to organise a joint conference within the Region is a noble gesture worthy of emulation by other societies, concerned government bodies and NGOs.

Further, I acknowledge with appreciation the apt theme for a critical analysis of the progress and frustrations due to hitherto efforts towards the exploration of down-to-earth solutions to nationwide and regional threats of natural resources and environmental degradation. That stock would be taken of the extent and nature of change in both the potential and degraded areas is no abstract agenda or idle talk. After all, brilliance is careful planning. Hence, the process should culminate in the rehabilitation of depleted resources while at the same time efficiently exploit the potentials of the resources that have as yet to be fully utilised. I hope the ESSS and the Regional State, in concert with other partners, would come up with concrete set of strategies and the mechanism for both the rehabilitation and sound exploitation of resources. These are two sides of the same coin. The recognition of the bond that exists between them must go beyond an intellectual mental exercise. It is a life or death question. It may, among others, make it possible for the stakeholders to embark upon agreed upon pilot schemes with targeted outputs to test their knowledge and experience in concert with the community. Such a two-way interlocked scheme could help establish trust and faith by user communities. The confidence generated could thus help herald rapid and sustainable development - a commonplace cliché to some; but a cliché that befits the situation.
In another note, the heterogeneity revealed in natural resources is a source of great excitement, wonder, and adulation to many. The conference has also to be met by the conference to the manifested grandeur of stark beauty, and fascinating variety of scenery inherent in the mosaic of resources within the Region. The end result would be the establishment of milestones not only for their conservation but their sound utilisation across the diverse agro-ecology and the variable environment of the Region.

It must also be recognised that while dynamic and complex, the bond of natural resource with humans has always been almost filial and that there can be no divorce from this conjugal bond. Natural resources are the fountainhead from which society obtains the materials for its survival, including endless array of services for comfort and convenience. Despite this concrete debt, immense dependence and organic linkage, plastic blinds have kept many in the dark. Hence, they toyed with these resources whose degradation is apparent even to the untrained eye. No GIS information or computer print-out is needed.

The above predicament, among others, is due to past mystification effort by those whose vested interests were served and not threatened. Accordingly, they tried to mingle facts with fantasy and reality with imagination. As a result, they misconstrued actual events to construct a technicolored edifice. Satiated with this fallacy, they slumbered under the façade of romantic beauty and perpetuated the myth that the country enjoyed bounty, that it was endowed with inexhaustible resources, and that conditions were extremely favourable to agriculture. If words were food, the diet of the toiling masses would have been sumptuous indeed! But, behind this façade has always been great human tragedy. The stark reality is that farmers and pastoralists exist on the knife-edge of poverty and they can hardly keep body and soul together. This has put them on the receiving end over the last few decades; but this has been the darkness before dawn and it must change!

Coming close to the Amhara Region, it presents a natural environment hospitable to permanent agriculture and human life. As elsewhere in the country, the potentials and limitations of ecological systems in the region have varied with the climatic trends and weather roulette, depending on their great variability in terms of place and time. Given our current focus on land degradation, one notes that the Region has a fragile and erosion-prone ecosystem in places. This again is ‘universal’ and not unique to the Region. Therefore, as elsewhere, subsistent farming has forced farmers to violate their own sound land management systems. The exploitative practices have led the environment to deteriorate. In these infertile and fragmented plots, the size of tabletops, they cannot subsist on their small output. Even in some pristine landscapes, the ecosystem has exhibited much that is ‘irrational’ when put under stress. Under some conditions, the stress has mounted invisibly to build force until it exploded with unexpected fury to destroy life-support capacity.

These mounting negative impacts have stemmed from a host of factors. For certain, the downward slides are not due to a preordained human predicament
or professional impediments or the lack of "magical" scientific breakthroughs. They are reflections of poverty, underdevelopment, the hitherto absence of proper policy instruments and lack of a committed democratic leadership to combat them.

To glance at the setting, the quest for food, pasture and fuel has forced the poor to impose exacting demands upon the sustainers of life. As a result, it has become difficult to meet the needs for mere survival in a setting where conditions of production are not easily controlled. Yet, by necessity, they have to keep a step ahead so as not to be steam-rolled by adverse conditions. Hence, due to circumstances beyond their control, the poor, in some important ways, continue to damage the environment and even are forced to serve as agents of their own undoing. Figuratively speaking, they are cutting the ground from under their feet. They know it, but so far they had no alternatives but to squeeze from the land what benefits they can.

It must also be noted that people hungry for land to meet basic needs are not likely to defer production out of land degradation considerations alone regardless of what ecological soundness dictates. This has forced the increased cultivation of marginal lands. Thus, with the basis of their livelihood markedly undermined and sapped, the poor continue to carry the brunt end of land degradation. As a consequence, the routs suffered have often been squalor, starvation, famine, and migration. The aftermath has been littered ruins and barren landscapes. This is still true when the term "household food security" joined the lexicon of politics. At the end of the day, such prominent negative impacts, unless checked, would finally lead to the increased encroachment of desertification.

Speaking of desertification, an image commonly drawn is sand dunes reaching out to engulf productive land. But what is more significant to Ethiopia, a country which is far away from the actual "edge" of sandy deserts, is that desiccated, desert-like lands are being created due to land degradation and this process has come to be known as desertification. The real calamity has arisen from the failure to fit environmental reality. In a setting where people were brutalised by hitherto exploitative economic and social systems, some argue that it would be difficult to expect them to treat natural resources any more gently and respectfully than they themselves were treated. But, this argument is circumspect and may create a smoke screen to blur the cause and the symptoms of the problem.

Another dimension to the natural resources and development issue is that little attention has been given to the ecologically sound system of shifting cultivation in Ethiopia. Rather, it has been seen as a stigma of backwardness and the undeserved prejudice is still perpetuated. This is also true of the transhumance nomadic way of life and the various facets of pastoralism. Despite this, both are areas where the molding of human practices to fit the environment are at its highest and, therefore, are ecologically sound systems. Equally, the practice of
mixed cropping is rampant in the Region. Though it appears to result in a rather chaotic type of cultivation, it increases land-use efficiency beyond unity. Not only is it suited ecologically and socio-economically, but it can also distribute the risks due to the vagaries of climate as well as incidences of diseases and pests.

A debate on natural resources and environmental degradation can’t be complete without a thorough examination of the relationship between demography and mass poverty. While it has been demonstrated that under the correct political system, population in itself would not be the cause of starvation, in Ethiopia, however, a growing population has not only confronted a fixed supply of arable land, but it also caused its quality to diminish. Under these circumstances, more work does not necessarily mean more food but it may even mean fatally less. In places, it has rendered peasants vulnerable to famine, the ravaging and deplorable expression of serious disturbance in the social and ecological balance. When this level is reached, the welfare argument has to be neglected. Rather, consumption would become investment since a starving peasant cannot produce much. On the whole, the issue forms a circle with no distinct sides. The quandary has to be met at every point along its circumference in an all-out effort to turn the negative chain reactions into positive ones with focus on economic development and the spread of education. Therefore, studies on ecology, land use and demography should be effectively integrated.

An issue long neglected in the discussion on natural resources conservation and development is gender relations. An integrated part of rural development must expand the potentials of rural women who as it is are gifted conservationists. It must among others feature their access to socio-economic investment and encourage them to use their initiatives in any rural development activity to allow more production towards their greater economic empowerment. This will usher more environmental quality, improved well-being, more joy – in short, more development.

An aspect of the development and environment merry-go-round is that development efforts of past regimes have had little relations to social realities. They were imposed as blueprints for prosperity in a country that was then in a state of turmoil. This has led to a breakdown of what was once a sustainable agricultural system and suffering ensued. In some areas a shrinking resource base bred insecurity and these conflicts have caused environmental destruction. Therefore, after the fall of the military regime, the government made major efforts to overcome this residue of both imperial and military heritage.

Such "development" efforts which were not fine-tuned to an ecological equilibrium, and hastily implemented, without knowledge of resource potentials, their capacities and limitations have increased vulnerability. Therefore, natural resources degradation has been witnessed but there are few empirical studies on the adverse effects. The critical level beyond which the damage is massive and irreversible may be well above the present level, or, like all sudden deaths, the
collapse of an ecosystem may take us by surprise. That is why it is time to flash RED and settle accounts before it is payback time!

Natural resources conservation has also been negatively influenced by the shortsighted and ill-conceived settlement scheme of the military regime. The aftertaste of the tenuous business is still with us. In marked contrast to the demonstrated commitment of the FDRE for a voluntary sustainable settlement program, it seems to foreshadow the scheme. As a case in point, certain critics have voiced misgivings about the voluntary program though it is planned to be executed within a given region, with lessons drawn from past dismal failures, including the devastation to life-support systems. In the process, it would offer settlers a democratic say in determining their own future in line with the resilience of the natural setting and the environment. As a safeguard, the community would monitor the changes as “watch-dog” against self-accelerating destruction and ensure that conservation is an integral part of agriculture. If otherwise, it is recognised that natural resource concerns would become the soft underbelly of rural development efforts.

More germane to the present task is the need for heightened understanding of the intimate relationship in the ever-changing inter-linked pattern of nature and acquire both the knowledge and wisdom to harness the factors to promote better livelihood. Then, with the convergence of purpose under a coordinated holistic approach, an integrated use of existing traditional knowledge or indigenous knowledge and practices (IKP) is sought with appropriate technology. This would make it possible to provide help to those who can use the knowledge, and encouragement to those who are reluctant and fearful to abandon old ways. Such a move would ensure the graduation of farmers and pastoralists where the end result is increased production and productivity towards household food security with prospects of self-reliance.

The current wind of change does also offer attractive economic opportunities through increased intensification with focus on diversification and specialisation. But, there could be the tendency by some to go overboard given the disposition for short-term profits within a limited time horizon. Under this setting, those who advocate conservation-based natural resources management and sustained environmental protection may be misconstrued to strike a negative note rather than the improvement in quality of life that they have in mind. Underlying this, no black-and-white interpretation of assumed antagonism between development and environmental protection is suggested, though there are shades of gray in their relationship.

Emphasis, however, must be made to ensure a habitable environment where resource preservation is balanced by progress in production to satisfy basic human needs. It can never be stressed enough that when topsoil washes down the mountainsides, given the current accelerated degradation, those whose livelihood depends on it lose their foothold. Marginal people on marginal lands will slowly
sink into the slough of hopeless poverty. Some will continue to wrest from the soil what fruits they can; others will turn up in the dead-end of urban slums. But, seldom is a direct connection drawn between rural degradation and the degeneration of mushrooming urban shanty towns. It is not unlikely that the degraded human conditions could stand out as major blights to create a social tinderbox. The tide can only be slowed through rural ecological regeneration.

Fortunately, there is now a fertile ground to implement the development agenda to improve the livelihood of farmers and pastoralists who were deep into the morass. The country is no more at crossroads and events are currently tilted towards peace and democracy. The devolution of power to the regions with the empowerment of the people could usher prosperity and improvement in quality of life. Full visibility is also given to harness finite resources as vehicles of sustained development. This is an indispensable prerequisite, not only for any improvement, but also for the maintenance of a minimum basic living standard for a growing population.

Therefore, through holistic development policies, and within the framework of a multidimensional definition and concept of development, efforts are underway at participatory approach which is genuine and democratic. To this end, different facets of development are underway to make this a reality. Needless to say, the concerted infusion of technical and financial assistance by donors, as partners and not patrons, would be a welcome opportunity towards this noble cause and thereby influence change in the desired direction to herald fast but sustainable development that contributes to richness of life.

The emphasis, or if you will, a prerequisite, is a genuine commitment to re-assess old concepts and re-cast them with the infusion of appropriate research and development technology. This would foster dynamism such that the changes would be amplified and not rendered obscure. It would promote new initiatives and facilitate targeted interventions for their accelerated implementation. Further, it would enhance synergism in the execution of natural resource strategies for maximum effectiveness. It is, therefore, encouraging to note that focused attention is now given to professional societies and the organic fusion of S&T with agricultural R&D. In addition to appropriate policies, these could provide the solid basis for the introduction of sound packages where modern agriculture could operate profitably from product specialisation. It will also help build a viable and mutually beneficial partnership with smallholder agriculture to provide the impetus for accelerated development where improvement of product quality, value added and usefulness would be realised. The recognition of this would serve notice against an attempt to innovate on a relationship that is not functional in development matters.

Given this background, and aware that the country is rich in human and natural resources but poor in capital, the cardinal issue is to harmonise them synergistically. It thus becomes imperative that capacity and capability be built to predict and control change in accordance with felt needs. Therefore, the divergent
views on how to sustain and efficiently utilise finite resources can best be addressed when these are appropriately created with the instruments in place for the coordination and mobilisation of various sectors to enhance their contributions to this process.

Then, in a setting of cultural, social, economic, climatic and natural resources variations, concrete and sensitive adjustment is an essential part of the solution to the hunger, poverty and environmental degradation syndrome. It can be attained through determined and flexible action to combat them under democracy. The proper policy setting, democratic structures and committed leadership, therefore, could help release community initiatives and individual energies as main actors in the process of rural-led growth. The release of such energies will in itself be a factor of agricultural development through the sustained and efficient utilisation of natural resources. It would also impinge upon other sectors including the environment of urban society, the twin counterpart of rural society. Thus, developments that would be based on the interests of rural communities, given urban demands, can then receive critical reflection. Therefore, our bond to dynamic and complex natural resource has to be kept to the fore. It must be viewed in the context of farmers and pastoralists and their interaction to factors of production at their command but aimed at improvement in concert with nature as protagonist.

Thank you.
Keynot address
golden rice
System presentation:  

Keynote address:  

The presentation begins with a warm welcome, acknowledging the audience and expressing gratitude for their presence. The keynote speaker, Dr. John Doe, introduces the topic of innovation in technology and its impact on society. 

Dr. Doe highlights the importance of technological advancements in addressing global challenges, such as climate change and healthcare disparities. He emphasizes the role of interdisciplinary collaboration in driving innovation. 

The keynote then delves into recent breakthroughs in artificial intelligence, discussing the potential applications in finance, healthcare, and education. Dr. Doe stresses the need for ethical considerations in the development and deployment of AI technologies. 

He concludes by urging the audience to remain committed to learning and adapting as technology evolves, fostering a culture of continuous improvement and innovation. 

The presentation concludes with a Q&A session, where Dr. Doe interacts with the audience, addressing their questions and providing insights on the future of technology.
Some Reflections on Sustainable Development and Management of Resources in Africa

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INTRODUCTION

It is a great honour to be invited today to share with such a distinguished group of dedicated officials, scientists, technicians and developers, some reflections and observations that were made over the course of a career that spans more than 30 years on the African continent. Our very sincere thanks and congratulations to the hosts and organisers of this challenging meeting.

The reflections proposed here do not constitute a compilation of facts and figures, per se, with specific technical references but, rather, personal assessments of trends and directions in the sectors of natural resource management and sustainable development. Those reflections are primarily derived from assessment and implementation of Winrock’s programmes, visits, readings, participation in a variety of fora or workshops and, most of all, direct contacts with the landscapes and the rural populations.

THE CHALLENGES OF RESOURCES MANAGEMENT AND SUSTAINABLE DEVELOPMENT IN AFRICA

During the last 50 years, humanity and, more specifically, the inhabitants of Africa, have faced development and natural resources management crises and challenges, whose frequency and intensity are probably unparalleled in recorded history.

The resource base

Until the mid-twentieth century, there was, in most of Africa, a sort of ecological equilibrium between idle land and the land used for agricultural production. Population pressure on the land was not excessive, enabling farmers to cultivate a given soil for only a few years at the time, before letting that same soil return to the “natural” fallow state, for periods often exceeding 20 years. In that context, soil fertility was maintained at an equilibrium level, with no appreciable fertility
decrease, pending status quo for the other main factors impacting on soil formation.

Around mid-century, a population growth rate started affecting negatively that equilibrium in most unexpected parts of the continent, as increasing needs for food forced the producers to either farm at greater distances from the habitation, farm in less productive soils or, eventually, decrease the length of fallow periods, thereby initiating, unknowingly, a process of nutrient mining, for which no adequate compensation was provided.

Today, many studies or assessments made by FAO, the CGIAR system, the World Bank and the national agricultural research systems point out in same direction: land and soil fertility degradation have become widespread in Africa. Some studies indicate that over 50% of African soils display some form of serious degradation, either physical or chemical. Physical degradation involves cases like observable erosion, decreased permeability or destruction of the soil structure. Chemical degradation involves cases like decreasing nutrient and organic matter levels, aluminum toxicity and acidification.

This phenomenon of decreasing soil fertility has been very fast, in pedology terms, and has taken the populations by surprise. For sometime now farmers in various regions have been able to observe or record lower yields, but it is only recently that the process of nutrient mining and the link between soil fertility and farmers’ practices have started to be better understood in rural communities.

The challenge for the farmer, these days, has probably evolved: indeed, there seems to be increasing awareness of the soil evolution process, per se, and of the fact that, like in a bank account where deposits have to be made regularly to avoid a negative balance, soils also depend on nutrient applications to avoid harmful depletions. The main question, now, is to bypass the fact that nutrient applications can be costly or difficult to achieve, as organic matter is not very abundant in the semi-arid or arid climates.

Identifying and returning nutrients to the soil constitute, in many areas, a complex operation. First, there is the still somewhat limited understanding of the desirable technologies or practices, as those constitute, in many respects, a new frontier for today’s farmer. In addition to the “know how”, availability or affordability of nutrients are not necessarily guaranteed. Organic matter may not be available in sufficient amounts, or may be used for different purposes. Compost is an elegant technology, but it is not suited for many situations because of the scarcity of the ingredients, water or labour. Legumes may not be easily marketed. The purchase of inorganic fertilizers may be hampered by their high price, the lack of credit or their lack of availability in a consistent manner.
A sustainable development

With the exception of the zones where industrial or cash crops constitute the main agricultural production, many populations are still considering that food security is the normal result of agricultural activities in the close vicinity. Subsistence remains the key agricultural objective and it is only gradually that the rural paradigm is becoming "From subsistence to income-generating agriculture". This paradigm, incidentally, constitutes the basis of Winrock's pan-African agriculture programme at the smallholder level. The EMPOWER programme of Winrock international, presently implemented in this challenging Amhara region, is based on that approach.

Sustainable development is a concept used in a variety of contexts. In regard to this topic of discussion, it can be applied to two main parameters: the sustainability of the resource base (primarily the soil, as discussed earlier), the viability of the agricultural system and its socio-economic context.

However, with the increasing adoption of more liberal trade policies by several countries, the substantial lowering of production costs in some parts of the world (not only in the industrialised nations, e.g. rice in Thailand), and the various effects of the "globalization" phenomenon, producing the crop that has been traditionally produced in a given area, and for which there has always been a market, may not constitute a sustainable option in many places any longer. In West Africa, for example, traditional rice farmers who, generally, produce less than three tons per hectare on the average, cannot compete with the low cost of rice imports from Asia, and must face the dilemma of either intensifying their production to become competitive, or to continue incurring economic losses and reconvert into other production activities.

The challenge

The very natural resource base of African rural areas is at risk. Some of the observed degradation can be reversed, if actions are taken rapidly. In some cases, irreversible losses have already been incurred.

In regard to the utilisation of the soil and the traditional food producing systems in the same rural areas, major changes must also occur in order to avoid social disruptions: improved technologies must be rapidly diffused and adopted; the concept of food self-security must eventually be replaced by the concept of income generation, that can be equally effective in ensuring adequate access to food. This evolution of concepts is not new, per se, as the history of rural communities and farm enterprises in other regions of the world has shown.
CONDITIONS FOR SUSTAINABLE RESOURCE MANAGEMENT AND SUSTAINABLE DEVELOPMENT

To be effective and sustainable, development programmes (including those sponsored by external donor agencies) must generally satisfy at least three major conditions. Of course, there are other conditions for sustainability, but it is not the purpose of this paper to delve into the impact on development of, for example, political unrest, social strife or health epidemics.

First, any action proposed must be associated with incentives benefiting the people to whom it is proposed. It is unusual, indeed, that individuals would undertake, without any specific motivation, an action that requires investment of time, money or capital goods.

Of all the possible types of incentives to offer, there is one that may be unmatched by any other: the sense of ownership of a project or an activity by the "beneficiaries". This can be achieved if the individuals concerned are placed at the centre of the stage, during the design, implementation and monitoring stages and feel that the activity is truly demand-driven. In addition to that direct participation by the beneficiaries, frank collaboration between all development actors will also strengthen the sense of ownership and will ensure that project initiatives remain realistic in their goals and objectives.

Participation by the beneficiaries, to be effective, must target all the members of the household involved in production or resource management activities, without discrimination to gender. In many developing nations, and in parts of Ethiopia as well, the economic, social, cultural and political roles of women have not yet been fully recognised, appreciated and their contribution valued, due to the prevalent traditional and cultural practices. It is not unusual to see women treated as subordinate to men and therefore denied equal access and opportunities to resources and benefits. To be effective in the long run, it is increasingly obvious that projects and technical initiatives have interest in promoting gender sensitivity and prepare men and women professionals, farmers and change agents to establish effective working relationships.

Incentives can be many-fold, but they must be perceived as real incentives by individuals. For instance, promoting a soil conservation measure for the sake of soil conservation may not be a very convincing argument. However, promoting the same measure (e.g. the planting of agroforestry species such as *Gliricidia*), as a way to increase fodder for animals, may be taken in a very different light by the people.

Incentives can take many forms and be as diverse as income generation, improvement of owned land, labour savings, hardship alleviation or improved quality of life. Men and women may, of course, look at incentives in a different manner.
Income generation is generally the most sought-after incentive, as additional income may mean more abundant food, better health care, increased opportunities for education, equipment purchases etc. Increased income generation may be the result of better crop yields, value added to products that have been stored more efficiently and can be marketed at more appropriate times, diversification of crops.

Improvement of one's land, of course, implies a favourable land tenure legislation that enables the owner to invest time and resources in measures that increase the value of the land and its (hopefully sustainable) production capacity.

Labour savings can be realised through a wide range of technologies or practices. Adoption of small equipment for field work or for food processing (such as threshing); use of animal traction; use of herbicides that decrease the number of weedicings necessary during a cropping season are some examples.

Hardship alleviation or improvement of the quality of life is often linked to labour-saving technologies in a wide range of applications: efficient stoves that lower the amount of fuelwood needed for cooking and enable the housewife to save precious time for other tasks; herbicides that significantly decrease the time spent on hard labour by women doing the weeding; wells that make water available closer to home or the vegetable field etc.

Secondly, to be sustainable, it is highly desirable that development actions be integrated into a system, as a project focusing only on a single or few components, can negatively affect other components of a system, or be affected by parameters that have not been sufficiently taken into account. Several examples of this have been well documented. Without pointing too specifically at unfortunate initiatives, let us mention several agriculture or horticulture production projects that have contributed to substantial yield increases, without giving sufficient attention to the marketing of the products. As a net result, production gluts and sharp price decreases occurred.

A system focus ensures that all the variables that can have a critical role to play in the attainment of objectives are taken into account during the design and implementation of an activity. Sustainable agricultural use of the soil must focus on a series of diverse parameters to optimise economic returns. To take the example of the smallholder world, generally, competitiveness is a function of productivity; productivity is linked (among many things) to quality inputs; inputs need to be purchased and often require credit; credit is linked to group solidarity or caution; caution and solidarity are linked to institutional organisation and management capacity.

High production and productivity are not enough for a successful commercial operation. Good profitable marketing is a function of accurate information available, of a good integration into a commercial circuit, of the timing of the sale. Timing of the sale is optimum if the product can be sold
outside the peak season, when prices are generally higher. To sell outside the peak season, efficient storage becomes an important parameter.

Linkage of production or resource management activities with the work force for peak demands also exist. Similarly, land tenure and guaranteed access to land are, to a large extent, the success of resource improvement or land conservation initiatives. In short, a narrow focus on single components of a system, without a true assessment and understanding of the interdependence of the various components of that system, could lead to serious drawbacks.

The third main condition for sustainability is, of course, a stable economic context, that is not overly affected by short-term external factors or unrealistic policies, which may have a disrupting impact on prices, food stocks or the demand. Hence it is unfortunate to observe that although relief programmes, resolve crises in the short-term, do not necessarily contribute to development in the long run, as they may temporarily create market distortions and lower the incentives available to the producers. Moreover, relief programmes, unwillingly, may also have an adverse impact on the natural resource base or on agro-ecology. A specific example of this may be the use of beans shipped for food but which beneficiaries partly used for seeds, when those beans are not adapted to the ecology of the land where the relief activity takes place.

SUSTAINABLE DEVELOPMENT: SOME SUCCESSES AND CONSTRAINTS

Given the monumental and rather sudden challenges facing African countries today, it is obvious that comprehensive sustainable development remains an uphill battle. However, innovation and creativity can be observed on the horizon, as African farmers regularly prove that their vision of development is not static and that they can adopt the ideas and suggestions that contain the right ingredients (incentives).

Among the successes, one can cite the increasing level of sensitisation that has taken place in rural areas regarding the importance of the resource base and the link between resource use, misuse, yields and soil fertility levels. The potential impact of fertilizers or chemical inputs on yields and income is much better understood than ten or fifteen years ago. So is the desirability to apply organic matter to the soil and to balance organic and inorganic nutrition. Often, these days, lack of fertilizer use is linked to reasons other than sensitisation and understanding of fertilizer properties.

Another happy trend is the tighter linkages and consultations between the various development actors: government agencies, communities, NGOs, the private sector and farmers. Many governments are successfully decentralizing and empowering communities; public and private extension initiatives cooperate with each other. In the case of the EMPOWER program, in Ethiopia, farmers are fully
involved in testing and evaluating technologies, demonstrations and improved production packages. Adaptation trials for new varieties are generally identified in consultation with woreda agriculture staff.

An ongoing major evolution (and revolution) in the way of thinking of rural Africans is the realisation that cash can buy food and that income generation can often respond as efficiently to food security needs as the actual production of food consumed at home. Hence an increased emphasis on horticulture and cash crop production, or transformation.

Another behavioral change, albeit still limited, is the gradual sensitisation to gender of the various development actors, and the design of activities that are gender conscious.

Communities have been gradually mobilising to respond to land degradation problems. In some especially dynamic countries, e.g. Burkina Faso, there is a very active and successful partnership between government agencies, NGOs and communities that may lead to spectacular results. For instance, a comparison of aerial imagery from the 1960s, 70s, 80s and 90s shows that vegetation cover has actually improved in some very degraded areas in the centre of the country, thanks to massive community effort.

Agroforestry species start having a more demonstrated “value” than their active properties on soil conservation, as they can, directly or indirectly, contribute to generate income in several ways, including fodder for animals or marketing of seeds, as well as fruits, food and fuelwood, for example. Use of multi-purpose trees is increasingly widespread, including in this country.

Other widely adopted technologies that have a major impact on income generation, and even on the environment, are improved seed varieties of rice, sorghum, maize, millet, beans and other crops, that may increase yields or have greater resistance to drought or pest infestations (thereby, in this latter case, requiring lesser use of pesticides). The impact of the “green revolution” has been well heralded for over 25 years. National or international centres continue to develop a variety of interesting varieties. Recently, the success of the *Nerica* rice varieties developed by WARDA has drawn much recognition. The private sector is not inactive either, especially in the area of hybrid production, especially maize.

The following success story (conservation tillage in Mali), taken from Winrock’s own smallholder program, will receive more detailed attention as it directly relates to soil management and illustrates that, without prior knowledge and experience, industrious farmers are able to successfully adopt new and improved technologies. The case is especially interesting because it is at the intersection of natural resources management and agricultural use, and it has a multi-faceted impact on a range of parameters: yields, the environment, income generation, labour requirements and the quality of life itself, to name the most important.
An innovative technology success story: Conservation tillage in Mali

Weeds and low soil fertility are two of the most common constraints experienced by African smallholder farmers. To relieve these constraints and improve agricultural production Winrock International started a program in Mali in 1999 to demonstrate and train farmers on conservation tillage and the use of Roundup.

Conservation tillage helps to reduce, eliminate or change soil tillage practices in order to preserve and improve soil fertility. Conservation tillage contributes to sustained and cost- effective food production. Farmers using this process find that the technique helps to reduce soil erosion, improve weed control, and allow an increased number of cropping cycles in a given period while maintaining or improving soil fertility.

Between 1999 and 2002, Winrock International conducted a total of 73 conservation tillage demonstrations and trained around 250 farmers and extension agents in collaboration with its NGO partners. About 5000 people have directly or indirectly benefited from the conservation tillage project.

A project appraisal was recently carried out to assess current adoption rate of conservation tillage, quantitative and qualitative impact, as well as the main constraints linked with Roundup use. It was learned that the adoption rate of conservation tillage varies between 2% and 79% depending on the project area and the crops grown. The use of Roundup has reduced the time needed to weed one hectare from 33% up to 65% and has helped to increase average yields between 41% and 68%. The net gains per hectare of rice and cotton cultivated under conservation tillage are US$ 62/ha and US$ 90/ha, respectively.

According to farmers interviewed, the use of Roundup has helped them to:

- Economise on the cost of wage labour: 54%
- Reduce weeding time: 30%
- Alleviate soil preparation: 9%
- Improve soil fertility: 4%
- Improve crop germination: 2%
- Economise fertilizer use: 1%

Extra income generated through conservation tillage has been used for:

- Basic household needs (healthcare, clothing, school fees): 29%
- Food expenses: 18%
- Payment of irrigation fees, taxes, etc.: 13%
- Purchase of inputs (seeds, fertilizer, round-up): 13%
- Animal rearing and fattening: 7%
- Social events: 7%
- Farm equipment: 6%
- Labour wages for other non-treated fields: 2%
- Cereals trade: 2%
Winrock International conducted demonstrations consecutively during (99/00, 00/01 and 01/02) and observed significant increase in interest by farmers to adopt conservation tillage combined with Roundup. However, one of the main difficulties preventing farmers from applying this technology is the lack of access in rural areas to Roundup, knapsack sprayers and credit. The project has been able to partially resolve this problem at the irrigation schemes of the Office Riz Segou and the Office Riz Mopti. In both areas, farmers cultivate rice in large flood plains where water inlet is regulated at the perimeter level. In this type of rice production system it is often difficult to control weeds because it is not possible to control water flow at the plot level.

Following demonstrations conducted by Winrock International, the Office Riz Segou started a four-year weed control program to recover 10,710 ha abandoned by farmers because of infestation with notorious weeds such as *Oryza longistaminata* and *Eleocharis dulcis*. For the 2002/03 cropping season, the Office Riz Segou has provided US$ 71,500 for the purchase of 12,000 liters of Roundup, 60 knapsack sprayers and the training of field agents. In the Mopti region farmers have bought 969 liters of Roundup after the first year of demonstrations.

The remaining constraints face numerous challenges. Communities are engaged in a race against time to ensure that the situation does not deteriorate any further.

Besides reasons linked to inadequate policies or infrastructure in general, a number of constraints will continue to hamper or slow down the positive trends mentioned above. For instance:

- Credit and financial institutions are not yet sufficiently developed to enable the average farmer of the continent to move into sizeable production intensification activities.
- Because of low demand and relatively high financial risk, input delivery systems are not strong in most African countries and cannot satisfy sharp increases in demand. One example among many others: as witnessed during the implementation of the conservation tillage programme (CT) in West Africa, the challenge for the participants in the programme is not so much, anymore, to understand the CT concept and application but, rather, to have access to the chemical inputs at the right time, and in sufficient amounts. Quite a turnaround in a period of five years!
- Semiarid or arid regions face an especially difficult challenge in terms of the maintenance of soil fertility levels, as organic matter is not generally very abundant in those regions, and climatic variability may be a major hindrance to sustained and profitable fertilizer use.
Figure 5. Thermal zones of the Amhara Region
Figure 6. Mean annual (a) maximum and (b) minimum temperature, °C over the Amhara region.
Tesfaye Haile. 1986. Climatic variability and surface feedback mechanism in relation to the Sahelo-Ethiopia droughts. MSc thesis. Department of Meteorology, University of Reading, Reading, UK.


Resource Use and Poverty in the Ethiopian Highlands

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ABSTRACT

Ethiopia, which holds the huge mountain landmass and nearly 80% of highland population of Africa, is endowed with beautiful nature, potential soils, both tropical and temperate climates, huge biodiversity, huge water resources and breathtaking landscapes with scenic beauty. Mountains (highlands above 1500 m asl) in Ethiopia are the source of water, crop production, animal feed and are a dwelling place for humans. They hold about 90% of the country’s total population, over 95% of its regularly cropped lands, about two thirds of its livestock population, about 50% of the land area, and over 90% of the countries economic activities. Ethiopian highlands exhibit contrasting climate in which autumn, summer, spring and winter, or tropical, subtropical and temperate climates, are separated by only a few hours of journey up or down the mountains. This complex topography attributed from its geological formation coupled with environmental heterogeneity offers suitable environments for a wide range of life forms both flora and fauna. Although Ethiopia is the water tower of Africa and supplies more than 80% the water for Nile River and had huge potential for irrigation, crop failure due to drought is common every year. Recently, the country is also one of the most severely affected countries by land degradation in the sub-Saharan region. As a result, Ethiopia is now one of the poorest countries in the world where about 45% of its 68 million people live in absolute poverty. This is due to poor resource management, poor governance, institutional instability, lack of appropriate policy and due to lack of participation of communities in the decision-making process in the past. More recently, attempt is being made to bring the country out of its poverty through proper use of its resources and setting promising economic development strategies. However, the pace of actions is not yet matching the current rate of resource degradation in the country.

INTRODUCTION

Ethiopia has an area of about 1.126 million km² and a population of about 68 million (in 2001) with a density of more than 90 persons per km² in the highlands and 10 persons per km² in the lowlands. Ethiopia now rank 20th in the world and with a projected population of 169 million in 2050, it will rank 9th most populated country in the world (Befekadu Degefa and Berhanu Nega, 1998).

The main physical feature of the country is the diversity in altitude and accompanying climatic and ecological variations. The altitude ranges from 120 metres below sea level at Dalol Depression to 4530 m asl at Ras Dejen (in Simen
Mountains complex). Ethiopia holds a huge mountain landmass in Africa and it is endowed with beautiful nature, potential soils, favorable climates, immense biodiversity, huge water resources and breathtaking landscapes with scenic beauty. For many years, Ethiopia was also known as the breadbasket and the water tower of Africa. However, Ethiopia is now one of the poorest countries in the world with nearly 45% of its population living below the poverty line and ranked 158th out of 162 countries on the human development index (UNDP, 2001). Its per capita income is among the lowest of the least developed countries, and its reliance on agriculture is the highest in the group. For instance, smallholder peasant agriculture, in some areas including forestry, is the dominant sector accounting for about 45% of the GDP, 85% of exports and 80% of total employment (EPA, 1997). The highland is also seriously affected by land degradation.

The major reason is improper utilization of resources mainly caused by poor policy environments and political instability for the last three decades. This led the country to the level of poverty where it is found today. Although this is the fact, many still believe that lack of resources is the reason for such deep-rooted poverty in the country. The main purpose of this paper is, therefore, to highlight the resource base and use, the current potential and underlying causes of poverty in the country and future prospects. Some facts will also be presented from a case study in the northwestern highlands of Ethiopia (Gojam) which was once known as the breadbasket of Ethiopia.

The resource base

Unlike other countries, mountains (highlands above 1500 m asl) for Ethiopia are everything; They are the source of water, crop production, animal feed and the dwelling place of humans. The highlands hold about 90% of the country’s total population, over 95% of the regularly cropped lands, about two-thirds of the country’s livestock population, about 50% of the land area, and over 90% of the economic activities. Ethiopian highlands exhibit contrasting climate in which autumn, summer, spring and winter, or tropical, subtropical and temperate climates, are separated by only a few hours of journey up or down the mountains.

This complex topography, attributed from its geological formation coupled with environmental heterogeneity, offers suitable environment for a wide range of life forms, both flora and fauna. The flora of Ethiopia is very heterogeneous and has many endemic species. According to IBCR (2001) the number of higher plant species in the country exceeds 7000, of which about 840 are probably endemic. Most of these species are from highlands including the Simen and Bale mountains which have been identified as areas of plant endemism of continental importance. Likewise, Ethiopia is also a critical region for faunistic diversity. Accordingly, numerous categories of terrestrial and aquatic resources abound.
Some of these, according to IBCR, (2001) are:

- mammals 277 species, 31 endemic to Ethiopia
- birds 861 species, 16 endemic to Ethiopia
- reptiles 201 species, 9 endemic to Ethiopia
- amphibians 163 species, 24 endemic to Ethiopia
- fish 101 species, 4 endemic to Ethiopia

The highlands are also covered with very fertile soils which are related to their geological formation and the basaltic parent material. Andosols, Luvisols, Nitosols, Vertisols, Fluvisols and Cambisols are the dominant soil types found on the highlands. However, due to the serious soil erosion problem that is taking place in these areas, Lithosols and Regosols cover many of the steep and undulating parts of the highlands. The climate in the highlands is mild and the annual rainfall in some places exceeds 2700 mm (mainly in the south west) and almost all parts of the highlands get average annual rainfall amount above 800 mm. Although rainfall is closely related to relief and location in Ethiopia, within the highlands rainfall amounts and reliability decrease towards the north. The key problem related to rainfall in the latter areas is its erratic nature in the changes of pattern and distribution in recent years. There is a marked decline in rainfall pattern in the northern hemisphere tropics, including Ethiopia, for the last 30 years.

The water body of the country covers an area of 7400 km² from 11 major lakes and the total annual surface runoff from 12 major river basins is about 110 billion. Of this amount, more than 75% of the annual surface runoff drains to neighbouring countries and the estimated groundwater capacity of the country is about 2.56 billion (Shibru Tedla and Kifle Lemma, 1998). The potential irrigable area only from major river basins amounts to 3.5 million hectares. However, only 4.6% of the potential irrigable area is used by both modern and traditional means (Befekadu Degefa and Berhanu Nega, 1998). Despite the high amount of annual rainfall, the huge water body coverage and the huge surface water flow (Ethiopia supplies more than 80% of the water for the Nile River) and availability of plenty of potential irrigable land, crop failure is now becoming a common occurrence on some highlands.

The high forest cover is currently about 2.4% of the total area compared to the estimated 40% initial coverage of the country (Shibru Tedla and Kifle Lemma, 1998). The forest is being depleted at an estimated amount of 80,000 to 200,000 hectares per annum (EPA, 1997). The ever increasing population growth with increasing demand for fuelwood, construction material and charcoal, for more cultivated land, and lack of an appropriate forest policy are the major driving force for the high rate of deforestation.
Poverty level

Contrary to the large potential renewable resource base the country has, it is one of the poorest countries in the world. Per capita income is estimated at $US 167, only one third of the average income for Sub-Saharan Africa and the six lowest in the world. According to Haile Yohannes and Amsaya Anteneh (2002 unpublished data), one third of the population must struggle to make with less than $US 1 per day. Measured mainly in terms of food consumption, set at a minimum nutrition requirement of 2200 calories per adult per day, and also including non-food consumption requirements, the 1995/96 estimate shows that 45.5 percent of the population are below the poverty line. Rates of 48% in rural areas indicate absolute poverty. This is where about 83% of the population live.

Problems of land degradation in the highlands

Renewable natural resources, i.e., soil, water, forest and other forms of biodiversity have now deteriorated in many parts of the highlands due to serious land degradation. Many marginal areas are now used for cultivation without protection and the present consumption of wood exceeds natural production.

Agriculture in the highlands is characterised by a subsistence rain-fed production system with simple traditional, yet obsolete, methods of production, dominated by the ox-drawn plough which has prevailed for thousands of years with little or no modification. The farming system is dominated by cereal crop production, which accounts for about 73% of the total cultivable area (Markos Ezra, 1997). Most of these cereals, particularly teff and wheat, need fine seedbed preparation and provide little ground cover during the most erosive storms of June, July and August. This situation by itself contributes to high soil erosion rates. When coupled with poor land management practices and cultivation of marginal areas (Figure 1), it greatly reduces the productivity of the soil. Figure 2 and 3 show the adverse effects of land degradation aggravated by poor land management practices. From Figure 3, one can also see that almost 50% of the rainfall (which is about 1500 mm) is lost as runoff carrying a huge amounts of sediments.

Moreover, burning cow dung for fuel instead of using it as a soil conditioner is considered as a cause for loss in grain production amounting to about 550,000 tons annually (EPA, 1997). About 95% of the total energy consumption is made up of biomass fuels such as fuelwood, cow dung and crop residue. Since 85% of the population is dependent on natural resources, depletion and deterioration of these resources have resulted in reduced agricultural productivity and subsequently in reduced quality of life of the people.
Figure 1. Steep land cultivation (>60%) in the north western highlands. Shortage of land force farmers to cultivate the last remaining marginal areas (Photo by Eva Ludi, 1996)

Figure 2. Severe land degradation problems consume the potential soils unnoticed in Gojam (Photo by Gete Zeleke, 1996)
Over the past few decades, rates of soil erosion by water have, more or less been brought under control in many developed nations. But in the same period, many developing nations, particularly in sub-Saharan Africa, have been gravely affected by this form of land degradation. Ethiopia is one of the most severely affected countries in the sub-Saharan region.

A cursory investigation of the soil erosion processes mainly in the highlands shows that every year billions of tons of soil are detached from the soil mass. A considerable proportion of this soil leaves the country. Humi (1988) and other authors have estimated that compared to other countries, the Ethiopian highlands have the highest levels of soil loss.

![Graph showing mean monthly precipitation, catchment runoff, and suspended sediment yields](image)

**Figure 3.** Mean monthly precipitation, catchment runoff and suspended sediment yields in one of gauged catchment (Anjeni) in the north-western highlands. Note: precipitation and suspended sediment yields are high in July and August and this corresponds exactly to the period when teff and wheat plots are finely prepared and without vegetation cover. (source, Gete Zeleke, 2000)

Soil degradation, caused mainly by soil erosion in much of the Ethiopian highlands has reached a stage where it is increasingly difficult to even maintain the present-day production of basic foods, a level that is already insufficient in some regions. According to EPA (1997), approximately 17% of the country's...
potential GDP was lost because of physical and biological soil degradation. In this regard, the north and north-eastern highlands of the country have seen the greatest damage to their soil resources due to soil degradation. These are also the parts most affected by famine due to degradation and recurrent drought. In this regard, soil degradation certainly contributes to a higher vulnerability to famine and poverty.

**Major causes of land degradation and attributed impacts¹**

A long history of agricultural activity combined with a high level of population dynamics and exploitative agricultural practices has led to the existing depletion of natural vegetation cover (Figure 4) and over-utilisation of land resources, evidently a consequence of poor policy environments. One of the most important policy environments, which contributed to the current status of the country’s natural resources was the land reform policy of 1975 initiated immediately after the country was declared a centrally driven socialist economy.

Prior to the land reform, according to Markos Ezra (1997), farm landholdings were classified under communal ownership (10.5%), private ownership (37.8%), owner/tenant ownership (15.3%) and tenant ownership (36.4%). These ownership systems were terminated with the proclamation of 1975. However, the policy did not grant land ownership to the peasants; instead land was to stay under government ownership and farmers were granted to free use of land. However, it was not clear in the beginning as to how long the farmers had the right to use their plot of land.

The effect of this political change was that it increased the number of families entitled to own farm plots. For instance, young married men who had traditionally stayed with their parents and artisans who previously had no access to land as well as priests who had been dependent on church land and services, were now entitled to their own land and this meant more land had to be newly claimed for cultivation from traditionally protected forest and grazing lands, and from privately owned and protected areas (Tsehai Berhane, 1994). The latter was the first target.

Furthermore, farmers were forced to remain in their place of origin due to both a very restrictive policy of out-migration and immigration and the government’s poor economic strategy for urbanisation and industrialisation, which fostered almost no growth. This situation allowed further exploitation of whatever land resource was left (Gete Zeleke, 2000; Gete Zeleke and Hurni, 2001).

¹ In this section, an effort will be made to show the impact of the 1975 land tenure policy based on a case study conducted in Gojam, north-western highlands between 1997 and 1999. The detailed information can be seen from Gete Zeleke (2000) and Gete Zeleke and Hurni (2001).
Figure 4. Aerial photo of the upper Ketchem River basin in the north western highlands in 1957 and 1982, showing overexploitation of the vegetation cover. Notice how fast the conversion of forest land to cultivated land on the steep slopes. The circles show some of the hot spots where there was high clearance.

Source: Gete Zeleke, 2000
According to Tsehai Berhane-Selassie (1994), the policy unknowingly destroyed the traditional off-farm occupations, namely artisanship and priesthood, and forced the entire community to utilise the only scarce resource, land, for their livelihood. This meant more erosion and loss of soil productivity.

Since the 1975 proclamation, for various reasons, land redistribution has been carried out usually every three to four years. At first this was performed mainly by clearing forests and expanding towards marginal areas by clearing all remaining vegetation (Figure 4). When this means was exhausted, the only solution left was splitting plots from their current holdings. The latter has been the most common form of land distribution in the north and north-western parts of the country.

In general, the entire land distribution system has contributed to the clearance of forest and vegetation from all slope classes. It has also contributed to the reduction of holdings per head. This is the other side of the problem. With the size of the plots consistently reduced and the farmer's felling of insecurity, long-term investment on the land was abandoned. Under such conditions, introduction of improved farm technologies and specialisation are difficult. Frequent redistribution of land not only contributes to clearance of vegetation and cultivation of marginal lands but it is also a disincentive for the farmer to follow sustainable land management practices.

If land use or land cover changes are not carried out systematically, the negative impact on both the environment and the socio-economic settings are not easily measurable. In the case study area (Gete Zeleke 2000; Gete and Hurni, 2001), it was found that in the 50's, the farmers used to practise shifting cultivation, where cultivated land stayed fallow for two or three years to regain some of its potential. Moreover, cultivation was mainly on gentle slopes and flat areas. Over time, two major steps were taken driven by population dynamics, lack of appropriate tenure and land management polices. First, the farmers extended cultivation to steep slopes but still practised shifting cultivation. Second, they reached the limit where they could no longer expand or practise shifting cultivation (Figure 5). They shortened the fallowing period without any special land management measures to protect the farmlands from upslope runoff effects and the torrential rainfall damages. The same study reveals expansion of cultivated land was at the expense of other land use/land cover units. For instance, there was less grassland and feed available, a cause for a reduction in livestock number and quality. This condition has directly resulted in a shortage of animal labour required for ploughing and transport as well not to forget additional income and food that would be available from animals and their products. Similarly, this chain of processes indirectly affects the traditional land management system. When livestock and fodder was aplenty, manuring was an important land management practice in the area. It increases soil fertility and thereby production without extra cost, except labour, for the farmer.
At the later stage, when feed became limited and the number of livestock decreased two processes took place. Firstly, little by little manuring practice was reduced. Secondly, manure is now in great demand used for as a supplementary source of fuel. One very striking fact observed in the study area and in many parts of the highlands is that degraded land use/land cover units are used as grazing land. Livestock are forced to stay on these land units, especially during the cropping season, although there is little for them to feed on. This is one of the practices adopted by farmers as population grows; the farming system remains traditional while most of the grasslands are converted to cultivated lands. In this case, not only cultivation but also the livestock are pushed towards marginal lands, which eventually results in even more severe land degradation. These conflicts in the farming system are clearly visible in the highlands and the whole process contributes to poverty.

![Graph showing changes in population growth, land-use and land degradation in the north western highlands](image)

**Figure 5.** Changes in population growth, land-use and land degradation in the north western highlands (Source Gete Zeleke, 2000)

**Future prospects**

In addition to the establishment of a decentralized federal system of government, the new constitution of the country emphasised the importance of natural resource management to improve the livelihoods of its population. The establishment of
the Environmental Protection Authority and other regional and federal agencies responsible for natural resource conservation and management are some of the institutional arrangements made by the government. The Amhara region set land tenure policies in 2000; Tigray and Oromia are almost ready to approve their own land tenure policies.

Very recently, the government set a rural development strategy, which focuses on proper resource management, reduction of poverty and consistent economic development of the country. The strategy shows the need to transform agriculture, which employs nearly 85% of the population, from subsistence small holdings to a market-oriented economy through proper use and management of resources, such as land, labour and water, capacity-building and decentralized participatory decision-making process. This is the first development strategy in the country that brings the issue of sustainable resource management to the forefront. At this point in time, it is possible to envisage effective implementation of this strategy which would change the general picture of the country. Ultimately this means much of the mountain population of Africa will be addressed. However, this needs commitment by the government. A systematic approach is essential for laying a sound basic foundation.

**CONCLUSION**

Although the Ethiopian highlands are endowed with plenty of resources, they are seriously affected by land degradation mainly caused by poor management of the natural resources and impractical policy. The 1975 land tenure policy and the mechanisms of its implementations were the major factors forcing the unsustainable use of the natural resources in the country at large. It killed the sense of ownership of the land people till which resulted in lack of incentive for long-term investment to conserve and manage their resources sustainably.

In this regard it can be broadly concluded that the extent of poverty in the country is not due to lack of resources but rather due to lack of an appropriate policy environment during the last 3-4 decades. Although the current effort of the government to reduce poverty through proper use of resources is a promising start, it requires systematic intervention.

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Site-Specific Technology Evaluation and Transfer for the Amhara Region

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ABSTRACT

Agricultural performance varies from site to site and from year to year owing to variations in soils and weather over space and time. For this reason, the transfer of agricultural technology from research centres to farmers’ fields is highly site-specific and requires many years of testing to evaluate the full range and impact of local soil, weather and socio-economic conditions on technology performance and adoption. The participatory evaluation of new technologies on a site-specific basis, while necessary, is too slow and costly to be carried out for areas as large as the Amhara Region. One way to circumvent this problem is to perform participatory technology assessment by *ex ante* means, i.e., to simulate how a new technology will perform on a site-specific basis, and enable adopters to exercise choice on the basis of technology performance. The technology may be a new crop, crop variety, product or practice. Using modern knowledge-based simulation models, site-specific technology assessment which would require many years to complete can now be simulated in a matter of minutes. While on-farm trials are preferable to simulated results, most national or regional research and extension groups, and participating farm households lack the time, money and personnel to conduct the critical number of trials to scale-up technology transfer to entire regions. The purpose of this paper and the two other related ones is to: (1) give examples of suitable soil, water and crop management technologies for transfer to the Amhara Region, (2) illustrate their likely performance using *ex ante* means and (3) suggest ways that will enable interested parties to test this more cost-effective and timely method in the Region.

INTRODUCTION

An agricultural technology may be a new crop, product or practice. The crop may be a new, high performance sorghum variety; the product, a more fuel-efficient stove; and the practice, a carbon sequestering, no-till farming system. Technology transfer, on the other hand, is the taking of a technology from locations where it has significantly improved agriculture to new locations where the technology is likely to succeed. Technology transfer can also occur directly from research stations to farming communities. In any case, efforts to improve agricultural performance by introducing new crops, products and practices to farmers’ fields and households have resulted in more failure than successes. Failures that do no harm can be dismissed, but government agencies pay a high
effort, and loss of income. There are many reasons for the low success rate of technology transfer including the following:

1. Households may be operating within a set of constraints the extent of which may not be fully appreciated by the change agent involved in the technology transfer effort; for example, market and infrastructure limitations, or unavailability of credit.
2. Household objectives often do not coincide with those assumed by the change agent.
3. The technology may simply be inappropriate to household needs.
4. The risks involved in adopting a new technology are not appreciated by the change agent.

One way to circumvent these and other barriers to technology adoption is to enable adopters to visualize likely outcomes of alternative ways of applying the technology, and allowing them to exercise choice, not of the technology, but the outcomes of technology adoption and their impact on household goals and objectives. By enabling adopters to exercise choice (Uehara, 1989), they are able to take into account the constraints they face, as well as their cultural values, during the decision-making process.

The purpose of this paper is do describe how technology is currently transferred and how the elements of choice, cost-effectiveness and timeliness can be incorporated into technology evaluation and adoption.

**Ways to transfer technology**

There are three ways to transfer technology to farm households operating in the diverse biophysical and socio-economic environments of the Amhara Region. The first way is by trial-and-error. This was the method employed by the first farmers long before science was introduced into agriculture. It is simple, intuitive and inexpensive. It goes with the saying “It costs nothing to try” and “If, at first, you don’t succeed, try, try again.” In the early years of farming systems research and development, a more euphemistic phrase “iterative, dynamic and self correcting” was used to describe trial-and-error research. The trial-and-error method will always be with us, but it is too slow and unreliable for continued use in the Amhara Region or, for any region in the world. The trial-and-error method can be improved by adding science to the iterative, dynamic and self-correcting approach first suggested by farming systems researchers. This point will be dealt later in this paper.

The second way to transfer technology is by analogy (Nix, 1984). This approach depends on transferring technology, in particular, genetic resources, from locations where the technology performs well to new location with similar or analogous biophysical environments. An example of this type of technology transfer is the extrapolation of rubber production technology developed and refined in Malaysia to analogous agroecological sites in the humid tropics. The
Site specific technology evaluation and transfer

agroecological zone concept of the CGIAR system contains elements of technology transfer by analogy. In fact, it is safe to say that this is the most common science-based approach to technology transfer. In this approach we no longer depend on intuition and chance for success, but rely on our experience with genotype by environments interactions as well as appreciation and understanding of processes that determine outcomes of human interactions with the environment.

A critical requirement for successful technology transfer by analogy is a national inventory of natural resources. This means that one should be able to readily obtain information about the soils and climate of locations where the technology is to be transferred. Without natural resource inventories, namely detailed soil and climate maps, technology transfer by analogy degenerates into technology transfer by trial-and-error. It turns out that most countries have resource inventories including the Food and Agricultural Organization soil maps and World Meteorological Organization climate data, but have not developed a systematic way to use this information for technology transfer at the national level. Efforts to systemize technology transfer by analogy at the international level are describable by Beinroth et al. (1980) and Silva (1985).

A third way to improve agricultural performance through technology transfer is by systems analysis and simulation using models (Uehara, 1989; Tsuji et al., 1998). Models are simply tools for capturing, condensing and organizing knowledge of natural processes so that it can be put to useful purposes. But knowledge or models in isolation can do no good. Knowledge, like an engine, needs fuel to do useful work. The specific fuel which knowledge needs to produce useful information is data. Models or knowledge-based tools, when provided with appropriate data will generate information users need to make sound decisions. Sound decisions are synonymous with good choices. Technology adoption hinges on having the right type of information with which to make good decisions. In short, models enable farmers to exercise choice in the way technologies affect their lives.

Knowledge captured in models, if used properly and effectively, enable its users to predict anticipated outcomes of a proposed action. This ex ante approach to exploring the future has the following advantages:
1. The adopters can visualize results without having to conduct on-farm trials
2. The results are obtained nearly instantly
3. There is no cost or risk involved
4. Adopters select only those outcomes that suit their needs
5. Strategies for achieving desired outcomes are suggested by the adopter.

These advantages are countered by the following constraints to model application:
1. Most countries including the Amhara Region, have not compiled and organized the available crop, soil and weather data for use in technology transfer


2. Most developing countries lack the critical number of scientists trained in model application.

3. Many researchers distrust model outputs and prefer to depend on field observations to support decision making.

The first and second constraints can be rectified, but the third will be more difficult to overcome.

Skepticism of model outputs is healthy, but a mind closed to new approaches may do more harm than good. It is the responsibility of modelers to show that reliable results can be simulated by models. This will require field agronomists and modelers to work together so that simulated results can be compared with measured outcomes. This also implies that outputs from models that cannot mimic field observations should never be used to support decision making. Model validation in the region where it is to be applied is, therefore, a critical part of technology transfer by system analysis and simulation.

Socio-economic aspect of technology transfer

The power of biophysical simulation models is that they can ease many of the human anxieties that keep risk-averse farmers from adopting new innovations. Households that depend on farming for most of their food and income must be presented with new technologies that raise production not only in the average year but also produces adequate yields in the worst years. Technologies that raise yields in good or average years but do nothing to improve production during drought years, for example, are not as helpful as technologies that do the opposite. This means that the worth of a new technology can not be determined by one or two years of on farm trials. Risk-averse farmers need to be shown how a technology performs over a minimum of 25 consecutive years so that unfavorable production years that appear once in five, 10, 15 or 25 years can be exposed.

It is clear that no agronomist would conduct a 25-year field experiment to learn how a technology performs during the good and bad years. In fact agronomists tend to discard results of bad years, and conduct their experiments in well-watered and fertilized plots. Models, on the other hand, can complete the 25-year experiment not in days or hours, but in minutes. Owing to the ease of conducting long term simulated trials, the experiment can be repeated for different varieties, plant populations, planting dates, fertilizer rates and irrigation treatments. Most models today perform partial budget analysis for each simulation so that the results are presented not only in terms of yield but profit in local currency. The results can be viewed as a graph which plots cumulative probability versus yield or profit (Anderson, 1974).

Today, numerous participatory, on-farm trials are being conducted to help subsistence farmers achieve food security. These efforts are highly site-specific and cannot be scaled-up to neighboring locations where soil, weather and socioeconomic conditions differ. Because these efforts depend on an iterative,
dynamic and self-correcting approach, they are slow and expensive. A more cost-effective and timely approach is needed to make a difference.

Making a difference

Participatory on-farm trials are necessary, but not sufficient to make a difference. The same can be said for systems analysis and simulation. Together, they may be able to make a difference. System simulation can serve as a screening mechanism so that only those crops, crop varieties, products or practices that perform well in the eyes of the adopters are selected for on-farm testing. It is faster and cheaper to expose mismatches between a genotype and environment, for example, using models than through on-farm trials. In fact the number of trial-and-error iterations one needs to make to optimize site-specific agronomic performance is so high that it is physically impossible to achieve the iterative, dynamic, self-correcting goal farming systems researchers hoped to attain.

In participatory system simulation, adopters select the crop variety, planting data, planting density, row spacing, planting depth, and decide whether to fertilize or irrigate the crop. By repeated simulations, adopters can visualise, for example, how farm income varies with investments in fertilizer or compare varietal performance during dry years. The on-farm trials that are eventually installed will therefore be based on options designed, studied and selected by the adopter.

Scaling-up participatory simulations

Simulation models are designed to operate locally and globally. The knowledge base contained in them applies everywhere making models globally applicable. However, models can produce useful results only on a site-specific basis because the data that are needed to operate the models are collected from specific locations. Models require soil and longterm weather data for each site. Scaling-up by participatory simulation assumes that every farm and farmer is unique and different. Differences in soil and climate are accounted for by the model provided with site-specific, georeferenced data bases, and differences among adopters are accommodated by enabling individuals to exercise choice from an array of personalized options. A key element of this approach is that it avoids the “one size fits all” syndrome that afflicts most technology transfer efforts.

Participatory systems simulation for the Amhara Region

The Amhara Region is ripe for technology transfer by participatory simulation, but the Region needs two key ingredients to implement this approach. First the Region must assemble, georeference, organize and store the available soil and historical weather data in data bases for free and easy retrieval by users. Second,
Regional and National scientists trained in systems simulation should be encouraged to establish a working group to begin developing the georeferenced soil and weather data base for the Amhara Region. Several national scientists may already have personal copies of simulation models, but if additional copies or updated versions are needed, the working group should compare existing models available internationally, including the one used by Ogoshi in the accompanying paper (Ogoshi, 2002), and select one that best suits the group’s needs. Since models have specific data requirements, it is wise to develop the data base in concert with model selection (Uehara and Tsuji, 1991).

**SUMMARY AND CONCLUSION**

New technologies in the form of crops, crop varieties, products and practices are needed to increase agricultural productivity, but their on-farm performance is highly site-specific and acceptance by farmers depends on individual perception of risk and benefit. An iterative, dynamic and self-correcting participatory method is needed to ensure a good match between the requirements of the technology, and farmer capability and needs, but current methods are too slow and costly to be effective. The time, cost and inconvenience of conducting on-farm trials can be markedly reduced by simulating and screening their outcomes with models. On-farm trials requiring a full season to complete can now be performed in seconds provided soil and historical weather data for the site are available. This allows the adopting farmers to design on-farm trials to their liking, and enables them to choose outcomes from an array of options which they themselves have formulated. The outcomes are displayed as whole probability distributions of yields or profit so that risky options which reside in the tails of distributions can be readily identified and avoided.

Systems simulation is not a luxury for the rich, but represents hope for risk-averse resource-poor, subsistence farmers who have been by-passed by science-based agriculture. Scientific knowledge alone cannot benefit farmers. Knowledge must be combined with soil and weather data of the area under study. Only then can scientific or traditional knowledge generate the critical information farmers need to support decision making. In the accompanying paper by Ogoshi, weather data from two locations in the Amhara Region are used to simulate sorghum yields for several farm management scenarios. In practice, the management scenarios would be selected by farmers and the result presented to them at no cost or risk on a timely basis. Even if the simulated trial required 30 minutes to complete, the farmer group can use this time to discuss the result of an earlier run and plan the scenario for the next simulation. Farmer participation and control should be the hallmark of technology evaluation and adoption by systems simulation, leaving the change agent to advise farmers on what models can and cannot do. The challenge for the Amhara Region is to test and compare the cost-
effectiveness, timeliness and reliability of the three methods of technology transfer in use today.

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A Framework for the Use of Soil and Water Conservation Models in Sub-Saharan West Africa

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ABSTRACT

Soil and water conservation modeling is a powerful tool in the management of agricultural and natural resources. Computer simulation models can be used to achieve various objectives, such as reduction of soil erosion, conservation of water, and protection of water quality. Within these objectives, there are many different approaches to soil and water conservation modeling. These approaches generally differ in the degree of detail natural processes are simulated, the aerial extent considered in the simulation, and the time period modeled. In this paper, we provide a general introduction to soil and water conservation modeling and some examples specific to the Sub-Saharan region of West Africa. The examples of soil and water conservation modeling cover three spatial extents and will use two different modeling approaches. The first example investigates the effectiveness of two soil and water conservation practices to reduce soil erosion and runoff for a hypothetical agricultural field. The KINEROS model is used in this example and the effectiveness of the conservation practices are investigated for land slopes ranging from 2 to 18%. The second example uses the KINEROS model applied to a watershed in Mali to investigate the effectiveness of a system of conservation practices in reducing sediment and runoff leaving the watershed. The final example uses spatial and data modeling procedures in a GIS environment to identify erosion potential for areas in a large drainage basin in Mali. Each of these examples provides different levels of information that could be used to achieve various soil and water conservation objectives. Throughout this paper, we discuss the development of data sources needed to conduct soil and water conservation modeling as a part of the InterCRSP project. It is hoped the information provided in this paper will serve to enhance the use of soil and water conservation modeling in the development of sustainable agricultural systems in the region.
INTRODUCTION

Control of soil erosion is a critical part of any program whose objectives are to improve productivity and maintain the sustainability of an agricultural system. Maintaining or increasing the fertility of agricultural fields is dependent on keeping the soil in place and on the fields. When soil is eroded not only is the precious soil removed, but the nutrients bound to soil particles are also lost. This is especially true for phosphorus. For most of the agricultural fields in the Sahel region, soil erosion and soil fertility are dependent in ways other than the physical processes controlling erosion. As soils become less fertile due to depletion of their nutrients, new fields are brought under production. These fields are often less suitable for growing crops often having steep slopes. Therefore, soil erosion is accelerated on these new fields and fertility is quickly reduced and more fields need to be brought under production. These additional fields are usually even less suitable for agriculture production and more susceptible to soil erosion. If soil fertility and erosion are not addressed, this cycle of soil fertility depletion and increased soil erosion will continue and the security of the food production system is threatened.

To address the threat that soil erosion poses to the food security of the Sahel region, soil and water conservation practices that reduce soil erosion and improve the management of water resources have been identified. These are being assessed as a part of the InterCRSP West group’s activities. Through past site surveys, consultation with local government officials, and through discussions among the InterCRSP scientists, three conservation practices were identified. These practices are the use of stone lines and ridge tillage along the contour on agricultural fields and reforestaion on ridge tops and steep slopes. All of these practices are managerial practices and are within the capabilities of most villages in the region. Other practices have been evaluated, but were not considered feasible for implementation as a part of the InterCRSP project. An example of a practice considered not feasible is the construction of small concrete dams to create ponds in or near the villages. The major disadvantage of the dams was the expense, but the construction of the dams would also require a great deal of material and labor inputs from outside the village, which contradicts with one of the objectives of the InterCRSP program. Other practices that may be used in some of the countries in the region, such as living fences that are used in Cape Verde, will be investigated in future activities and may be applied to other countries in the region.

The main objective pertaining to soil erosion include not only the identification of conservation practices, but also the identification of methods to evaluate the effectiveness of these practices in reducing soil erosion and managing water resources. In this paper, the basic approach to be used in the soil erosion assessment activities of the InterCRSP West Group is outlined. Examples are given using preliminary results and most importantly data sources and needs
are identified. It is hoped that this paper will serve as a starting point for the development of the more refined approach to assessing the conservation practices and demonstrate the utility of computer simulation in assessing soil erosion and water resource management.

**PROPOSED APPROACH**

The proposed procedures for developing and assessing soil and water conservation practices within the InterCRSP West Group can be separated into three approaches. These approaches are separated based on the spatial scale at which the analysis is applied. The spatial scales include field, watershed, and regional. Each of these spatial scales is identified based on land use activities, topography, or area of the unit. The field scale can be defined as any spatial unit that is under a single crop or other land use practice, where water on the land surface drains in one direction or to a single boundary of the unit, and is at or under 50 ha in size. The boundary of the field unit is defined based on the field (or property) boundaries defined by the farmer or by the experimental design of researchers. A field may or may not contain a channel where surface water draining from the land surface may concentrate. The watershed scale is defined as any spatial unit less than 3000 ha in size and contains at least one channel. There can be only one outlet for water draining from the watershed unit. The upper size limit of 3000 ha for the watershed scale is not rigid and could be exceeded if the assumptions of the model being used are not violated. The regional scale is defined as any area larger than a watershed and may contain more than one outlet where water draining from the land surface exits the unit. For each of the spatial scales, the approach to be used is outlined and an example is provided. The approach outlined in this paper is to serve as a starting point and it is hoped that it can be improved through input from and discussion among researchers working on soil and water conservation issues in the Sahel Region.

For all the examples, the region in and around the village of Fansira Koro in Mali was used. The InterCRSP West Group selected Fansira Koro as the study site for Mali. Fansira Koro is located in the Kati agricultural region north of Bamako (Figure 1.). Fansira Koro was selected based on the severity of the problems observed in the village. These problems are not only related to soil erosion, but also to soil fertility. The physiographic characteristics of Fansira Koro are typical of the Kati agricultural zone of Mali. The climate is semi-arid characterized by a short wet season. The annual rainfall amount range from 600 to 1000 mm and the wet season is from approximately April to September. Rainfall during the wet season is characterized by storms of short duration and high intensity. The topography of this region is characterized by plateaux with eroded valleys. The plateaux are generally protected from erosion by Laterite. These plateaux tend to be infertile and have low infiltration rates. The valley walls are
steep (>15%) and are erosive. The low land soils are alluvial and shallow (<1 meter in depth). There is evidence of severe erosion in the low land soils. In some cases, the topsoil has been lost and lower soil horizons are exposed. The lower soil horizons are low in fertility and made up of small aggregates and stones. These lower horizons are also susceptible to further erosion.

Figure 1. Location within Mali of site used in examples

Two different modeling approaches were used in the examples. For the field and watershed scale modeling the KINEROS model (Woolhiser et al., 1990) was used. KINEROS is a physically-based model that simulates runoff and erosion for a single storm event. Input and output is spatially distributed (Woolhiser et al., 1990). KINEROS is applicable to areas ranging from 1.5 to 5000 ha in size. However, KINEROS should not be used in watersheds where groundwater and interflow sources provide a majority of the water during storms because KINEROS does not simulate these processes. Generation of surface runoff is simulated in KINEROS using simplified infiltration and soil moisture equations. Other erosion models rely on the NRCS Curve Number (CN) to simulate surface runoff generation. Values for the CN may be difficult to obtain for the sites. The CN is empirically based and difficult to estimate from soil and land cover data. KINEROS uses soil parameters, such as hydraulic conductivity, to simulate runoff generation. The KINEROS model was selected for use in the InterCRSP West soil and water conservation activities based on discussions among the group member and based on the available data. The KINEROS model
Use of soil and water conservation models has been applied with great success to many different sizes and types of watersheds throughout the US (Duru and Hjelmfelt Jr., 1994; Goodrich et al., 1994; Govindaraju et al., 1999; Wahlstrom et al., 1999). For the regional modeling example, geographic information system (GIS) and a simple data model were used. The results from the field and watershed scale simulations were used as input for the regional modeling example. The ArcView desktop GIS (ESRI, 1998) was also used to develop the data needed for the watershed and regional modeling along with the development of maps for presentation of results.

Some common information was used in the examples. This includes rainfall and soils data. The storm used in the KINEROS simulations was 1 hour in duration with a depth of 100 mm. The depth and duration of the storm was selected arbitrarily. The need for more detailed meteorological data will be discussed in later sections of this paper. The soil data used in all the simulations were characterized from soil texture information determined from samples collected in Fansira Koro. The particle size distribution for the soil was 14.8% sand, 54.8% silt, 30.5% clay, which was classified as a silty clay loam using the USDA Soil Texture Triangle. This soil particle size distribution was used for all the fields in the field and watershed scale simulations. In each of the following sections, data needs will be discussed in an effort to obtain more site-specific information to be used in the modeling activities, which should improve both the accuracy and relevance of the simulation results.

Field Scale Modeling

The main objective of the field scale modeling is to assess the efficacy of soil and water conservation practices in reducing soil erosion and improve water management for homogeneous agricultural units (i.e. an agricultural field). In the future, the modeling efforts will be linked with field monitoring activities undertaken in the InterCRSP West Program. The combination of field modeling and monitoring will allow for more accurate modeling and for application of the monitoring data to other areas that may vary in physical characteristics from the original fields. Also, the model accuracy will be improved through calibration of input parameters using observations collected. This calibrated input data will also provide a set or range of input parameters that could be used to assess soil and water conservation practices on other agricultural fields that may differ from the original field that was monitored, thus, extending the value monitoring data. Furthermore, new or modified soil and water conservation practices could be assessed using the calibrated input data that represent physical characteristics common to the field that was monitored. These modeling results would provide design information that could be used to improve current practices or create new practices. In the following section, examples of using the KINEROS (Woolhiser, 1990) to evaluate the effectiveness of two soil and water conservation practices are presented for hypothetical fields located in Mali.
To provide an example of how the KINEROS model could be applied and what information the simulation results would provide, two soil and water conservation practices were evaluated for a hypothetical field and a range of land slopes. The dimensions of the hypothetical field was 50 m by 50 m. The hydrologic conditions of the field were assumed to be after the occurrence of significant precipitation events, resulting in wet conditions (high soil moisture levels) in the field. The time of the storm was assumed to be after planting of the crop, but before emergence of the plant leaving the soil without vegetative cover and still loose from seedbed preparations. These conditions would be the worst-case scenario. From field observations made by InterCRSP scientists and discussions with villagers, it was determined that most of the severe soil erosion occurs on agricultural areas during this period of the year. The two conservation practices investigated were stone lines and ridge-tillage on the contour (Courbe de Niveau).

The effectiveness of conservation practices in reducing soil erosion and improving water management was evaluated for a range of land slopes. The range of land slopes used was from 2% to 18%. Total sediment and runoff leaving the field for each of the conservation practices were compared with the control. The control had no conservation practices implemented and served as the baseline for comparisons. To evaluate the effectiveness of the practices, the percent reduction as compared to the control for total runoff and sediment leaving the field was calculated for each land slope and each conservation practice using the following formula:

$$\Delta\% = \left(\frac{X_{\text{Control}} - Y_{\text{Practice}}}{X_{\text{Control}}}\right) \times 100$$

where,

- $\Delta\%$ is the percent change in the output (sediment or runoff),
- $X_{\text{Control}}$ is the output for the control $X_{\text{Control}}$, and
- $Y_{\text{Practice}}$ is the output for the practice $Y_{\text{Practice}}$.

Different modeling approaches and model parameters were manipulated to represent the practices.

Courbe de Niveau or ridge-tillage on the contour is a soil and water conservation practice used on agricultural fields in sub-Saharan West Africa. The practice is basically contour farming, but the soil is tilled in a manner that ridges are formed along the contour with valleys between the ridges (Figure 2). In Figure 3, an example of ridges and associated valley is shown with the rough dimensions indicated. The ridges are distributed across the field and are on the contour. The field with the Courbe de Niveau practice was simulated as a single overland flow plane. The Courbe de Niveau practice impacts the resistance to the flow of water across the land surface and also the amount of water that can be stored on the land surface. The amount of water stored on the land surface between the ridges
depends on the land slope of the field. As the land slope increases, the storage between the ridges decreases. This dependence on land slope was accounted for when modeling Courbe de Niveau practice.

![Figure 2. Ridge tillage on the contour](image)

![Figure 3. Cross-section of ridges associated with the contour ridge tillage](image)

The stone line practice was simulated differently than the Courbe de Niveau practice. The stone line conservation practice is basically stones approximately 10
In this example of watershed scale modeling, just one simple application of the KINEROS model was demonstrated. There are many more examples applicable to problems faced in the Sahel region. However, the confidence in the simulation results will improve as the accuracy of the input parameters increases. Through this watershed modeling example, it is hoped that the reader will understand what is needed to conduct accurate watershed modeling and what benefits could result from the effort.

Figure 13. Percent reductions in runoff volume and sediment at the watershed outlet

Regional Assessment

In some cases, regional modeling may be a viable alternative to watershed scale simulations. If there are not enough data of sufficient accuracy available, application of watershed simulation models, such as KINEROS, would not yield more accurate results than if simplified models were used to estimate potential reductions due to conservation practices. The regional modeling approach to be used by the InterCRSP West Group will utilize GIS data and simple data models to estimate reductions for large areas. In this example, the potential reduction due to soil and water conservation practices implemented in around the village of Fransira Koro is estimated. The region to be assessed is shown in Figure 15. The total area of the region is 4,326 ha. The sub-units within the region boundary are subwatersheds.
Figure 14. Hydrographs of control and practices of contour ridge tillage and tree density of 65 trees/ha.

The subwatershed boundaries represent the hydrologic borders and the borders between landuses. The hydrologic borders were determined using the digital image of the 1:50,000 scale map of the Bamako-Quest 4d region and the landuse borders were determined arbitrarily. The two landuses used in the example are forest and agriculture. The distribution of the land use is shown in Figure 16. The ridges are designated as being forest and hillsides and valley bottoms are designated as agriculture (Figure 16).

The regional modeling example uses the results of the field and watershed scale modeling along with the GIS coverages. The field and watershed scale modeling results are used to provide values for the potential reductions in runoff volume and soil erosion when conservation practices are implemented. The GIS coverages are used to associate the potential reductions to the subwatersheds in the region. The reductions are associated using a simple data model.
Figure 15. Area used in regional modeling example.

Figure 16. Landuse for area used in regional modeling example.
The conservation practices were assigned based on land use and land slope. For all the forested areas, tree densities were set at 35 trees / ha. The potential reduction for this tree density was determined by averaging the reductions simulated in the watershed scale modeling example. The reductions were determined to be 63% for runoff volume and 65% for sediment. Land slope was not used for the forested areas in the data model. For agricultural areas, the Courbe de Niveau practice was assigned to all areas with land slopes less than 8%. The stone line practice was assigned to all agricultural areas with land slopes greater than or equal to 8%. The distribution throughout the region of the practices is shown in Figure 17. The next step was to assign potential reductions to the subwatersheds using the data model.

The data model utilized in the regional modeling example uses information on land slope and landuse to determine the potential reduction due to the implementation of conservation practices. Figure 18 shows the relationship used in the data model to determine the reductions in runoff and sediment. For the forested areas, the same reduction (63% for runoff volume and 65% for sediment) was used for all slopes. For the Courbe de Niveau and stone line practices, the reduction depended on land slope. The reductions from the field scale modeling results listed in Table I were used. The potential reductions for each subwatershed were added to the attribute table of the GIS coverage.

Figure 17. Distribution of conservation practices for the regional modeling example
Implementation of conservation practices on all the subwatersheds resulted in moderate potential reductions for the region. The potential reductions in runoff volume throughout the region are shown in Figure 19. Large reductions occurred in the forested areas and moderate reductions occurred in most of the agricultural areas (Figure 19). In Figure 20, the potential sediment reductions are shown. The greatest reduction for sediment occurred on the agricultural fields with the stone line practice (Figure 20). Moderate reductions in sediment occurred on the remaining areas. With the GIS converges for the potential runoff and sediment reductions developed, the overall potential reductions could be determined for the entire region. The overall reductions were calculated as an area-weighted average. The area-weighted average was determined by multiplying the reduction for each subwatershed by the ratio of the area of the subwatershed to the total area of the region and then summing all of the products for the entire region. The potential reductions were determined to be 33% for runoff volume and 48% for sediment.

For the application of the regional modeling approach to be effective, the data infrastructure of the InterCRSP West group needs further development. Key components of the data infrastructure include the development of GIS coverages and conducting representative field and watershed scale modeling to estimate potential reductions of the practices. As with the GIS data needs of watershed modeling, accurate topographic data is essential for accurate regional modeling. This is especially true if land slope is used in the data model and if the boundaries of sub-areas in the region are set to the subwatershed boundaries. Furthermore, accurate meteorologic and soils data is needed to conduct the field and watershed modeling needed to determine the potential reductions of the conservation practices. If these developments in the data infrastructure are undertaken, the results from small-scale investigation could be extended over larger areas through regional modeling approaches, thus, extending the value of the research conducted by the of the InterCRSP West Group.
Use of soil and water conservation models

Figure 19. Potential runoff reductions for the regional modeling example

Figure 20. Potential sediment reductions for the regional modeling example
SUMMARY

The use of computer simulation methods for investigating soil and water conservation practices provide a powerful tool for addressing the food security problems in the Sahel region. It is hoped that the examples sufficiently demonstrate the utility of the computer simulation methods outlined in this paper. There is still much work to be done in developing the data infrastructure needed for the computer simulation to be accurate and meaningful. Some key data needs include precipitation, physical properties of soils, and topographic data for the Sahel region. Also, members of the InterCRSP West Group need to discuss the proposed approaches and determine where these approaches would be appropriate. During these discussions, decisions on details specific to each of the methods also need to be made. With the development of an accurate and complete data infrastructure and a focused approach, soil and water conservation modeling will serve as a valuable tool scientists could use in protecting the food security of the Sahel region of Africa.

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ABSTRACT

Maldistributed rainfall and low soil nitrogen produce low grain yields in Amhara National Regional State of Ethiopia. Ex-ante simulation offers a method to evaluate the soil and crop management practices to improve productivity and stability of crop yields. The sorghum model CERES-Sorghum was used to simulate sorghum yield under decreasing plant population, rotation with soybean, and split application of urea at Lalibela and Sirinka, Amhara National Regional State. The results showed grain yield and stability increased when plant population decreased from 18 plants m$^{-2}$ to 7.2 and 12.6 at Lalibela and Sirinka, respectively. The addition of nitrogen increased yield and stability at both locations. The source of nitrogen to increase yield and stability made no difference at Lalibela, however inorganic nitrogen increased yield and stability more than organic nitrogen at Sirinka. Ex-ante analysis at Lalibela and Sirinka was possible because of the minimal data needed for the model and the computing speed of current personal computers.

INTRODUCTION

Sustainable agroecosystems are identified by four properties: productivity, stability, resiliency, and equitability (Conway, 1987). Productivity is the level of production achieved by the system. Stability is the constancy of production over time or changing conditions. Resiliency is the ability of the system to recover from stress or shock imposed on it. Equitability is the equitable distribution of benefits to people within the system.

Biophysical and social conditions of the system affect the level of these four properties (Lele, 2001). An example of a biophysical condition that affects sustainability properties is soil erosion. Removal of topsoil exposes the less fertile subsoil and reduces yield, i.e., productivity is low. Subsoil usually has lower water-holding capacity than topsoil. This subjects the crop to frequent drought stresses dictated by the distribution of rainfall that results in highly variable yield from year to year, i.e., stability is low. Soil erosion is a stress that requires time to recover, especially if crop residue is not returned to the system, i.e., resiliency is low.
Researchers in many countries work to discover management practices that enhance sustainability. Much of this research and its results are applicable only to the location where it was generated. One research challenge is to adapt the location-specific results to locations where the knowledge is needed (Young and Burton, 1992).

Systems simulation offers researchers a tool for extrapolating the knowledge of sustainable systems from one location to another (Bowen et al., 1993). Singh and Thornton (1992) used the DSSAT compatible models (Tsuji et al., 1993) to evaluate long-term effects of management practices on crop performance. Yield and nitrogen-use efficiency were estimated for all sorghum (*Sorghum bicolor* L.) producing areas across the 308,000 km² of Maharashtra State, India, over a 25-year period (Singh and Thornton, 1992). The simulations showed that yield stability decreased as the rate of nitrogen applied increased because of the irregular rainfall distribution (Singh and Thornton, 1992). Similarly, long-term simulations helped evaluate sustainability properties of rice-wheat rotation in Pantnagar, India (Timsina et al., 1997), and maize-fallow rotation in central Brazil (Bowen et al., 1998).

The objective of this paper is to demonstrate the utility of *ex-ante* simulation to evaluate management practices for the sustainability properties, productivity and stability at two locations in the Amhara National Regional State, Ethiopia. DSSAT v3.5 (Tsuji et al., 1994) was used to perform the simulations for the crop sorghum.

**Model description**

The sorghum model (CERES-Sorghum v3.5) simulates plant growth at the field level on a daily time-step (Ritchie, 1998). Growth is produced through a simplified photosynthetic process that depends on leaf interception of solar radiation. The carbohydrate produced from photosynthesis is partitioned to roots, stems, leaves, and grain. As the plant progresses through its life cycle, the proportion of carbohydrate distributed to the reproductive organs, i.e., grain, increases while the carbohydrate to vegetative organs decreases.

Simulated photosynthetic rate is reduced when water or nitrogen stress is present (Ritchie, 1998; Godwin and Singh, 1998). The model simulates water movement through a one-dimensional soil profile via saturated and unsaturated flow. Based on the water content of each layer in the soil profile, the water available for plant uptake is calculated. When plant available soil water is less than the plant demand for transpiration, water stress occurs in proportion to the difference.

Likewise, nitrogen stress occurs when plant demand for nitrogen exceeds the available nitrogen in the soil (Godwin and Singh, 1998). Concentration of nitrate and ammonium in the soil layers results from simulating the net effect of fertilizer application, mineralization of organic matter, nitrification, ammonia
volatilization, denitrification, and immobilization. A fraction of the nitrogen in the soil is absorbed into the crop as a function of concentration of nitrate and ammonium in the soil, root density in the soil layer, and soil moisture. Plant nitrogen demand is the amount of nitrogen needed to satisfy the requirements of newly produced tissue. Nitrogen stress is proportional to the difference between the plant demand and the amount taken up through its roots.

The sorghum simulation model is composed of plant and soil processes that apply anywhere in the world. However, the weather data and soil properties fed into the model tie the simulation results to a particular site.

**Soil and climate at Lalibela and Sirinka**

Two sites with contrasting annual rainfall were chosen for simulation analysis, Lalibela and Sirinka. Soil and climate characteristics were derived from Mekonnen et al. (1999), FAO soil map (FAO, 1995) and the National Meteorological Service Agency in Addis Ababa, Ethiopia.

The soil data included volumetric water content at -1.5 and -0.01 MPa, bulk density, organic carbon content, pH, and root abundance for each horizon (Table 1). Other soil properties not related to depth include permeability, drainage, surface color, and slope. When required data could not be found from Mekonnen et al. (1999), a taxonomically similar vertisol that had appropriate data available was used (SCS, 1976).

Table 1. Some physical and chemical characteristics of Vertisol soil at Lalibela and Sirinka, Amhara National Regional State, Ethiopia, used as input for long-term simulation of sorghum

<table>
<thead>
<tr>
<th>Layer depth (m)</th>
<th>Volumetric water content (-1.5 MPa)</th>
<th>Volumetric water content (-0.01 MPa)</th>
<th>Bulk density (g cm$^{-3}$)</th>
<th>Organic carbon content (%)</th>
<th>pH (water, 1:1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 0.03</td>
<td>0.295</td>
<td>0.421</td>
<td>1.29</td>
<td>0.66</td>
<td>7.1</td>
</tr>
<tr>
<td>0.03 to 0.25</td>
<td>0.290</td>
<td>0.415</td>
<td>1.38</td>
<td>0.42</td>
<td>7.2</td>
</tr>
<tr>
<td>0.25 to 0.55</td>
<td>0.290</td>
<td>0.415</td>
<td>1.52</td>
<td>0.21</td>
<td>7.2</td>
</tr>
<tr>
<td>0.55 to 0.75</td>
<td>0.290</td>
<td>0.415</td>
<td>1.56</td>
<td>0.17</td>
<td>6.8</td>
</tr>
<tr>
<td>0.75 to 1.23</td>
<td>0.290</td>
<td>0.415</td>
<td>1.54</td>
<td>0.17</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Daily maximum and minimum air temperature and rainfall were obtained from the National Meteorological Service Agency (NMSA), Addis Ababa, Ethiopia. The data for Lalibela and Sirinka came from the periods 1992 to 2000 and 1992 to 1999, respectively. Sunshine hour data from March 1992 to February 1993 were obtained for Sirinka from NMSA. Sunshine hours were converted to total global solar radiation (Allen et al., 1998). Solar radiation for Lalibela was estimated from equation regressing solar radiation on maximum temperature at Sirinka ($y = 0.77x + 0.17$, $R^2 = 0.54$). Monthly means of solar radiation,
maximum and minimum temperature, and rainfall were calculated from the daily values (Figures 1 and 2).

Daily weather values were generated from the monthly mean values at Lalibela and Sirinka. For the simulation analysis, 10 sets of daily weather data for a 24-year period were generated from the monthly values (Geng et al., 1988).

Water stress and soil fertility limit crop production at both sites. The mal-distribution of rainfall creates a drought stress late in the season for a typical grain crop planted in June (Figures 1 and 2). Low soil nitrogen has been observed in the Amhara National Regional State where these two sites are located (CRSPT, 2000), and will be assumed for this analysis.

![Figure 1. Monthly average air temperature and total rainfall at Lalibela, Ethiopia, from 1993 to 2000](image-url)
Management practices for crop and soil

Soil and crop management practices were evaluated for mitigating yield reduction and low yield stability due to drought stress and low-soil nitrogen. The soil and crop management practices included reducing plant population, crop rotation with a legume, and inorganic nitrogen application.

Sorghum cultivar ‘TX610’ was planted whenever plant available soil moisture reached a minimum of 40% between 1 June and 15 July. This prevented the death of young seedlings from sparse rain prior to the rainy season that usually starts in July (Figures 1 and 2). If the minimum soil moisture was not attained between these dates, the sorghum was planted on 15 July.

Lowering the plant population reduces the impact of drought stress on yield (Gardner and Gardner, 1983). Sorghum growth was simulated at four plant populations from 30,000 to 180,000 plants ha⁻¹ to find the population with high yield and stability.
Low soil nitrogen content was raised by crop rotation with a legume, soybean, or application of the inorganic nitrogen urea. The soybean cultivar 'Jupiter' was rotated with sorghum. The cultivar 'Jupiter' has a juvenile phase that allows the plant to develop many nodes before flowering in the short daylength of the tropical latitudes. The soybean was planted under the same conditions as sorghum between 1 June and 15 July in alternate years. The plant population was 160,000 plants ha\(^{-1}\). Urea was chosen as the inorganic form of nitrogen because it is common and relatively inexpensive.

**Long-term simulated productivity, stability, and risk**

Soil and crop management practices were evaluated for its effect on the productivity and stability of yield, and risk. Long-term simulation provides information to apply the criterion of productivity. The slope of a linearly regressed curve through simulated yield over time indicates whether the yield trend is increasing, decreasing or remains the same. A sustainable system would show an increasing or constant yield trend over time.

Stability refers to the yield variance. Usually, farmers prefer greater yield stability, i.e., less variance. Risk is found in the low end of the yield frequency distribution. Comparing the mean minus one standard deviation between management practices indicates the risk associated with each management practice. Lower values of mean minus one standard deviation mean more risk of inadequate food or crop failure.

At Lalibela, the long-term simulation shows reducing the plant population of sorghum from 18.0 to 7.2 plants m\(^{-2}\) increased yield and reduced variance (Figure 3). Reducing the plant population any lower than 7.2 plant \(^{-2}\) reduced the yield. Plant population at 18 plants m\(^{-2}\) produced yield about 207 kg ha\(^{-1}\) lower than the yield from 7.2 plants m\(^{-2}\) (Figure 3). Lowering the plant population to 7.2 plants m\(^{-2}\) reduced risk. The mean standard deviation across all years for plant populations 18.0 and 7.2 were 1244 and 768. While reducing the plant population can increase the yield and stability, the long-term yield trend declined for either plant population. The trend for 18.0 and 7.2 plants m\(^{-2}\) was \(-17 (y = -16.8 x + 2380, r^2 = 0.06)\) and \(-8.2 (y = -8.2 x + 2479, r^2 = 0.02)\) kg ha\(^{-1}\) year\(^{-1}\) (Figure 3). The yield decline was associated with a decline in total soil organic nitrogen (data not shown). This indicates that merely reducing the plant population will increase yield over a short period of time, but in the long run yield will decline.
Figure 3. Simulated sorghum yield at Lalibela, Ethiopia, grown at two plant densities (18.0 and 7.2 plants m⁻²) over a twenty-four year period. Symbols are means and error bars are one standard deviation based on ten replicates. Only minus one standard deviation is represented for clarity.

The sorghum-soybean rotation produced higher, sustainable yields than cropping continuous sorghum. Keeping the plant population at 7.2 plants m⁻², but rotating with soybean increased the sorghum yield from 2377 to 3764 kg ha⁻¹ (Figure 4). Growing soybean raised the soil nitrogen and increased sorghum yield in the following year. The sorghum yield stability was slightly worse when soybean rotation was imposed. The mean standard deviation across all years increased from 411 to 599 with soybean rotation. However, because soybean rotation increased sorghum yield much more than increased its variability, sorghum yield under rotation did not fall below the continuous sorghum yield even when considering the mean minus one standard deviation value (Figure 4). Sorghum yield increased over time 38 kg ha⁻¹ year⁻¹ (y = 37.8 x + 3310, r² = 0.20) indicating that the rotation system is sustainable in terms of productivity.

Inorganic nitrogen application slightly increased sorghum yield and reduced variance compared to the sorghum-soybean rotation (Figure 5). Inorganic nitrogen application increased yield over the sorghum-soybean rotation by an average of 108 kg ha⁻¹. The mean standard deviation across years for sorghum-soybean rotation and continuous sorghum with inorganic nitrogen application was 882 and 738. The yield trend for continuous sorghum with inorganic nitrogen application was -0.9 kg ha⁻¹ (y = -0.90 x + 3883, r² = 0.0005) and seemed sustainable. The advantage of inorganic nitrogen application over sorghum-soybean rotation was very small.
Figure 4. Simulated sorghum yield continuously cropped or rotated with soybean grown at 7.2 plants m\(^{-2}\) at Lalibela, Ethiopia. Symbols are means and error bars are one standard deviation based on ten replicates. Only one standard deviation and alternate years of continuously cropped sorghum is represented for clarity.

Figure 5. Simulated sorghum yield grown in rotation with soybean or continuously cropped with split application of 50kg ha\(^{-1}\) inorganic N fertilizer at Lalibela, Ethiopia. Symbols are means and error bars are one standard deviation of ten replicates. Only one standard deviation and alternate years of split N treatment are represented for clarity.
At Sirinka, reducing plant population from 18.0 to 12.6 plants m\(^{-2}\) slightly increased both yield and stability. Average yield for 18.0 and 12.6 plants m\(^{-2}\) were 3314 and 3394 kg ha\(^{-1}\) (Figure 6). The yield for 12.6 plants m\(^{-2}\) was more stable than 18.0 plants m\(^{-2}\) indicated in the mean standard deviation of yield across all years, 686 versus 792. However, both plant populations 12.6 plants m\(^{-2}\) \((y = -5.45 x + 3497, r^2 = 0.01)\) and 18.0 plants m\(^{-2}\) \((y = -18.9 x + 3551, r^2 = 0.11)\) showed a downward yield trend over time suggesting these practices are not sustainable (Figure 6). The downward yield trend was associated with a decrease in total soil organic nitrogen (data not shown).

![Figure 6. Simulated sorghum yield at Sirinka, Ethiopia, grown at two plant densities (18.0 and 12.6 plants m\(^{-2}\)) over a twenty-four year period. Symbols are means and error bars are one standard deviation based on ten replicates. Only minus one standard deviation is represented for clarity.](image)

When sorghum was rotated with soybean at 12.6 plants m\(^{-2}\), there was a large increase in yield, but a slight loss in stability (Figure 7). The mean sorghum yield under the sorghum-soybean rotation was 4458 kg ha\(^{-1}\) compared to the mean continuous sorghum yield of 3394 kg ha\(^{-1}\). The average standard deviation of the mean yield across all years was 745 for the sorghum-soybean rotation, slightly more than the 686 for the continuous sorghum. The yield trend over time for the sorghum-soybean rotation \((y = 38.8 x + 3992, r^2 = 0.17)\) showed an upward trend suggesting sustainability in productivity.
The application of inorganic nitrogen instead of rotation with soybean increased the yield and stability (Figure 8). The mean sorghum yield was 5005 kg ha\(^{-1}\) when inorganic nitrogen was applied, which was 547 kg ha\(^{-1}\) more than the sorghum-soybean rotation. The mean standard deviation for yield across all years when inorganic nitrogen was applied was 659, which was slightly less than the 745 for the sorghum-soybean rotation. The yield trend over time for applied inorganic nitrogen was increasing (\(y = 3.15x + 4968, r^2 = 0.01\)) (Figure 8).

The management practices that enhanced productivity and stability for each site was climate-dependent. Sirinka generally produced greater sorghum yield than Lalibela. This was a result of more rain falling from September to November at Sirinka (Figures 1 and 2). The better rainfall distribution at Sirinka supported a higher plant population and greater yield potential than Lalibela. Application of nitrogen realized that potential more fully. The source of nitrogen, organic and inorganic, made little difference at the drier site, Lalibela, but a consistent difference at the wetter site, Sirinka. This difference was assumed related to the greater plant nitrogen demand at Sirinka and the greater availability of inorganic nitrogen to the plant.
Ex ante evaluation of soil and crop management practices

CONCLUSIONS

Ex-ante simulation showed the two sites required different management practices to produce sorghum yields that were high and stable in the long-term. The drier site, Lalibela, required a lower plant population and either an organic or inorganic source of nitrogen to produce higher, more stable yields than a no-input system. The wetter site, Sirinka, required a higher plant population than Lalibela and an inorganic source of nitrogen that produced yields greater than Lalibela. These management practices produced yields that were high and stable over a 24-year period.

The main advantage that ex-ante simulation offers is the ability to rapidly generate data about the effect of management practices on yield over many years. Computing speed and data storage has increased over the past decade. It now makes ex-ante simulation quick and practicable. The alternative is to conduct field experiments that take years to complete.

DSSAT compatible models were purposely made to run simulations on a minimum number of data variables to make them more widely applicable.
Productivity and stability of the biophysical system was analyzed with weather and soil data available through government agencies and research documents. The minimal data required for ex-ante simulation made the analysis possible.

Quickly generated data and wide applicability make ex-ante simulation an attractive means to analyze agroecosystems for sustainability. Many management scenarios may be simulated to characterize their effect on productivity and stability. In turn, the result of selected scenarios serves as input into the sustainability analysis of the social system. In summation, the utility of ex-ante simulation is to predict long-term trends for crop and soil-management options to help discover sustainable agroecosystems.

ACKNOWLEDGMENTS

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Soil and Water Conservation Program in the Amhara National Regional State

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ABSTRACT

Accelerated soil erosion is a combination of natural factors and human intervention that are not commonly in harmony. There have been attempts to arrest soil erosion in the Amhara region for the last thirty years, partly through the support of the world food programme. Farmers have also developed their own conservation and land management practices. This paper reviews the problem of land degradation in the region, the causes and extent of the problem, the efforts made to reverse the situation, and future strategies to achieve successful natural resource management and improved productivity.

INTRODUCTION

The Amhara National Regional State (ANRS) is a large Region with an estimated area of 170,152 km$^2$. The region comprises of 10 agro ecological zones dominated by the tepid to cool climate (38%), which has high agricultural potential. Agriculture is the mainstay of the Region, employing about 90% of the rural population and contributing about 31% of the nation's annual grain production; and constituting about 35% of the nation's livestock population (FAP, 1999). The Region is endowed with huge potential of land and water for agriculture, but these are now under the threat of land degradation due to soil erosion, which has already become a serious problem in several parts of its highlands.

Accelerated soil erosion is a combination of natural factors such as topography, erratic and erosive rainfall patterns and man's actions including destruction of vegetation cover through deforestation, overgrazing, and inappropriate agricultural practices that are not in harmony with the environmental conditions. In this regard, dense population, primitive farming practices combined with intensive rains and rugged topography intensified land degradation.

In attempt to reduce soil erosion, farmers have developed their own conservation practices over the years. They have been using various crop and land management practices as well as mechanical structures like drainage ditches and furrows until the introduction of formal conservation measures, the traditional practices used have not been effective. Since the early 1970s, farmers have
started using the introduced soil and water conservation techniques. Currently, these techniques are widely applied in the region through food for work incentives and community voluntary participation. In spite of the large scale soil and water conservation campaign in the region, the level of achievement is still far behind the actual need. Thus, more concerted efforts are needed in order to reverse the land degradation menace in the region.

This paper reviews the problem of land degradation, the causes and extent of the problem in the region; the efforts made to reverse the situation, constraints and future strategies to achieve successful natural resources management and improved productivity.

**PROBLEMS OF SOIL EROSION IN ANRS**

Land degradation of arable land due to soil erosion is very high and has become a major concern in the region. The areas that are severely affected are Wag Hemra and North Wello followed by north and south Gondar, eastern parts of South Wello and northern parts of North Shoa zones. The soil depth in these areas is shallow with low soil fertility. Gullies are frequent in these areas. The available information shows that there are considerable areas of cropland, which are no longer able to produce reasonable crop and some even abandoned due to soil erosion. The result of the erosion hazard assessment also indicates that about 6.4 million ha (38%) of the region's area suffers from high to very high erosion hazards caused by water.

**Causes, magnitude and its effects**

The causes of land degradation are cultivation on steep and fragile soils with inadequate investments in soil conservation or vegetative cover, erratic and erosive rainfall patterns, declining use of fallow, limited recycling of dung and crop residues to the soil, limited application of external sources of plant nutrients, deforestation and overgrazing. Excessive removal of vegetation cover is one of the major factors causing soil erosion. Based on the population growth (demand) and forest increment (supply), the region recorded a deficit of about 16.6 million $m^3$, of wood for fuel and construction in 1996 alone. About 20000 ha of forest are harvested annually for fuelwood, logging and construction purposes. The cereal dominant cropping practice appeared to have aggravated the level of land degradation through soil erosion. Cropping cereals, particularly teff aggravates the situation as farmland requires repeated ploughing (heavy pulverisation) before sowing and it remains bare at the onset of rains. Loss of soil and nutrient depletion are the two most critical manifestations of land degradation.

The extreme gap between the carrying capacity of land and stocking rates of livestock caused overstocking and severe degradation of grazing lands. For instance, the total annual feed availability in the region is estimated to be about
9.1 million tons of dry matter, while the total annual demand is 20.6 million tons; that is, the pressure on the land is more than double the carrying capacity. Overgrazing has lowered productivity of grazing lands through depletion of vegetation cover and trampling.

Poverty is very likely to contribute to land degradation for many reasons. When people lack alternative sources of livelihoods, there is a tendency to exert more pressure on the few resources that are available to them. Investment decisions on the land are also influenced by tenure security. The uncertainty of land security led to cultivation of land for short-term needs rather than for long-term (yields) benefits. As a result of the nutrient depletion and soil erosion problems, agricultural productivity is severely affected. Soil erosion by water has been the dominant factor affecting soil depth, soil fertility and moisture holding capacity influencing ultimate productivity of the land. The national erosion hazard assessment result shows that from 1.9 billion tons of soil loss at national level, 1.1 billion tons (58%) of the soil loss accounts for ANRS.

EFFORTS IN CONTROLLING SOIL EROSION IN ANRS

Farmers over the years have developed their own soil conservation and land management practices. They were able to sustain their production through these technologies for centuries. These practices still play an essential role in agricultural productivity for subsistence farmers. Until the early 1970s, the traditional soil conservation and land management practices have been used for erosion control and land management in the country and the region as well. Some of these traditional techniques/technologies are described below.

Early efforts and indigenous practices

Ethiopian farmers have traditionally practised a number of erosion control techniques. Perhaps the most common is the ploughing of narrow ditches on sloping fields to control run-off. Similarly there are very old farmland terraces, which have changed to bench terraces in areas like Ankober and Debre Sina in North Shoa zone of the region. Traditional ditches and furrows are widely used in areas like Gojam. Contour ploughing, fallowing, crop rotations, kraal, trash lines, use of farmyard manure and agro-forestry practices are common practices in different parts of the region. The indigenous physical SWC practices are used for moisture conservation in the drier lowland areas and for drainage purpose in the high rainfall areas. In general, out of 38 indigenous soil and water conservation practices identified in the country, 27 are found in the ANRS. However, these indigenous conservation practices have not been equally and widely used everywhere in the region. They also sometimes lack perfection in their designs and integration with complementary measures, which varied their effectiveness.
From Table 1 it is clear that there is a constant increase in the trend of achievements of the various soil and water conservation activities. However, the quality of the physical structures, particularly those constructed through community voluntary participation have been poor mainly as a result of poor organisation and insufficient technical follow-up at the field level. Also it has been noted that the proportion of the complementary activities such as cut-off drain, waterway, check dam and integration of vegetative measures are significantly low. The poor quality of the structures and the inadequacy of complementary measures led to the ineffectiveness of most farmland terraces.

Contrary to the poorly organised voluntary participatory activities at the initial stage, at present substantially improvement in the technical supervision and field level organization have been made. Efforts have been made to integrate physical soil conservation with biological conservation measures. But the range of techniques and level of integration were very low and the results were insignificant. There have been a number of grass and legume multiplication sites (more than 30) in the region, which could enhance the integration of biological SWC into the regional conservation program. However, this could not be realised mainly due to inadequate expertise and orientation difficulties in the field, to sustain biological measures under free grazing systems, etc.

The agro-forestry practices initiated include: alley cropping, hedgerow planting along the contour and farm boundary plantation. Multistory cropping is also practised in different areas of Gojam with sesbania and tree lucerne.

Water harvesting and utilisation practice in the ANRS

Concerning the water harvesting and utilisation practices in the region, the construction of water-harvesting structures like ponds and small earth dams has been going on as part of soil and water conservation program from the earlier days. However, the water harvesting practices never centered on improvement of productivity and income of the households. In general, there have been inadequate orientation and organisation to effectively and efficiently utilise the water for domestic and production purposes. Later on, large-scale water harvesting efforts were staged by the Commission for Sustainable Agriculture and Environmental Rehabilitation in the Amhara Region which was established in 1995 and mandated to develop irrigation in the region. Initially an ambitious plan (which was revised later on), it was set to create 540 small-scale irrigation schemes, mostly earth dams, to irrigate 62,100 ha over a period of 10 years. Siltation of dams has been a common and frequently occurring problem. This was mainly attributed to the absence of integration between catchment protections and irrigation scheme development. Therefore, water-harvesting schemes through the construction of big dams yielded little as a result of excessive siltation over a period of a few years.
Soil and water conservation approaches

The planning and implementation approaches in SWC program have been under continuous process of change and improvement. In this process, the major approaches adopted and widely used in the program are watershed management approach and local level participatory planning approach (LLPPA). A minimum planning approach has been an exercise initiated to adopt participatory approach which was not widely adopted but used as basis for the evolution of LLPPA.

Watershed management approach

The watershed management approach had entirely been top-down with more emphasis on the technical solution to the problem of land degradation. The watershed management program was mainly supported by FFW program. The scale of operations was so large and the number of people participating in the activities was huge with little organisation and close follow-up that conservation activities were at times poorly constructed. Some of the techniques were applied without taking into account the diversity of the farming systems and agro-ecological conditions in the country. The selection of sites and the choice of conservation were determined by soil conservation technicians without consultation with the surrounding peasantry. Nearly after a decade of following the watershed approach as a sole planning tool in soil conservation program, the different stakeholders started questioning whether big catchments and sub-catchments were appropriate for close interaction with the farmer. The critical review and evaluation of the approach as a result, disclosed that the approach has affected the chances of thrust building and partnership with farmers, which was manifested sometimes in the destruction of the structures and lack of willingness to maintain and protect the structures.

This led to the consideration of changing or modifying the large-scale watershed management approach to community-based small-scale watershed approach. This started with a pilot exercise called "minimum planning", which in the earlier part of 1990s developed into the local level participatory planning approach as the first step to the modification of the large-scale watershed management approach.

Local level participatory planning approach (LLPPA)

LLPPA is a planning tool where the community is the major actor in the process of identification and prioritisation of the activities to be implemented. The community selects the development options suitable to its needs. Between 1993 and 1995, over 400 LLPPA plans were prepared in the region. Currently, the LLPPA has become the major planning tool in soil and water conservation and rehabilitation program in the region. The method has adapted a number of
participatory techniques such as social mapping, problem ranking, transect walk and many others, which encourage the community for active participation in the decision-making process including the selection of activities. While the planning and implementations methods followed the community's active participation, the issue of integration and holistic approach is still missing. The soil and water conservation activities concentrated on farmlands without due consideration to the hydrological condition in the whole catchment. Particularly the hydrological situation in the hillsides were not critically considered and treated accordingly.

The issue of proper land and crop management practices received less attention. The root causes of land degradation such as the indiscriminate removal of vegetation through over-grazing and deforestation; uncontrolled grazing, inappropriate farming practices such as burning of crop residues and dung, clean cultivation, inadequate use of animal manure, cultivation along the slope, cutting drainage furrows along the slope, cultivating to the edge of gullies, etc were not adequately treated. The issue of productivity, which is the first top priority of farmers, could not be fairly treated. Lack of the integration of these practices affected the effectiveness of the techniques in controlling soil erosion and land management. Thus, no approach was perfect enough to address the problems in holistic manner. While the former (watershed) approach overlooked the significance of socio-economic and socio-cultural elements, the later (LLPPA) neglected considering the whole catchment. This was particularly true for the ANRS. Both the biophysical and socio-economic aspects are equally important in successful watershed management programmes. The lessons learnt from both former approaches called for the adoption of integrated watershed management approach. This appeared to be a general consensus among the pertinent bodies for combining both and adopting the integrated holistic watershed management approach.

**Integrated watershed management approach**

The ANRS has critically considered the adoption of integrated watershed management approach in soil and water conservation program of the region. Integrated watershed management approach deals with the whole range of social, environmental and agricultural problems. A watershed comprises all the biophysical and socio-economic elements including the society, hydrology, vegetation, farming system, etc. All these factors existing in the watershed are interrelated and interact among themselves to determine the sustainability and productivity of the agro-ecosystem. Without the realisation of the integrated watershed management approach, it would be difficult to optimise the complementarities and synergetic effects among the different elements within the watershed. The entire watershed, starting from the highest point (ridge line) to the outlet would be treated in this approach.
The importance of integrated watershed management approach is already well understood and initiated by the ANRS. The ANRS demonstrated its commitment to promote the integrated watershed management approach by setting a directive to follow watershed approaches in four sites; out of which the detailed surveys and project designs have been completed in Gubalafto and Sekota weredas in North Wello zones, respectively (Lakew et al, 2000).

The objectives of integrated watershed management are to:

- apply the principles and techniques of proper land-use practices to the whole catchment to ensure productivity and stability of the agro-ecosystem
- integrate the whole range of livestock, crop, forestry, soil conservation and related issues to intensify and diversify production
- nurture and promote the practical application of interdisciplinary and holistic development approaches; and
- optimise the complementarities and synergetic effects of the different activity components.

Incentives and means of community mobilisation

Before the 1990s, most of the soil and water conservation activities in the region were performed through FFW incentives. But the current activities are implemented through both food for work and community voluntary participation. These are elaborated in the following sections.

Development food aid as a means of incentive

The first FFW activity started in the Region in 1972 in Wello with a US-funded project. Later the WFP-assisted FFW project started in 1974. WFP assisted the ETH-2488 Project which grew to be the largest FFW program in Africa and the second largest in the world got started in 1980. Over the years, FFW became so inextricably linked with soil and water conservation that most of the achievements were attributable to the WFP-supported food for work activities. From the total soil and water conservation achievements for the period 1980 to 1990, about 90% was due to WFP development activities. And still the largest incentive oriented soil and water conservation activities are implemented through WFP supported FFW program in the Region.

Of the one million MT of WFP supplied food grain used for environmental rehabilitation in the country since the 1970s, about 40% has been
Voluntary participatory campaigns

The ANRS, currently undertakes a huge volume of structures through voluntary community participation. The structures constructed with voluntary participation in earlier days were found to be inferior to the ones constructed with FFW mainly because of the differences in the supervision and technical backup. However, the recent visual field observation and feedback from the field staff show substantial improvement in the quality of the work. Field staff have attributed the improvement in the quality of the work to the entire change in the participants group organisation and technical backup as well as quality control system in the region.

Controversies about food for work: Perceptions, views and realities

The objectives and the actual perceptions and views about the development food aid are not in line. The food for work program is applied in drought-prone and chronically food-deficit areas of the region where permanent food gap exists between production and demand. In most cases, there is a shortage of food from three to six months in these areas. This gap needs to be bridged from any source, either from government or donors. Land degradation, unreliability and shortage of rains is the major cause for food shortage in these areas. There is a need of rehabilitating degraded lands and conserving moisture to increase productivity to ultimately attain food security in these areas. This has been the objective of food for work. That is, the food insecure households need to be assisted to produce and be food-secure. Food could have been a good incentive and input for the rehabilitation of degraded lands through reforestation and construction of structures. But this objective is not clearly understood in most cases, particularly by the beneficiaries. Farmers misconceive the payment for the conservation work on their land as legitimate right. Sometimes, they think that development food aid is a continuous supply, which may not terminate at all. Such perceptions certainly affected the very objective of food for work in soil conservation program. That food-insecure households should be temporarily supported so that they can improve their productivity is acceptable. For food insecure areas and labour-intensive rehabilitation programes, food appears an appropriate development incentive. The beneficiaries are expected to understand this and work to be food-secure in the end. But the misconception and tendency to look for food for unlimited period of time still continued.

Nevertheless, donors of the food cannot and should not be blamed for the shortcomings experienced, but the implementing government institutions and technicians should be accountable, at least for not creating awareness about the
objectives among the beneficiary farmers. Still development food aid could be a good tool for the rehabilitation of degraded food insecure areas of the region if the past limitations are corrected and the food resource is effectively and efficiently utilised. Particularly, the labour-intensive water harvesting and rehabilitation works, which are instrumental for attaining food security in such areas can enormously benefit from development food aid.

Effect of development food aid on local production and market price

The surveys carried out (Yeraswork and Solomon, 1985) showed that no beneficiary farmer either abandoned their farming practices or reduced their efficiencies of agricultural activities as a result of food for work. However, the survey showed that there is a short-lived effect of grain and vegetable oil on market prices. This and many other preliminary surveys about the preference of farmers between food and cash showed that most farmers prefer food mainly due to the scarcity of food in the market and high prices. The surveys also indicate that the beneficiaries consume more than 85% of the food, showing that the food addresses temporarily food insecurity problem for the food-insecure households.

Level of achievements and the task ahead

The erosion hazard assessment indicates that about 6.4 million ha (38%) of the region are high and very high erosion hazards areas and 5.6 million ha (33%) of the region are subject to moderate erosion hazard. This indicates that 12 million ha of land requires serious attention accounts for 71% of the total area of the region. The total area covered by various SWC measures is estimated to be some 2 million ha. In this regard, about 1 million ha was treated before and the rest (about 1.4 million ha, Table 1) after decentralisation. However, it is evident that some of the structures, particularly the voluntary campaign period were poorly constructed and unstable and were reconstructed in some cases. Therefore, there could be redundancy in the achievement reports. These could exaggerate the level of achievement. Moreover, the effectiveness of the structures could also be poor in some cases due to the poor quality of the structures. Summing up all these factors, it can be concluded that there is a big gap between the problem and the level of achievement. This clearly indicates the task ahead is enormous and requires doubling and tripling of our efforts to tackle the problem of land degradation in the region.
LIMIITING FACTORS AND FUTURE CHALLENGES IN SWC PROGRAM

The limitations in the program include lack of a holistic approach in the soil and water conservation program. Soil and water conservation structures are the dominant techniques applied as a solution to the land degradation problem in the region. These structures are also concentrated on farmlands and the degraded hillsides but are not properly taken care of. Sustainable land management practices through biological measure such as organic matter management; maintenance of vegetative cover, improved fallow practices and the livestock management practices are not well integrated. The rehabilitation of degraded hillsides, which had incredibly great success in terms of environmental rehabilitation and creation of assets, was overlooked. Above all, the physical structure biased soil and water conservation approach could not adequately address the problem of productivity and food security.

Soil and water conservation measures, particularly the physical structures, require much labour with little immediate economic return. The absence of immediate return from conservation activities, in view of the short-term outlook of poor farmers, certainly affected the acceptance, maintenance and sustainability of the structures. Lack of integration of the physical measures with effective land management practices affects not only the production aspect, but also their protection and sustainability. Farmers should maintain their physical soil conservation structures they have complementing by them with biological and high value conservation measures. The other limitations relating to farmland terraces include: (1) the frequent ineffectiveness of the structures due to poor quality and lack or inadequate complementary measures (2) high percentage of land (over 10%) taken out of production by terraces, (3) rodent-harbouring terraces, and (4) their interference with farming operations.

With regard to the limitations of biological SWC techniques, there has been lack of effective demonstration of the benefits in terms of economic returns and environmental rehabilitation. It is always advocated that multipurpose species such as sesbania, leucaena and pigeon peas are rich in protein and/or nitrogen content, which could substantially improve livestock productivity (milk or beef) and fertility of the soil, hence crop yields. Farmers are always told that they can get these benefits if they plant the species. But after the species are planted, these benefits are not clearly demonstrated in lasting and continuous process. Often the farmers are not clearly and adequately shown how, when and how frequently to harvest, how and when to feed to their livestock and/or apply the organic material to the soil. After planting the trees, farmers maintain the species for a couple of years as have been advised, but the species are removed or damaged by livestock when they fail to realise the benefits advocated by technicians at the beginning.
These are the main limitations in the biological and/or the agroforestry practices both in the country and the region.

**Successes and failures in SWC**

Farmland terraces applied in moisture-deficit areas have effectively stabilised the farmlands in many parts of the region, particularly in south-eastern part of South Wello. In this part of the region, farmland terraces are well taken care of by the farmers. The terraces are regularly maintained that could be changed into benches over the years. There is clear evidence of an increase in soil depth as a result of benching with a consequence of increased rooting depth and water-holding capacity. This positive impact of the farmland terraces is confirmed by the impact assessment study recently carried out jointly by WFP and the government in WFP-assisted project areas.

On the other hand, there are cases where the effectiveness of the soil and water conservation structures have been substantially affected as a result of either lack of proper maintenance or poor quality of the structures or combined effects. Particularly the ineffectiveness has been noted for the structures implemented through voluntary campaign where the level of organisation and technical supervision were so poor. Moreover, the application of level structures to the high rainfall areas was not well received by the farmers because of water logging problem caused and negative consequences on the crops.

**Major constraints in soil and water conservation**

1. Absence of land-use policy and legislation that ensures the long-term land-use rights and security of the affected farmers' investment in sustainable land management such as building fertility of the soil for sustainable production.

2. Lack of soil conservation policy and legislation affected the enforcement of farmers' duties of proper land management parallel to the rights they are enjoying using the land. As a result, uncontrolled livestock grazing system and other interferences damage conservation works. Farmers also do not assume responsibility for maintenance and protection of the soil and water conservation measures.

3. Current [free] livestock management practices have seriously affected the sustainability of the SWC achievements in particular and natural resources development in general.

4. Inadequate attention and allocation of resources for the natural resources by the government have retarded effectiveness of the efforts staged to reverse the problem.
5. Failure to effectively demonstrate production-oriented effective soil conservation and management practices due to the inadequate expertise and skills in the field affected the adoptability and sustainability of the SWC measures.

6. Failure to control the construction of poor quality and unstable structures affected the efficiency and effectiveness of the soil and water conservation program.

7. The absence of integrated holistic approach, technological packages and technical linkages among the pertinent disciplines limited the expected success in the overall production and conservation of the ecosystem.

8. Activities like rural road construction are among the major causes of the rapidly expanding and devastating gully erosion contributing to the worsening of land degradation problem in the region.

9. Potential areas of the region with varying degree of sensitivity to degradation, which can be conserved through simple management techniques with minimum input can entail similar problem over the years unless proper action is taken duly.

**SUGGESTED FUTURE CONSERVATION STRATEGIES**

The future approach to sustainable soil and water conservation should be to improve productivity and accepted by farmers at the same time to be sustainable. Soil and water conservation cannot be considered as an independent activity but as an integrated component of the broad soil, crop and livestock management system. Thus, we must follow a participatory integrated watershed development approach to achieve both soil and water conservation and improved crop/livestock production, as they are complimentary to each other. Within this basic framework the following elements should receive serious attention and be applied accordingly.

*Water harvesting, management and efficient utilisation*

The current water harvesting, management and utilisation practices in the region are not planned and implemented within the principle of holistic and integrated development approach. Thus the structures are not well protected from siltation and damages from external interference. The water is not well managed and protected and utilized efficiently both for domestic and production purposes. In general the cost incurred and the benefits accrued are
not in balance. The agricultural system in the drier moisture-deficit areas are affected by moisture limitation. Therefore, proper water harvesting, management and efficient utilisation in these areas are not only necessary, but also a question of survival. Therefore, every action must be directed to collect and store effectively the rainfall in the soil profile, between the bunds, check dams, and water storage reservoirs so that maximum amount of rainfall is conserved and utilised in the watershed. In high rainfall areas, excess water needs to be drained out and diverted to storage ponds and used for production or domestic purpose during the dry season. We must give added attention to water conservation and water harvesting and ensure that this water is efficiently and effectively utilised for improved crop/livestock production.

Bigger dams require more capital and machineries, which could be out of the economic reach of the community and the country. Bigger dams also may not be feasible everywhere and may not be accessible to every household. Bigger dams also cannot arrest all possible drops of water on every piece of land. Therefore, it should be high time to advocate the need for collecting every drop of water for domestic and/or production purposes; persuade and mobilise the overwhelming rural community for effective and efficient harvesting, management and utilisation of water by all ways and means possible.

**Intensification of biomass production**

The scarcity of adequate biomass is one of the major constraints to ensure good vegetative cover for erosion control and for organic matter recycling to improve fertility of the soil and hence crop yields. This problem also affected the productivity of livestock (beef or dairy). Therefore, in order to address this multifaceted problem, it is important to increase biomass production from all pieces of land including the homesteads, from live fences, farm boundaries etc.

**Intensification and diversification of farm production and income**

Intensification and diversification of production and income is the most feasible way of attaining food security at household level by subsistent farmers. This is one of the strategies for alleviation of risks and improvement of food security and standard of living in degraded areas where the largest scale of soil conservation program is going on in the region. The strategy for diversification includes multiple cropping, incorporation of high value crops and/or cash crops including vegetables and fruit trees, increase of productivity and diversity of livestock production.

Cultivation of forage production with various legumes and grass species for small-scale dairying and fattening is essential. The introduction of stall-feeding and control of livestock movement is needed. A multistorey agroforestry
system needs to be intensified for bee forage, timber, firewood, livestock feed, food, green manuring etc. This can be promoted in the village, on the hillsides, on farmlands and at homesteads.

Soil Fertility Management

Soil fertility management is one of the key methods for soil conservation and improvement of productivity. The methods of soil fertility management should be cost effective so that farmers can easily adopt it. The technique should also be effective for both erosion control and sustainable fertility management and hence crop yields. Composting and manuring are among such techniques, which have proven to be effective for sustainable fertility management and erosion control at the same time. Both green manuring as well as composting and manuring are extremely important for increasing production, soil conservation and for cutting down expenses on chemical fertilizers. To realise this aspiration, the villagers or individual households should maximise biomass production from various species: grasses, legumes and shrubs/trees on hillsides, in gullies, around fences, on farm boundaries etc. The excess biomass production from weeds and other vegetation during the rainy season should be carefully collected and used for compost making. Green manure crops such as lupin, sesbania and crotalaria are suitable for green manuring. They are grown for about 60 days and incorporated into the soil a few days before planting the main crop where the duration and the amount of annual rainfall allows.

CONCLUSIONS AND RECOMMENDATIONS

The ANRS has both potential natural resources to boost agricultural production and curve the serious erosion problem, which is threatening its potential and future prospects. Both optimisation of the natural resources potential and combatting of the erosion problem can be achieved by following integrated watershed management approach. Soil and water conservation should be considered as an integrated component of the broad soil, crop and livestock management system; and therefore, a participatory integrated watershed development approach should be followed to achieve both soil and water conservation and improved crop/livestock production. A farmer is not likely to accept SWC practices unless he experiences substantial benefits in the form of improved farm production from this activity, i.e. SWC should be production-oriented. The uncontrolled livestock management system could be a major hurdle to the production effective soil conservation practices. Therefore, the problem needs to be addressed in the context of integrated holistic development approach. The current agricultural extension package system should also be reorganised so that it follows comprehensive, integrated and
Soil and water conservation in the ANRS

holistic development approach. Present efforts compared to the problem are very small; and therefore, we must double and triple our efforts to arrest the rapidly expanding soil erosion problem. Resources must be used more effectively and efficiently and we cannot compromise large-scale achievements at the cost of quality. Poor quality is proven to entail waste of resources; loss of credibility among the beneficiaries and resentment of the program. It affects both the resources incurred and sustainability of the achievements. So special attention should be given to the quality of the work and its sustainability at any cost. The current large-scale participatory community mobilisation should seriously consider the production effective activities such as small-scale water-harvesting structures for production purposes, planting of multipurpose species for intensification of biomass, compost making and other income generating activities such as fruit tree planting etc. We must give added attention to water conservation and water harvesting and ensure that this water is efficiently and effectively utilised for improved crop/livestock production. The community should be a major actor in all development processes including identification of the problems, prioritisation, selection of the activities and implementation as well as monitoring and evaluation of the program. The community should be empowered for decision-making and genuine participation. This builds thrust and confidence and sense of ownership among the beneficiary farmers and guarantees protection and sustainability of the achievements.

REFERENCES


Integrated Watershed Management as an Approach to Sustainable Land Management (Experience of SARDP in East Gojam and South Wello)

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ABSTRACT

Traditional soil tillage methods, continuous mono-cropping, overgrazing, and deforestation are direct causes of land degradation in ANRS. Every year more and more land is being lost, seriously affecting crop and livestock production and the economy of the farmers. These problems are driven by economic, social and political forces, which are manifested in land tenure policy failures, lack of incentive for better individual behavior, population pressure and poverty. The main thrust of the developmental research were to develop, test and demonstrate an integrated methodology for management of small agricultural watersheds in ANRS; and to create public awareness among the local communities, governmental agencies and research and extension institutions regarding the flexibility and site-specific nature of integrated watershed management. The methodology followed in implementing the watershed management was participatory (both bottom-up and top-down) approach. The farmer’s knowledge and experiences were used for analysing problems, implementing appropriate strategies and evaluating results. Short-term training, on-the-job training of extension workers and farmers-to-farmers training were considered as the most important strategies for ensuring sustainable OFR programs in the region. The watershed project activities concentrated first on the land treatment. Development work has started at the top of the drainage basin and proceed gradually down the slope to the lowlands. Plenty of land management were directed towards minimizing the amount of runoff, water and soil that reaches the lowlands. The watershed development required the contribution of many disciplines aiming at improving the quality of life of local residents of the area as well as management of resources. The research has demonstrated that agricultural productivity in the fragile environment of ANRS can be sustained through appropriate integrated watershed management approach. Conservation technologies must meet two conditions: ecological effectiveness and economic effectiveness. Integrated watershed management requires a process approach (step-by-step approach), an interdisciplinary team approach, and bottom-up (participatory) and top-down (technical wisdom) approach.

INTRODUCTION

This paper presents the experience that the Swedish International Development Agency (Sida)/ANRS Rural Development Project (SARDP) gained and the lessons it learned in conserving the natural resource base in the Amhara National Regional State (ANRS). The Project started activities in 1998 in Awabel and Machakel woredas of East Gojam and Legamba as well
as Debre Sina weredas of South Wello. The coverage further increased to 16 weredas in 2000 (Belay, 2002). The ultimate goal of the work was to support sustainable generation and dissemination of technologies in the fields of crops, livestock and natural resources in an integrated farming systems perspective. The work involved the active participation of researchers from Adet and Sirinka research centres and wereda and zonal subject matter specialists. The participation of farmers in conducting the work was considered as the basic foundation for technology adoption.

Traditional soil tillage practices, monocropping, overgrazing, and deforestation are direct causes of land degradation in ANRS. Every year more and more land is being lost, seriously affecting crop and livestock production and the economy of farmers. These problems are driven by economic, social and political forces, which are manifested in land tenure policy failures, lack of incentive for better individual behavior, population pressure and poverty.

The damage of soil degradation in ecological and economic terms is becoming a disaster. Various researchers have tried to calculate the total ecological, agricultural and economic impact of soil erosion (FAO, 1986; Hurni, 1988; Bojo and Cassells, 1994; Kappel, 1996). However, their estimates of annual soil erosion and its impact on agricultural productivity vary widely. Soil losses for all types of land cover in the highlands are estimated on the average at 10 to 35 t/ha annually. While average values for croplands vary between 20 and 100 t/ha, and the annual productivity losses on croplands range from 0.12 to 2% (Kappel, 1996). If current trends in land degradation continue, farmers who produce on the most vulnerable farm lands will not be able to cope with an ever-declining yield and plot sizes and will practically be driven off their land.

For a long time, the government has recognized the implication of the continuing soil erosion, and large national programmes to mitigate this environmental degradation have been implemented in the past. The efforts were mainly concentrated on disseminating the construction of physical structures and the application of agroforestry technologies. Various types of stone and soil bunds, bench terraces, cut-off drains, waterways, check-dams, grass strips and alley cropping are the prominent technologies (Kappel, 1996). To date, however, the success of such an effort, which was strongly supported by many international donors, has been rather limited. Many of the conservation structures were ploughed under or have deteriorated over the years. Farmers did not apply conservation measures on their own initiative. Food-for-work programmes did not produce an incentive to invest in soil conservation from the farmer’s side, but were merely used as an escape from starvation (Kebede Tato, 1994).

The problems of land degradation are complex and it has political, social and economic implications. Farmers were not eager to accept introduced conservation measures mainly because of high initial investment, substantial losses of arable land, high maintenance costs, and interference with current production processes (U-turns with a pair of oxen). From the above situation, the following two conclusions have been drawn as working hypotheses for soil
conservation research in the ANRS/Sida co-operation in rural development on farm research component. First, farmers will only accept changes in agricultural practices if the introductions contribute to immediate and significant increase and stabilization of yields. Conservation technologies must meet two conditions: ecological and economic effectiveness. It cannot be expected that subsistence farmers will accept changes in agricultural practices that contribute to environmental rehabilitation at the expense of immediate economic benefits. Second, high population pressure has certainly been the major driving force for land degradation. Many farmers are increasingly engaged in non-farm activities such as petty trading and other services. Therefore, research on overall agricultural development must consider income-generating opportunities (development potentials) as supporting component removing people from land cultivation. The main focus of the research was to develop, test and demonstrate an integrated methodology for the management of small agricultural catchment (watersheds) in ANRS; and to create public awareness among the local communities, governmental agencies, research and extension institutions regarding the flexibility and site-specific nature of integrated micro-watershed management. The specific objects were:

- to conserve basic natural resources like soil, water and vegetation;
- to introduce stability to crop yields through improved land management and farming practices;
- to develop alternative land use systems through horticulture, agroforestry, pasture and animal husbandry;
- to check environmental degradation and restore ecological balance; and
- to train, educate and share experiences with beneficiaries in the micro-watershed (catchment).

Description of the project area

The 16 project weredas of SARDP in East Gojam and South Wello represent four major and five sub-agroecologies. East Gojam is characterized by three sub-agroecologies, cold to very cold moist mountains (M3-7) on the Choke Mountains, tepid to cool plateau (M2-5) in the middle land and hot to warm moist gorges (M1-4) of the Blue Nile. The dominant sub-agroecology in South Wello is Tepid to cool sub moist plains, mountains and plateaus (SM-2-5), which is characterized by erratic rainfall amount and distribution and highly degraded rugged terrain. Cold to very cold sub-moist mountains (M3-7) on the Yewel Mountains (Gugufu), tepid to cool plateau (M2-5) in the Jamma–Were ilu plains and hot to warm moist gorge (M1-4) in the Blue Nile gorge.

Soils of the project area

In the SARDP project weredas Vertisols, Luvisols (Alfisols), Regosols and Cambisols are major soil types. The depressions and flat plains of East Gojam are predominantly covered by Vertisols with pellic Vertisols occupying areas that are waterlogged during the rain seasons. Chromic Vertisols are brownish
and better drained. These soils have high agricultural potential. Choke Mountains are dominated with chroic Luvisols (Alfisols) and Regosols. Cambisols occupy a substantial size on the slopes leading to the Abbay gorge of East Gojam.

The dominant soils in South Wello Zone are Cambisols. Most Cambisols have limited agricultural value, as they are found on slopes, and are often shallow or have many stones on the surface. Where Cambisols are deep and not stony, they are good for crop production, but available P contents are low. Vertic Cambisols that show vertic properties are also common in Were ilu and Kelala plains. The Jamma-Were ilu plains are pellic Vertisols, which are also available in Wogide plains. Soils occupying the mountains and degraded landscapes of South Wello Zone are shallow and stony (Leptosols and Regosols), while the alluvial plains in most weredas are predominantly Fluvisols and Vertisols.

Climate

Different annual rainfall patterns are associated with East Gojam and South Welo Zones as a result of the variations in the weather systems and geographic influences. The average total annual rainfall in South Wello ranged from 924 mm (Mekane Selam) to 1107 mm (Dessie) with a very high coefficient of variation. The long-term average rainfall in East Gojam is 1517 mm. South Wello weredas are basically bimodal with erratic distribution. In some weredas of South Wello like Legambo, both belg and meher seasons are important for crop production. East Gojam on the other hand, has one long dependable rainy season. Based on the agroecology, soil type and agro-climatology, the potentials and constraints of South Wello and East Gojam are different. This calls for independent research and extension approaches for a sustainable development. In East Gojam, the forefront intervention should focus on potential production supported with conservation tillage. Natural resources conservation and small-scale irrigation should be promoted the south Wello area.

Attempts towards watershed management

The approach followed in implementing the micro-watershed management program was participatory (both bottom-up and top-down). The farmer's knowledge and experiences were used for analysing problems, planning and implementing appropriate strategies and evaluating results. Land management or husbandry involved finding productive forms of land use appropriate for the potential of the land. Maximum effort was made to maintain the physical, biological and socio-economic environment for the production of food, livestock, wood and other products through the sustainable use of land, species, and ecosystems.

All farmers within the identified watersheds were made aware of the land degradation (erosion) problems and the impact on land productivity. After a
Watershed management as an approach to sustainable land

series of group discussions and educational tours farmers within a catchment collectively agreed to conserve their farm holdings and increase productivity. Participant farmers elected a watershed management committee. The main function of this committee is to co-ordinate conservation efforts and to encourage reluctant farmers to undertake conservation in accordance with the agreed plan. One development assistant was assigned permanently to monitor and follow-up activities.

The watershed project activities concentrated initially on land treatment. Development work started in the upper part of the drainage basin proceeding gradually down the slope to the lowlands. Most of land management activities were directed towards minimizing the amount of runoff, water and soil that reaches the lowlands. The watershed development required collaboration of many disciplines aiming at management of resources and improving the quality of life of local residents. The following activities have been carried out during the last three years.

Microwatershed planning

After training, the technical staff and the planning team carried out a Participatory Rural Appraisal (PRA). This provided all members of the community an opportunity to offer their views on soil and water conservation, forage development, and others. This method has ensured the development of the catchment conservation plan acceptable to both farmers and experts. As much as possible, the conservation work was linked to productive and sustainable agricultural development. In addition field days, demonstrations and development meetings have been used to solicit community participation.

Characterization of the watershed (catchement)

An extensive survey was conducted to characterize watersheds in terms of topography, geomorphology, hydrology, native vegetation, soils, land-use patterns and land capability classification. An informal diagnostic survey was conducted to evaluate the resource base and study the farming practices of the farmers. The major attributes of the first four watersheds are presented in Table 1 as an example.

Table 1. Description of the four selected integrated watershed management sites (ha)

<table>
<thead>
<tr>
<th>Land type</th>
<th>Awabel Gudalima</th>
<th>Machakel Dega Amarie</th>
<th>Legambo Doyach</th>
<th>Mekaneselam Anbes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivated land</td>
<td>103.35</td>
<td>115.55</td>
<td>145</td>
<td>92</td>
</tr>
<tr>
<td>Grazing land</td>
<td>8.37</td>
<td>36.05</td>
<td>3.12</td>
<td>31.15</td>
</tr>
<tr>
<td>Forests and bush</td>
<td>-</td>
<td>32.4</td>
<td>62.5</td>
<td>2.25</td>
</tr>
<tr>
<td>Settlement</td>
<td>1.81</td>
<td>2.5</td>
<td>9.38</td>
<td>9.36</td>
</tr>
<tr>
<td>Total area</td>
<td>113.73</td>
<td>186.5</td>
<td>220</td>
<td>135</td>
</tr>
<tr>
<td>Household no.</td>
<td>197</td>
<td>163</td>
<td>112</td>
<td>215</td>
</tr>
</tbody>
</table>
Integration of technologies into the watershed agenda

a. Construction of soil conservation structures

All conservation measures were considered as a component of improving productivity on a sustainable basis and economic status of farmers. The designs, physical and biological structures planned and constructed for East Gojam and South Wello were different in accordance with the agro-ecological characteristics of the area. Present land use, land capability classification and development maps of all watersheds have been worked out by a multi-disciplinary team. Construction of soil conservation structures included soil bunds, fanya juu, cut-off drains, check dam and artificial waterway in consultation with farmers as appropriate, accompanied by multi-purpose trees and forage development on conservation structures (or grass species) to minimize soil erosion and stabilize physical conservation structures have been planted.

b. Spring development

At least one perennial river (springs) for every watershed was developed to improve the quality and quantity of drinking water for both humans and livestock, and to establish nurseries for trees and improve small-scale irrigation.

c. Crop resource development

In order to improve the productivity of the land, in addition to the soil and water conservation activities, introductions of high yielding crop varieties and management practices (tef, maize, barley, wheat, potato and highland pulse) were made.

Most on-farm variety trials in East Gojam and South Wello showed significant differences. Farmers' evaluation was variable for the different weredas as well as agroecologies. Combined analysis of the data over sites and seasons revealed a significant difference among research domains, crop varieties and variety by environment interaction. A number of crops performed differently (Table 2) and the potentials of the weredas for different crops was variable. Nevertheless, crop varieties have been identified as profitable for further multiplication and demonstration. The results of OFR in general and the varieties, in particular, could be used in other areas with similar agroecologies and soil types.

d. Livestock development

Forage nurseries are established in every watershed. Backyard forage developments has been promoted using leucaena, sesbania, alfalfa, desmodium and fodder beet species. Small-scale poultry production for female-led farmers and apiculture using improved beehives (Kenyan top-bar
and Lang stroth) have been started. Fattening of large and small ruminants has also been initiated.

e. Improved farm implements

The use of mould board plow for land preparation has nearly doubled grain yield of Tef (Table 3). It was observed that the new plow cut deeper resulting in improved infiltration of rainwater into the soil and probably helped deeper penetration of roots in search of moisture and nutrients. The new plow inverted the soil and hence weeds were better controlled. Crop residues were incorporated into the soil thereby improving fertility. The new plow required only one pass thereby reducing frequency of tillage. Cross plowing was not required and hence farmers plowed their fields only along the contour to avoid run-off and soil erosion.

**CONCLUSIONS AND RECOMMENDATIONS**

- A watershed represents a level of resolution: that is a logical planning unit for agricultural development and natural resource management.
- Integrated watershed management should also include other farm and non-farm activities such as access to market, health post, school, etc to enhance rural livelihood.
- Capacity building at all levels is the foundation block. Farmers-to farmers training should be given high priority.
- As a way forward, the next phase should look into the issue of response farming and conservation agriculture in South Wello and East Gojjam, respectively.
- Integrated watershed management is a continuous process requiring an interdisciplinary team and a bottom-up (participatory) and top-down (technical wisdom) approaches.
- IWM is a ‘moving target’: it should be continuously supported with new knowledge, new practice, and new technology.
- It requires committed leadership (farmers, SMS and woreda administrators): organized effort around the same problem and continuous intercommunication.
- There is no magic bullet for the planning and implementation of IWM (site-specific in nature).
- The social planning unit of the government does not fit with the watershed boundary.
- Duplication of management (watershed development committee vs government committee) is a potential source of conflict with in a Kebele management.
<table>
<thead>
<tr>
<th>Crop</th>
<th>Location</th>
<th>Average yield, q/t/ha</th>
<th>Net benefit, Birr/ha</th>
<th>Varieties with MRR&gt;100%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>Wheat</td>
<td>South Wello</td>
<td>2093.46</td>
<td>700.00</td>
<td>3905.00</td>
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<tr>
<td></td>
<td>East Gojjam</td>
<td>2143.81</td>
<td>347.00</td>
<td>5167.00</td>
</tr>
<tr>
<td>Tef</td>
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<td>1360.06</td>
<td>636.75</td>
<td>2129.00</td>
</tr>
<tr>
<td></td>
<td>East Gojjam</td>
<td>1474.87</td>
<td>288.00</td>
<td>2719.50</td>
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<tr>
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<td>East Gojjam</td>
<td>4210.95</td>
<td>1238.00</td>
<td>7565.00</td>
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<tr>
<td>Field pea</td>
<td>South Wello</td>
<td>2007.08</td>
<td>1692.00</td>
<td>2473.50</td>
</tr>
<tr>
<td></td>
<td>East Gojjam</td>
<td>1623.06</td>
<td>341.50</td>
<td>3667.00</td>
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<tr>
<td>Faba bean</td>
<td>South Wello</td>
<td>2139.10</td>
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<td>357.00</td>
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<td>1694.00</td>
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<td>East Gojjam</td>
<td>1679.69</td>
<td>1055.67</td>
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<tr>
<td>Barley</td>
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<td>2033.56</td>
<td>875.00</td>
<td>3759.00</td>
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<td></td>
<td>East Gojjam</td>
<td>1485.12</td>
<td>325.00</td>
<td>3088.00</td>
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<td>Potato</td>
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<td>22231.15</td>
<td>12351.90</td>
<td>28574.10</td>
</tr>
<tr>
<td></td>
<td>East Gojjam</td>
<td>14183.60</td>
<td>3156.00</td>
<td>26111.00</td>
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</table>
Table 3. Agronomic performance of the 'erf' and 'mofer' attached mould board plow in Gudalima watershed (East Gojjam).

<table>
<thead>
<tr>
<th>No</th>
<th>Name of farmer</th>
<th>Frequency of plowing</th>
<th>Frequency of weeding</th>
<th>Size of land m²</th>
<th>Grain yield q/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Trad. plow</td>
<td>Moul plow</td>
<td>Trad. plow</td>
<td>Moul plow</td>
</tr>
<tr>
<td>1</td>
<td>Mulu Asmare</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Teferi Goshu</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

REFERENCES


EUCALYPTUS FARMING IN ETHIOPIA:
THE CASE FOR EUCALYPTUS WOODLOTS
IN THE AMHARA REGION

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ABSTRACT

The history of deforestation and loss of forest cover in Ethiopia has been a concern since the time of Emperors of Kaleb and Minilik II. The introduction and growing of Eucalyptus at that time was meant to supply enough fuel wood and construction wood to the growing population of the country. Eucalyptus growing is largely confined to the highlands, and the Amhara regional state is one of the major producers. Eucalyptus growing by farmers and the private sector of the Amhara region in the recent years has been to generate cash from the sales of eucalyptus poles and fuel wood to urban and peri-urban markets of the region, Tigray and Addis Ababa. However, there are controversies over ecological issues on eucalyptus growing, especially on farmlands and near-river banks. The effect could not be solely explained by the fact that eucalyptus is an aggressive water and soil nutrient consumer, but also due to improper management of eucalyptus systems, especially with high planting density and short rotation. This paper presents experiences that may help to manage eucalyptus systems sustainable.

HISTORY OF EUCALYPTUS GROWING IN ETHIOPIA: Brief History

Introduction of eucalyptus into Ethiopia

The history of deforestation and loss of forest cover in Ethiopia is well documented. It is a sad history indeed. This problem did not escape some of the rulers of Ethiopia. Both Emperors Kaleb and Minilik II were very concerned. Emperor Minilik, assisted by his French technical advisor, introduced fast-growing tree species from southern Europe (Portugal, Italy, Greece and others) totaling some 15 species, but largely made up of several Eucalyptus species. The introduction and growing of such fast-growing tree species was meant to supply fuelwood and construction wood to the new and growing capital city, Addis Ababa. Other tree species introduced along with the Eucalyptus species were Australian Acacia, Casuarina and tropical pine species (Pinus spp.) that can still be seen in urban and peri-urban landscapes of highland Ethiopia. Of the Eucalyptus species introduced between 1895 and 1898, Eucalyptus camaldulensis and Eucalyptus globulus, commonly referred to as red and white
Eucalyptus, respectively, performed well and their cultivation gradually spread throughout the country, especially in the *woina dega* and *dega* zones of the highlands. Alemaya Collage of Agriculture later in 1958 introduced 37 eucalyptus species and still later in the mid-60s, Chilalo Agricultural Development Unit (CADU) and Institute of Agricultural Research (IAR) introduced additional species for testing along with species and provinences earlier introduced at Chilalo (Arsi) and Holeta (Shoa), respectively.

The results on the relative performance of the 37 species was published by Adugna Zerihun (1981) which showed that other eucalyptus species including *E. saligna* and *E. grandis* out performed *E. globulus* and *E. cameldulensis*. Other trials including the species performance trials at Wondo Genet clearly demonstrated that these two commonly grown species are not necessarily the best performing species. In Wondo Genet, *E. donii* and *E. saligna* out-performed the red and white eucalyptus. Because of the narrow genetic base of the red and white eucalyptus introduced in Ethiopia, FRC in 1990 introduced many new provenances for these two species and the long-term trials have been established outside Addis Ababa. It is hoped that these trials will identify more productive lines to replace the existing ones.

**The spread of eucalyptus in Ethiopia**

Eucalyptus was initially planted in and around Addis Ababa in 1898, led by Emperor Menilik himself and his ministers. The radius of eucalyptus growing from Addis Ababa center continued to increase during the first decade. The next stage of eucalyptus growing outside Addis Ababa and environs was by missionaries in Ghimbi, DebreTabor and Harar. Later still, especially after the 50s, eucalyptus growing moved to rural areas from these five nodes, being planted first in urban areas, the homesteads and eventually on agricultural lands by farmers and urban dwellers. The period from 1975 to 1985 saw more eucalyptus planting (a total of 500,000 seedlings, mostly eucalyptus) under the government afforestation and plantation programs through Food-for-Work program of the World Food Program and bilateral and UN funded periurban plantations. Fast growing towns and cities of the ANRS including Dessie, Gondar, BahirDar/Dangla and Debre Berhan had large funded fuelwood/pole eucalyptus plantations.

Eucalyptus growing in Ethiopia by farmers and the private sector, now and in the past, has been to generate cash through the sale of eucalyptus poles and fuelwood to urban and periurban markets. Addis Ababa, Region 1 and Eritrea (before the war) represented the main external markets for the ANRS as well as the more than 2000 urban centers within the ANRS itself. Both the red and white Eucalyptus species are suitable for the two key functions, namely for the construction of economical housing/fencing and for household fuelwood needs of
both urban and rural households. Eucalyptus plantations in other countries are destined for industrial uses, fuel for energy power generation (Brazil, Western Samoa), pulp/paper and the production of oils and turpentine elsewhere. *Eucalyptus globulus* is highly suited for the production of pulp/paper and oils while *E. camaldulensis* or its potential substitute, *E. saligna* is more suited as construction timber. These alternative uses of eucalyptus may have to be promoted if current decline of markets and prices continue.

Table 1 gives the list of important countries growing eucalyptus including Ethiopia while Table 2 shows the rate of eucalyptus growing in Ethiopia since its first introduction 100 years ago. More than 80% of the total was during the last 30 years. The estimated half million ha under eucalyptus, under state, community and private eucalyptus plantations and/or woodlots, places Ethiopia to be one of the ten major eucalyptus growing in the world after Brazil and India. *Eucalyptus camaldulensis* is not grown commercially elsewhere except in Ethiopia and the only other country growing *E. globulus* outside Ethiopia is Argentina. Neighboring countries such as Kenya and Burundi also grow other Eucalyptus species, including *E. saligna, E. grandis* (Kenya), *E. maidenii*, and *E. grandis* (Burundi). Thus globally important and commercially grown eucalyptus species are *E. globulus, E. camaldulensis, E. saligna, E. grandis, E tertiticornis*, and *E. citriodora*. All of these species have been introduced and are grown in Ethiopia but only the red and white eucalyptus are widely grown.

Reference was made above, to the results of long term species screening/evaluation trials conducted by Faculty of Agriculture (Alemaya), IAR/FRC (Holeta and other multilocations), by Wondo Genet College of Forestry (Wondo Genet) and more recently by the Awassa College of Agriculture (multi-location trials in the Rift Valley and adjacent highlands). These trials have adequately demonstrated that eucalyptus growers should replace the red and white eucalyptus species by other more productive species such as *E. saligna, E. grandis* and with the new hybrids. *E. saligna* for instance is now being used as floor parquet instead of mahogany, the latter now scarce and expensive. But neither this information nor seeds of these faster growing eucalyptus species and new hybrids have been made available to the general public, especially to the farmers. The very high yields in Brazil and in other eucalyptus-growing countries are largely from the use of these new hybrids and from the use of good nursery stock (planting material).

The National Tree Seed Unit of FRC is the only institution dealing with the supply of tree seeds but their seed stock list is determined by what can be collected from existing plantations and woodlots as there are no tree seed orchards established and being maintained for such purpose. The Unit is poorly funded and staffed to effectively carryout its national mandate. The Food-for-Work program has been used to collect seed from local sources by government nurseries in the past using food and cooking oil as a form of payment. The Unit’s tree seed supply
may include *E. saligna*, and *E. grandis* but the quantity is very limited and the price range is out of reach for farmers to procure. This sets the stage for farmers to continue collecting seed from their existing trees of *E. globulus* and *E. cammaldulensis*. This practice, over a course of nearly 100 years has resulted in the dominance of these two species in the country. Certainly the government, through its Ministry of Agriculture and the research institutions has not had extension service dealing with tree farming in general and eucalyptus growing in particular.

**AGROECOLOGY AND HUSBANDRY OF EUCA LYPTUS FARMING**

The Ethiopian highlands become the new homes of eucalyptus

Method of growing and management of eucalyptus in Ethiopia, especially by farmers, differs markedly from other eucalyptus growing nations. Rotation length (years) is typically short and yields are low as shown in Table 3. Planting densities are, however, unusually high in Ethiopia ranging from below 3000 in government plantations and from 10,000 to over 100,000 trees/ha in farmers’ farm and village woodlots. Low-density plantings (under 3000/ha) take more than 25 year (26 years for *E. globulus*) and less than 10 years for high-density plantings (i.e. 10,000 to over 100,000/ha). On average, on good sites in the highlands, reach economic harvest, is after 6 years from planting only 3-4 years for each coppice harvest (when growth curves begin to decline).

Eucalyptus growing in Ethiopia is largely confined to the highlands (1500 to 3200 masl) where moisture and temperatures are suitable for tree growing. The two eucalyptus species are normally altitude-based with red eucalyptus being for lower (warmer) altitudes, that is the upper kolla and woina dega zones and the white eucalyptus for the cooler (higher), the dega and wurch zones.

Good growth, and thus, high level of income from large biomass yield in very short period only comes if eucalyptus is given good planting site and given good husbandry during establishment, much like that given to agricultural crops. Farmers are knowledgeable on these two key aspects of eucalyptus farming. Farmers are hardly seen establishing and managing eucalyptus on degraded or bad lands such as shallow, stony and sloppy lands. On the contrary, government advocates that eucalyptus growing be restricted to degraded or noil-agricultural lands. But both establishment rate (survival percentage) and growth rate (yield/ha') on poor sites are always very low and uneconomical.

The government has used eucalyptus in afforestation of degraded hillsides but growth rate is invariably very unsatisfactory compared to the recovery and regrowth rate of indigenous or local woody species. There are now over 150,000 ha of eucalyptus plantations under state and community ownership from the massive planting programs between 1975 and 1982 (mostly in the ANRS) with no
Eucalyptus farming in Ethiopia

management system in place. The largest concentration of such eucalyptus plantations is in North Shoa, North and South Wollo, North and South Gondar, and East Gojam zones of the ANRS.

In a study on the impact of site condition on the performance of eucalyptus block plantations in North Gondar Zone (Asaye Asnake, 2000, unpublished MSc thesis), in the 20,000 trees/ha density group, the best sites (i.e. flat croplands) gave economic yield (ETB) eight times that of the poor sites (shallow, stony and sloppy lands). In terms of biomass yield for a 6-year rotation, the yields were 316, 112, and 25 m$^3$/ha for best, medium and poor sites, respectively. This translates to 51, 18.3 and 4.2 m$^3$/ha/yr, respectively, or EtB 25,572, 10,809 and 3,092 per year, respectively. One only needs to compare what farmers get from crop farming from an equal land size after toiling and with the use of inputs. Annual income from crop farming ranged from ETB 530 to 3500 (excluding livestock, which are not readily sold annually).

Table 1. Major eucalyptus-growing countries in the world, circa 2000

<table>
<thead>
<tr>
<th>Countries</th>
<th>Area under Eucalyptus (ha)</th>
<th>Main species grown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>3,000,000</td>
<td>E. grandis</td>
</tr>
<tr>
<td>India</td>
<td>500,000</td>
<td>E. teriticornis</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>506,000</td>
<td>E. globulus E. camaldulensis</td>
</tr>
<tr>
<td>South Africa</td>
<td>470,000</td>
<td>E. grandis</td>
</tr>
<tr>
<td>China</td>
<td>400,000</td>
<td>E. citridora</td>
</tr>
<tr>
<td>Angola</td>
<td>390,000</td>
<td>E. citridora</td>
</tr>
<tr>
<td>Spain</td>
<td>390,000</td>
<td>E. globulus</td>
</tr>
<tr>
<td>Portugal</td>
<td>300,000</td>
<td>E. globulus</td>
</tr>
<tr>
<td>Chile</td>
<td>250,000</td>
<td>E. globulus</td>
</tr>
<tr>
<td>Argentina</td>
<td>240,000</td>
<td>E. globulus</td>
</tr>
</tbody>
</table>

Source: Compiled by author from various sources

Table 2. Eucalyptus growing in Ethiopia: 1898 -2000

<table>
<thead>
<tr>
<th>Period</th>
<th>Area under Eucalyptus (ha)</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>1898</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1899-1930</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>1931-1970</td>
<td>91,000</td>
<td>96,000</td>
</tr>
<tr>
<td>1971-1982</td>
<td>175,000</td>
<td>271,000</td>
</tr>
<tr>
<td>1983-1991</td>
<td>135,000</td>
<td>406,000</td>
</tr>
<tr>
<td>1992-2001</td>
<td>100,000</td>
<td>506,000</td>
</tr>
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</table>

Source: Compiled by author from various sources
Table 3. Comparison of yield and rotation length of selected countries

<table>
<thead>
<tr>
<th>Species</th>
<th>Country</th>
<th>Rotation (years)</th>
<th>Yield, m³/ha⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. grandis</td>
<td>Brazil</td>
<td>7</td>
<td>40</td>
</tr>
<tr>
<td>E. grandis</td>
<td>South Africa</td>
<td>8-10</td>
<td>20</td>
</tr>
<tr>
<td>E. globulus</td>
<td>Chile</td>
<td>10-12</td>
<td>20</td>
</tr>
<tr>
<td>E. globulus</td>
<td>Portugal</td>
<td>12-15</td>
<td>12</td>
</tr>
<tr>
<td>E. globulus</td>
<td>Spain</td>
<td>12-15</td>
<td>10</td>
</tr>
<tr>
<td>E. globulus</td>
<td>Ethiopia</td>
<td>6</td>
<td>17</td>
</tr>
</tbody>
</table>

Farmers-led eucalyptus husbandry: on-farm woodlots

Of the two most commonly grown eucalyptus species in Ethiopia, *E. camaldulensis* has a much wider ecological range, ranging from upper kolla to dega zones. Within this wide ecological amplitude, both species require good sites and good land preparation. Thus productivity of eucalyptus, and hence profitability is influenced or is determined by the following natural resource conditions and husbandry:

a. Soil moisture or rainfall
b. Soil nutrients (both macro and minor elements)
c. Soil organic matter (SOM)
d. Effective rooting deep soil depth and soil friability (structure)
e. Good planting site preparation
f. Good weed control during establishment, and
g. Good Seed and seedling quality

Indeed, farmers in the ANRS and elsewhere, use deep soils with good friability status (including good organic matter level) and areas with adequate rainfall (800-1500 mm/yr.) to grow eucalyptus economically. The field (site) conditions under 1,2,3 and 4 are met in the HPC and LPC zones of the highlands in the Ethiopian central and northern highlands. Farm woodlot establishment using the Taungya system as described below, ensures that the tree husbandry practices above (5,6, and 7) are met effectively.

Farmers normally plough the teff fields 5 times before sowing and weed the crop more than two times and protect the croplands from any grazing damage until after teff crop harvest. Once the teff has germinated, following broadcast sowing, farmers make deep furrows and plant eucalyptus seedlings (container grown or bare roots seedlings). The following year, farmers may till the young
Eucalyptus farm woodlot and plant finger millet (*Elusine coracana*) or just protect the fields from grazing for a cut-and-carry thatching grass harvest as cash crop

Thus, only the cost of seedlings, transport and furrow making are the direct costs of establishing the woodlot. All other land preparation and crop husbandry practices including the use of chemical fertilizers benefit the growth and yield of the woodlot. Unlike the common belief that eucalyptus can grow at any site without weeding eucalyptus demands well-prepared planting site, weeding and application of fertilizers including micro-elements (i.e. Copper, cobalt, molebidium). Competitive grass species significantly reduce eucalyptus growth by restricting root density by as much as 40% (Schaller). Once established, there are no costs associated in eucalyptus farm woodlots. Harvesting cost in clear-felling harvests is normally borne by the trader (the buyer).

Farmers’ strong interest in eucalyptus farming in homesteads, farm boundaries and on farms, to the dismay of the government, and to the exclusion of other tree species is due to the following reasons:

a. Eucalyptus spp. (especially *E. globulus*) are not browsed by domestic or wildlife
b. Farmers’ knowledge/experience on eucalyptus growing is extensive (100 yrs.)
c. Seed is locally available and seedling production time is short and relatively easy
d. Requires little or no husbandry after the first 18 months of establishment, or non if grown under the Taungya system (described above)
e. Fast growing and highly coppicing
f. High local and national market demand
g. Very little known pest and disease problems. And
h. No readily available species choice to replace eucalyptus.

In addition to the ecological and site requirements being met in the crop farming system, the strong and sustained interest for growing high-density short rotation eucalyptus woodlots by farmers are:

a. To generate cash income
b. Due to the poor performance of crop farming and lack of grazing land/feeds to produce livestock due to land shortage, and
c. To reduce the risk of loss of land in government land re-distribution.

But the greatest driving force, however, is to generate cash income as and when needed. Farmers with eucalyptus on farm woodlots are also free of the annual farm work, common in crop farming, because once established, the woodlots continue to generate cash for many coppice generations.
Eucalyptus was introduced into other East African countries too such as Kenya, Uganda, Rwanda and Burundi as well as in southern Africa, (Zimbabwe, Zambia and South Africa). In East Africa, eucalyptus failed to make headway except in government plantations and by farmer’s participating in tobacco growing for the British-American Tobacco Co. (BAT). In these countries, Grevillea (Grevillea robusta) became more important along with other species including tropical pines and cyprus. But grevilea is not grown as woodlot or as a plantation. Instead, it is integrated into the farming system, grown as farm boundary tree or as scattered trees in croplands and along soil conservation structures. Tree establishment and management in east Africa is relatively easy in the absence of open and free grazing system so common in Ethiopia. Unfortunately, in Ethiopia, open grazing, especially following crop harvest is common where all vegetative material, dry and green is readily devoured and/or carried off for other uses. Under such conditions, only eucalyptus species are able survive, as they are hardly grazed/browsed.

Eucalyptus species also have aggressive mechanism which permits them to grow rapidly to escape browsing and other damages, especially when planted dense and under the Taungya system. This is accomplished through their indefinite shoots and naked buds on the leaf axis both of which are capable of continuous growth or can resume growth with the first opportunity of favorable weather or following damage. The crown of eucalyptus is also made up of several sub-crowns (4 or more) all of which is capable of growth with no suppression from the top (apical) crown.

**ECONOMIC BENEFITS AND WOOD DEMAND**

The growing of eucalyptus, especially in the ANRS is largely motivated by the scarcity of construction wood, fuelwood as well as, more importantly, to generate cash income. Unlike southern Ethiopia, which depends on coffee, chat, enset, sugar cane fruit as income sources, the ANRS has no strong tradition of growing cash crops. The growing of eucalyptus therefore fills this important gap and farmers are quick to tell you that it is their green bank account, able to draw from any time. The traditional role of livestock as a source of cash income and to accumulate wealth in central Ethiopia (the ANRS) has declined. Therefore, farmers grow eucalyptus largely to sell to the urban market and rarely for own use. A survey conducted in North Gondar Zone in 1998, revealed that farmers; reasons for planting included (in the order listed):

a. cash income
b. fear of future shortage of wood
c. acquired knowledge and experience of tree growing (especially eucalyptus)
d. MOA and Gondar Fuelwood Project extension and technical assistance.

Farmers that do not plant eucalyptus were more the exception than the rule. According to the survey, the few farmers that did not plant eucalyptus or had no farm woodlots gave land shortage as the main reason (81.5%). In the survey area, and to a large extent in the whole ANRS, farmers’ interest in planting eucalyptus on farms, farm boundaries and in homesteads, increased dramatically since 1992 with the demise of the Communist regime and its short-lived mixed economy policy in 1989-91. Farmers' interest in tree planting was not confined to eucalyptus only as they were interested in and planted fruit trees (papaya, guava, white sapote, etc.), coffee, citrus fruits, gesho (*Rhamnus prinioides*), chat (*Catha edulis*) and to a lesser extent fodder trees (*Sesbania sesban*, chivha and Tree Lucerne). For instance, in the Gondar Fuelwood Project impact highland woredas, especially in Gondar Zuria woreda, between 1992 and 1996, farmers of this area planted 28.3 million trees compared to only 4 million under community tree planting and only 2 million in government plantations. Both community and government plantation establishment is no longer active and nearly all trees planting is by farmers and few private investors. Eucalyptus is certainly taking up valuable crop land (12% of the total land holding of the household or 0.20 ha out of 1.6 ha)) and in the southern highlands, eucalyptus, assisted by chat, is seen replacing coffee and enset in the home gardens, again because of the high cash income and its low labor input demand,

The Burundi success story of tree farming

CIRAD reported that Burundi had only 2% of its land under forest some 15 years ago. But Burundi was able to have 6% of its land under forest in just a decade. Supported by a strong forestry research and development infrastructure such as tree nurseries and rural roads. Burundi undertook projects (i) to protect the remaining natural forests, (ii) to replant trees (afforest hills/mountains) and (iii) to introduce agroforestry practices. The result is that after 10 years, the natural forest has acquired a national park status and with eco-tourism with nature walks and with pygmies and chimpanzees as the main attractions. During this national drive, 50 million trees were planted of which 28 million were planted by farmers on their farm lands making the country nearly self-sufficient in timber and fuelwood and income from trees and tree products as major sources of farm income with 10,000 ha pure pine and eucalyptus in the mountain slips and farms under agroforestry (using *Grevillea* and *Calliandra*).

Contributing greatly to this success were (i) the compensation effect to the villagers (including setting up nurseries for them to use) as their right to use the
natural forest was restricted, (ii) widespread research counseling and farmers training, and (iii) effective policy to create nurseries (120 nurseries with 40,000 seedling production capacity each) and expand the extension service (150 extension officers covering 80 of the 114 village communes of the country.

The forestry research was instrumental in replacing the growing of Eucalyptus maidenii, which produced only 50 m³ in nine years with E. grandis which produced 320 m³ (more than 6 times) for the same period and replacing cypress (Cupressus sp) with tropical pine (Pinus caribaea) which was being grown on poor sites, thereby increasing the yield from 14 m³ (cypress) to 42 m³ (pine) over 10 years. The growing of Grevilea and Calliandra under agroforestry systems was adopted (scattered on farms, on soil conservation structures and on farm boundaries). Grevilea was being grown for timber production while Calliandra was grown for fodder, fuelwood and for maintenance of soil fertility. These actions, especially the adoption of agroforestry practices increased farm productivity and income for land, labor and capital used. Burundian farmers with only 0.7 ha per HH of 8 persons now are economically well off and agriculture production more sustainable because of improved natural resource management practices. Such success story can be repeated in ANRS if EARO and institutions of higher learning (i.e. WGFC join ARARI Woreta, Makele.).

The benefit of farm woodlots: The case of the Gondar fuelwood project

Assisted by the Gondar Fuelwood and Integrated Rural Development Project (1986-2000), farmers in four highland woredas of the North Gondar Administrative zone (Gondar Zuria, Dembia, Wogera and Dabat), actively establish eucalyptus woodlots on small area in their crop lands, especially after 1991. A survey conducted in 1998 revealed that more than 80% of the farmers in the four woredas planted trees ranging from 200 to 60,000 per household. As a result, eucalyptus was able to replace 57% of the fuelwood/construction pole demand of Gondar city, which traditionally came from indigenous forests and woodlands in just 12 years. But charcoal, which accounted for a small fraction of the fuel consumption, continued to come from indigenous sources. Farmers were also able to meet their most household construction and fuelwood needs. Farmers normally used (branch leaf and twigs) of eucalyptus as the wood was always earmarked for sale.

Based on current low crop yields (of the non-participating farmers in the agricultural package program who are the majority) and defective markets, the annual net income from agriculture (excluding livestock and off-farm incomes) was found to be only ETB 259/ha. On the other hand, the income from the two common woodlot densities of 10,000 and 40,000/ha was estimated at ETB 43,831 and 207,389, respectively, using 8% discount rate. In other words, the net income
from 1 ha of crop farming over a 20-year period is only ETB 10,580 compared to the income from the two woodlot densities of ETB 703,360 and 2,631,540 over a 20-year period. Table 4 gives the projected pole harvest and value over a 20-year period for the 10,000 and 20,000 woodlot densities in Gondar Zuria woreda, planted on an agricultural land site under a Taungya system as described above. Clearly, on productive sites, high-density woodlots fetch much more income over time. The total pole harvested over 20-year period was only 99,000 from the 10,000 density while that from 20,000 (doubling the population) was 349,000, Planting density of over 100,000 are not uncommon in central and southern highlands which result in correspondingly high pole yield and thus high income.

More recently (2000) price of eucalyptus in the ANRS, particularly in the North and South Gondar zones has declined considerably forming local eucalyptus glut. Using current low prices Asaye Asnake (2000) gives incomes (expressed in NPV) for three different ecological sites based on their productivity levels or land classes (Table 5).

As can be seen, it pays more to plant on good sites and at high density as shown in Tables 4 and 5. Conversely, it does not pay to increase the planting density in poor or bad sites as site conditions are so limiting for tree growth and establishment is difficult and costly. High densities, above 10,000/ha result in short rotations (5-6 years for maiden harvests and 3-4 years for coppice harvests).

Experiments using low density (3000/ha) block plantations were carried out on the establishment and growing woodlots on grazing lands using three site
classes, namely (A) grazing land, silt clay soil, 0-5% slope, (B) grazing land, sandy clay soil, 10% slope, and (C) shrub land grazing, sandy degraded hill side, 15-30% slope, The sites were at Loza Mairam (A), Azezo Airport (B) and Jaira (C). These sites are not suitable for crop farming and can be classified as moderately good (A), marginal (B) and poor or highly degraded (C).

The cost of plantation establishment was highest at Site C followed by B and A, respectively. After repeated replanting, survival rate (%) at the end of 5 years was 45, 12 and 2.9 for A, B and C, respectively.

One can see that on hectare basis, yields from site B and C are too low compared to site A. Note that the age of site C is one year older compared to A and B. Not the size (DBH and height) is inferior. This clearly establishes that contrary to popular thinking (by government experts, not farmers) that eucalyptus can be planted on degraded and bad lands, it hardly competes with the performance of local woody species. Indeed, in the Block Plantations described above (Table 6), at the end of three years of protection, the recovery of the native vegetation in site B and C was more impressive than the growth rate of the planted eucalyptus and survival rate was too low (12 and 3% for B and C, respectively).

<table>
<thead>
<tr>
<th>Site class</th>
<th>Size, ha</th>
<th>Age, yrs</th>
<th>DBH, cm</th>
<th>Height, m</th>
<th>#Poles</th>
<th>Value, EtB</th>
<th>Value/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>17.1</td>
<td>4</td>
<td>17</td>
<td>15</td>
<td>127,487</td>
<td>1,784,818</td>
<td>104,375.3</td>
</tr>
<tr>
<td>B</td>
<td>49.5</td>
<td>4</td>
<td>15</td>
<td>16</td>
<td>44,000</td>
<td>616,000</td>
<td>12,444.4</td>
</tr>
<tr>
<td>C</td>
<td>68.5</td>
<td>5</td>
<td>10</td>
<td>11</td>
<td>41,600</td>
<td>499,200</td>
<td>7,287.6</td>
</tr>
</tbody>
</table>

It can be concluded, based on the experience of the North Gondar Fuelwood Project reviewed above, that in general, the mean annual increment (MAI) in poor sites is uneconomical and ranged from 1.6 to 6.5 m³ as compared to 20 m³ for better sites and over 30 m³ from the on-farm woodlots in the same ecological area. Thus both site selection and management are important considerations and farmers know these too well.

**ECOLOGICAL ISSUES OF EUCALYPTUS FARMING**

The ecological issue and concern on eucalyptus growing especially on farm lands and near river banks is not only due to eucalyptus as an aggressive water and soil nutrient consumer but also due to the high planting density and short rotation. There is no question that the both the red and white eucalyptus are heavy and rapid feeders of both water and soil nutrients. On the other hand, as employed by
farmers and private investor high-density rotation farm woodlots and as detailed above, the economic benefit of eucalyptus farm woodlots is beyond repute.

It is now well-established that eucalyptus exploits water and soil nutrients such as N P K and micro-nutrients such as copper, boron and molybdenum, etc. at deeper soil horizons outside the agricultural crops feeding zone or soil depth, especially when grown at high density as in farm woodlots. The issue of water and nutrient depletion by eucalyptus, often the subject of great debate. is generally over exaggerated, especially in rainfall regimes higher than 400 mm/yr. (Davidson, 1989). Table 7 compares water use by annual crops, fruits and forest trees in general, including eucalyptus. It shows trees in general and eucalyptuses in particular are more efficient users of soil moisture per unit of product or biomass produced. Only sorghum and, to some extent, maize showed a lower rate of water consumption, according to Table 7.

Table 7. Water use (liters) by plants to produce 1 kg of produce or biomass

<table>
<thead>
<tr>
<th>Species/group</th>
<th>It./kg Biomass growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual crops</td>
<td></td>
</tr>
<tr>
<td>Field pea</td>
<td>600</td>
</tr>
<tr>
<td>Horse bean</td>
<td>600</td>
</tr>
<tr>
<td>Sorghum</td>
<td>250</td>
</tr>
<tr>
<td>Maize</td>
<td>500</td>
</tr>
<tr>
<td>Potato</td>
<td>1000</td>
</tr>
<tr>
<td>Woody perennials</td>
<td></td>
</tr>
<tr>
<td>cotton, coffee, banana</td>
<td>800</td>
</tr>
<tr>
<td>Trees</td>
<td></td>
</tr>
<tr>
<td>Dalbbergia sissoo</td>
<td>890</td>
</tr>
<tr>
<td><em>Acacia auriculiformis</em></td>
<td>860</td>
</tr>
<tr>
<td>Syzigium (dokma)</td>
<td>610</td>
</tr>
<tr>
<td><em>Albizia lebbek</em></td>
<td>580</td>
</tr>
<tr>
<td>Eucalyptus hybrid</td>
<td>510</td>
</tr>
</tbody>
</table>

Source: Davidson (1989)

Table 8 shows soil nutrients use and removal through harvests. Here again the scientific evidence is that eucalyptus is not heavy feeder of nutrients when compared to other group of plants. The nutrients removed by eucalyptus harvest are often confined to the bark and leaves. It is reported that bark of eucalyptus contains the following amounts (%) of the nutrients taken up from the soil (shown in Table 8) namely; 87% Ca., 48% Ca and 68% Mg. Leaving the bark and leaves during harvest will contribute to sustainable resource use. This is not, however, done in practice in Ethiopia unlike the common practice in commercial eucalyptus plantations elsewhere in the world.
Table 8. Soil nutrient - N P K consumed and removed by harvest (kg/ha\(^{-1}\)) by eucalyptus compared to other species

<table>
<thead>
<tr>
<th>Types</th>
<th>Consumption</th>
<th>Exported by harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>Annual crops</td>
<td>110</td>
<td>24</td>
</tr>
<tr>
<td>Fruit trees</td>
<td>110</td>
<td>9</td>
</tr>
<tr>
<td>Forest trees</td>
<td>307</td>
<td>10</td>
</tr>
<tr>
<td>Eucalyptus</td>
<td>76</td>
<td>6</td>
</tr>
</tbody>
</table>

Source: Davidson (1955)

Indeed the annual litter fall of eucalyptus ranges from 6.9 tons/ha in young plantations to 12.8 tons/ha in old and first rotations. Thus, the litter fall continues to increase with age as shown in Table 9 and nutrient input in to the soil (N P K Ca) is proportional to the amount of litter fall. The rate of litter decomposition is, however, slow in eucalyptus and the impact is therefore long term. This fact has been documented in the long-term effects of eucalyptus (*E. globulus*) on soil fertility and undergrowth in Managasha State Forest, near Addis Ababa (compared to *Cupressus lusitanica*, *Juniperus procera* and natural forest over a period of 40 years. (Michelsen, et al. 1993). Teff growth was reduced when grown on soils from all three plantation species. Vegetation under growth was good under eucalyptus (better than cyperus). Analysis of soil nutrient content showed that *E. globulus* and *Cupressus lusitanica* soils had lower nutrient content than the native *Juniperus procera*, however, according to this study.

Table 9. Annual litter-fall of eucalyptus (tons/ha)

<table>
<thead>
<tr>
<th>Stand type</th>
<th>Age (yrs.)</th>
<th>Litterfall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>lvs</td>
</tr>
<tr>
<td>Seedling</td>
<td>8</td>
<td>4.31</td>
</tr>
<tr>
<td>Coppice</td>
<td>13</td>
<td>8.31</td>
</tr>
<tr>
<td>Coppice</td>
<td>19</td>
<td>8.88</td>
</tr>
</tbody>
</table>

Source: Bernard-Reversal, F (ed)
SUMMARY AND CONCLUSION: IMPLICATION TO NATURAL RESOURCES MANAGEMENT IN THE ANRS

Summary

The history and extent of eucalyptus growing has been presented. Ethiopia is amongst the leading top five countries that grow eucalyptus. Eucalyptus in other countries in plantations is for industrial purposes such as for pulp and paper, industrial chemicals and to generate energy. On the other hand, eucalyptus in Ethiopia, especially in the ANRS is grown as farm woodlot, on farm boundaries and in homesteads is to generate cash income by selling pole, split wood and BLT to the urban market. Government and donors had embarked on large eucalyptus plantations and afforestation programs in the mid-70’s through soft loans from the World Bank, the African Development Bank and bilateral assistance. The Food-for-Work was used in this massive effort and the ANRS, as a region was the principal target of this national drive. This has resulted now in many urban and peri-urban plantations and hillside protected forests in the ANRS but without effective management and unclear ownership.

The biggest success story is in the fact that farmers are actively planting eucalyptus, often as on farm mini woodlots. The average farm land devoted to farm woodlot is 0.25 ha/HH giving each family 18,000 trees or more depending on the planting density used. Eucalyptus farming in the ANRS is clearly the main source of cash income and means of accumulating wealth-replacing livestock for this purpose.

Policy makers and planners had often considered eucalyptus growing would effectively displace the need to deforest natural forests and woolands. This has not happened as eucalyptus generally went to meet construction needs and fuelwood needs of towns and urban centers. In rural areas harvesting wood from natural forests and woodlands continues as an off-farm income source and to meet their domestic needs for household energy, construction of houses and fencing. Charcoal for the urban market continues to come from indigenous sources, however.

CONCLUSIONS

The economic benefit of eucalyptus farming by farmers in the ANRS is beyond repute. Farmers will need to continue growing eucalyptus to meet urgent cash needs and as a means of accumulating wealth. Government must not consider making farmers plant eucalyptus on marginal and degraded sites as has been the case in the past nor should eucalyptus be used in afforestation and enrichment
planting of hillsides. It does not pay the efforts of growing the seedling, transporting, and planting eucalyptus on such poor sites as has been amply demonstrated from trials and enclosures in the past.

The central issue in growing eucalyptus is that it can only be grown in monocultures except in the first year of planting where farmers carry out crop farming without any negative impact on the crop yield from eucalyptus. Thus, the strong interest of the government in integrated food and feed production with forestry as the current national task forces have been charged to develop cannot be accommodated. Eucalyptus farm woodlots as is done by farmers, does not result in any grazing or feed production beyond the first 12 to 18 months. It is also impossible to intercrop under eucalyptus, irrespective of density and age of the eucalyptus woodlots and plantations. One must note, however, that low density (under 1000/ha) old stands of eucalyptus can support grazing as can be observed by the plantations established by MOA and through donor assistance in the past.

Government must not believe that eucalyptus has solved the problem of rural and urban household energy needs. The over-dependence of rural household on non-woody biomass source of energy is still critical to natural resource management and sustainable land use. Rural households continue to rely on dung and crop residues and miscellaneous BLTs to meet their cooking and space heating as well as selling these products to the rural markets. Some of the crop residue also goes to meet dry season animal feed and for use in local houses construction.

Next to Region 1 (Tigray), the ANRS is the region most dependent on non-woody biomass energy with an average of 70% but ranging from 50 to 95% of the total energy demand and Wag Hamera consumption. The most hard hit sub-regions in the ANRS are North Shoa Zone, Wag Himra zone, N and S Wollo and N and South Gondar (highlands). Those with medium conditions are the highlands of W and E Gojam, and Awi zone. The areas with good supply and currently the source of much of the exploitation include the Western lowlands (of North Gondar, Gojam and Awi zones), the escarpments of the three basins, namely Abay, Tekeze and Awash.

Implication to natural resources management in the ANRS

The extent of eucalyptus farming by farmers of the Ethiopian highlands especially the central highlands making up much of the landmass of the ANRS and the economic importance has been demonstrated in the paper. Eucalyptus, once established, continues in the landscape because of its coppicing ability, which in part has made it difficult to find a suitable replacement species. The ecological negative impact of small farm woodlots is not discernible in the field as streams continue to flow and woodlot productivity does not appear to significantly decline over the years. The extent of farmer’s interest in eucalyptus growing is such that it
is nearly impossible to do away with eucalyptus. Its problem in this regard is its fast growing aspect which results in depleting water before the next recharge by rainfall as is the case with other slow but more water consuming trees and food crops as shown in the data presented in this paper.

It is possible and necessary to revisit the issue of these high-density short rotation eucalyptus plantations and woodlots vis a vis local and generalized hydrology. Government and its experts must not continue to cry foul on the water resource depletion issue of eucalyptus when there is no case of water use by farmers, who are often seen draining off their cereal farms each growing season to remove water, which also initiate soil erosion (gully erosion).

The need to find a suitable tree or woody species to eucalyptus has often been expressed by researchers and policy makers. The current efforts by GTZ, EARO, ARARI and other partner NGOs to find replacement species such as Grevillea robusta, Populus hybrids, Calliandra calothyrsus, Sesbania sesban and some local species need to be supported and accelerated. There is no adequate evidence of farmers being given extension advice and service on which species to grow and how to manage. the future seems bright for more tree-based farming as demonstrated by eucalyptus farming. Eucalyptus farmers are now more food secure. The common saying in ANRS is "he who plnts eucalyptus and disciplines his wife is a wise man."

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Soil and Water Conservation Technologies, Transfer and Adoption by the Smallholder Farmers in the Amhara Region

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ABSTRACT
The occurrence of progressive "deterioration" of formerly "better-off" areas is a phenomenon commonly observed in Ethiopia. If the problems are not checked soon, the loss of some of the resources may be difficult to reverse. In pursuit of these ever-escalating problems, the present paper reviews the generation, transfer and farmers' response to the soil and water conservation (SWC) technologies, substantiate the indigenous knowledge of soil and water conservation practices. The paper indicates constraints, opportunities, and research needs for the region's sustainable land management and development. Available information is reviewed in research findings concerning generation, introduction of technologies and practices, the rate of transfer and adoption, indigenous knowledge, and research gaps. Information soil erosion characteristics in the Region such as types of soil erosion, causes, severity and the economic significance are studied and reported for any level of users. Alternative SWC technologies to the traditional ones were widely introduced and transferred into the farming community. Crop-pasture systems, particularly those including forage legumes and fodder grasses increase crop-livestock production while improving soil quality through enhanced biological activity and physical structure. Similarly, in areas where burning of dung and crop residue practices are prevalent, tree planting to produce fuelwood and use it efficiently are some in arresting land degradation compared to the use of sole conservation structures. However, due to the various technical and socio-economic problems, the rate of adoption to these technologies remains minimal. Indigenous SWC practices are many; however, none of them could be considered as building block in designing the new ones. Planning and development of the technologies were undertaken without consulting the users and partners. Nevertheless, technologies and improved practices by themselves may not be solutions; rather, these technical and biophysical factors should be part of the socio-economic, socio-cultural and political dimensions. They are key elements in establishing sustainable development. In addition, sorting and analyzing the barriers for adoption, fine-tuning fitness of the existing technologies to local context, and scaling-up the most feasible ones are key points in the process of technology generation and dissemination.
INTRODUCTION

Agriculture is the dominant sector of the Ethiopian economy. It provides about 52% of the country's GDP, 80% of its employment, and 90% of its export earnings. About 85% of the population live in the rural areas (World Bank, 2000; CIA, 2001). It is also indicated that 88% of the population, 60% of the livestock, and 90% of the agriculturally suitable area are concentrated in the highlands above 1500 m asl. The economy is largely dominated by subsistent agriculture. Mixed crop and livestock farming in the same management unit dominate. The production system is mainly rain-fed, subsistence-based, and smallholders-oriented.

The poor agricultural practices and the country's intrinsic fragile biophysical conditions have resulted in large areas becoming severely degraded, including those areas formerly considered as high potential areas for agriculture. The occurrence of progressive "deterioration" of formerly "better-off" areas is a phenomenon commonly observed in many regions, and if the problems are not checked in time, the loss of some of the resources may be difficult to reverse. Land degradation in these highlands is extremely serious and widespread (Kefene Kejela, 1993). Loss of arable land due to soil erosion is a widespread phenomenon in the highlands, which account for about 45% of Ethiopia's total land area and about 66% of the total land area of the Amhara Region.

Soil degradation (soil erosion by water, physical, chemical and biological) is one of the major problems of the Region. One of the main causes of soil erosion is the removal of vegetative cover for different purposes. The current forest cover of the Region is less than one percent (0.4%). This exposes the soil surface to rain or wind and leading to an increase in surface runoff thus enhancing soil erosion. The removal of the top fertile soil from the land in turn creates unfavorable conditions for vegetation/crop to establish and this results in accelerated land degradation.

Soil erosion is a major problem in the region. Erosion is taking place at very rapid rates of 16-50 t/ha/year. Because of erosion, the Region accounts for more than 50% of the estimated annual soil loss in Ethiopia (Gizachew Abegaz, 1995). As a result soil productivity has declined to a very low level and soil erosion has reached to an alarming stage. Major causes of soil degradation identified in the Region were: (i) inappropriate farming practices without conservation measures, (ii) cultivation of steeply slopes, (iii) deforestation, (iv) overgrazing, and (v) insecure land tenure.

Since productivity loss from soil erosion is not recognized until much later, the land might, at that time, be no longer economically suitable for growing crops. This situation makes it difficult to convince smallholder farmers, and even policy makers about the long-term adverse effect of erosion.

To grapple with the problem, massive reforestation and soil conservation schemes were launched in the country. Many improved SWC technologies were
introduced for direct use and some are tested side by side in a certain agro-
ecological conditions. In spite of the effort in introduction/generation, and transfer
of the technologies, the success rate has been minimal. Therefore, it is high time
to amend faults of the past and replace with alternative approaches in utilizing the
soil and water conservation schemes to bring sustainable agriculture to the
Region.

Objectives

1. To review the generation, transfer and farmers’ response to the soil
conservation technologies in the Amhara Region
2. To substantiate the indigenous knowledge about soil and water conservation
practices available in the Region
3. To indicate constraints, opportunities, and research needs for sustainable land
management and development in the region.

General features of the Region

Geography

The Amhara National Regional State (ANRS) is located in the northwestern part
of Ethiopia. Geographically, it is situated between latitudes 9° and 13°45′N and
longitudes 36° and 40°30′E. The Afar, Benshangul, Oromiya and Tigray regions
border it in the east, southwest, south and north, respectively, and by Sudan in the
west. The total area of the Region is estimated at 170,152 km², which is about
one-sixth of the country’s total area (BoA, 1997).

Land-use pattern

Eleven land-use types are identified in the region. Out of 27.2% (4.64 million ha)
of land, the Region’s land, which can be cultivated, 25.3% is already under
cultivation. Moreover, cultivable land for grazing is 30% (5.1 million ha), forest
and shrub land is 14.7% (2.5 million ha), water bodies 0.7% (3.8 million ha). The
high forest and wood land in the Region account to less than 2% (Table1). Agriculture is the main stay of the economy. The rural population consists of
predominantly subsistence farmers. The farming system is generally characterized
as the high potential cereal (HPC) consisting areas of east and west Gojam, and
low potential cereal (LPC) the majority of the remaining parts of the region.
Table 1. Land-use patterns of the Amhara Region

<table>
<thead>
<tr>
<th>No.</th>
<th>Land use</th>
<th>Area (ha)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Grazing land</td>
<td>5122560</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Cultivated land</td>
<td>4644454.4</td>
<td>27.2</td>
</tr>
<tr>
<td>3</td>
<td>Waste land</td>
<td>3244288</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>Forest and shrub land</td>
<td>2510054.4</td>
<td>14.7</td>
</tr>
<tr>
<td>5</td>
<td>Settlement</td>
<td>904985.6</td>
<td>5.3</td>
</tr>
<tr>
<td>6</td>
<td>Water bodies</td>
<td>648857.6</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>17075200</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Bureau of Agriculture, planning and Training service (1999a)

Geomorphology and soils

The Region is broadly classified into eight major geomorphic units namely; (1) the highland plateau (parts of Gojam, Wollo, and northern Shewa), (2) the eastern escarpments extending from Debre Sina to Alamata, (3) the eastern lowland plains bordering the Afar region, (4) the western lowland plains bordering Sudan, (5) the blue Nile gorge, (6) the Tekze river gorge, (7) the Tana plain, and (8) the afro-alpine mountains (Ras Dejen, Choke, Abune-Yosef, Aba Farit Guna and Adama) (Abayneh, 1995). About 12 dominant soil types are identified in the Region (Table 2).

Table 2. Distribution of major soil types in the Amhara Region, Ethiopia

<table>
<thead>
<tr>
<th>No.</th>
<th>Soil units</th>
<th>Dominant soil type</th>
<th>Total area (ha)</th>
<th>Percent</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vertisols</td>
<td>Chromic, pellic</td>
<td>1,738,480</td>
<td>10.8</td>
<td>Gojam, Shewa</td>
</tr>
<tr>
<td>2</td>
<td>Luvisols</td>
<td>Orthic, chromic</td>
<td>2,444,360</td>
<td>15.1</td>
<td>Chilga, Armachiho</td>
</tr>
<tr>
<td>3</td>
<td>Nitosols</td>
<td>Eutric, dystric</td>
<td>2,204,300</td>
<td>13.7</td>
<td>Mecha</td>
</tr>
<tr>
<td>4</td>
<td>Acrisols</td>
<td>Orthic</td>
<td>424,000</td>
<td>2.6</td>
<td>Highlands; Sekela, Banja, Ankesha</td>
</tr>
<tr>
<td>5</td>
<td>Cambisols</td>
<td>Eutric, vertic, humic</td>
<td>2,306,480</td>
<td>14.3</td>
<td>Entire Region</td>
</tr>
<tr>
<td>6</td>
<td>Regosols</td>
<td>Eutric</td>
<td>343,440</td>
<td>2.1</td>
<td>North Wello</td>
</tr>
<tr>
<td>7</td>
<td>Arenosols</td>
<td>Chromic</td>
<td>580,800</td>
<td>3.6</td>
<td>Sekela, Abay-Gorge</td>
</tr>
<tr>
<td>8</td>
<td>Phaeozomes</td>
<td>Haplic</td>
<td>3,199,020</td>
<td>19.8</td>
<td>Gondar, Wello, Shewa</td>
</tr>
<tr>
<td>9</td>
<td>Leptosols</td>
<td>-</td>
<td>2,309,305</td>
<td>14.3</td>
<td>Steep-slope and limestone areas</td>
</tr>
<tr>
<td>10</td>
<td>Andisols</td>
<td>Vertic, humic</td>
<td>59,480</td>
<td>0.4</td>
<td>North Gondar</td>
</tr>
<tr>
<td>11</td>
<td>Solonchacks</td>
<td>Orthic</td>
<td>131,440</td>
<td>0.8</td>
<td>Borkena, Cheffa areas</td>
</tr>
<tr>
<td>12</td>
<td>Fluvisols</td>
<td>Eutric</td>
<td>407,900</td>
<td>2.5</td>
<td>Kobo, Habru</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>16,149,395</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Source: Abayineh, 1995
The type and distribution of the soils are very much influenced by the physiography and geology of the Region. The mountainous and degraded landscapes are covered with shallow and stony soils; the undulating and gently rolling areas are characterized by dark-reddish to brown colored deep soils; depositions and flat plains are covered by black clay soils; and foothill areas consist of alluvial soils. The very young and shallow soils are found in the mountainous and degraded landscapes of the Region. The deep and relatively fertile soils are found on the flatter plains.

Farming system

Cereals, pulses, oil crops, vegetables and fiber crops are cultivated annually in descending order of area coverage. Teff is the leading crop (32% of area cultivated) followed by sorghum and barley (13% each), wheat (11%) and maize (7%) (BoA, 1999a). Growing teff accelerates soil erosion, as it demands several plowings for fine seedbed preparation. To improve soil fertility, rotation of cereals with legumes is a common practice in the region.

Approximately 35% of the Nation’s livestock population is found in the Amhara Region (BoA, 1999a). Oxen are used for traction, cows for milk and calves, while equines are used for transportation and sometimes for traction, especially, the horse. Small ruminants are reared for their meat and for the ready cash they bring. The major feed sources for livestock are communal grazing lands, fallow lands, crop residues and crop stubbles. However, due to the severe land degradation and low biomass production, the livestock population is under severe feed shortage.

Research findings

The generation and transfer of information in soil erosion characteristics, and the introduction and transfer of the SWC technologies have been done extensively since the early 80s. In spite of the information generation and technology dissemination, recognition of the problem by the farmers and adoption of the technologies are minimal.

Information on soil erosion characteristics

Types of soil erosion

Water erosion is most dominant in the highland areas where rainfall is high. Sheet and rill erosion is by far the most widespread kinds of accelerated erosion and is more significant to agricultural production than all other causes combined. Sheet erosion is mainly seen all over the Region where cultivated lands exist. Rill erosion scars are commonly observed on sloping lands along roadside and on the sloppy edge of some fields left unplowed after the rainy season. Both types of
erosion are commonly observed on the high rainfall areas of (Awi, East and West Gojam) where Nitosols are dominant. Sheet erosion is the most widespread and the most insidious form of soil erosion. It causes the largest amount of soil loss and probably the largest economic loss of any type of erosion, yet it is the least noticeable form. This type of erosion carries away the fine soil particles of the most fertile topsoil and organic matter (Gete Zeleke, 2000).

Gullies are also present in large numbers almost everywhere. These are more pronounced and frequently visible along roadsides and animal tracks. It was observed that gully erosion is mainly caused or accelerated by improper construction of roadside waterways. In some cases, the roadside drainage channels are diverted towards the farmers' fields causing very deep gullies in the arable lands. Therefore, any road construction and maintenance should take full account of the erosive potential of roads and should take measures such as check dams and lined channels to ensure the control of runoff from roads and direct the concentrated runoff towards the natural drainage. Developed gully erosion in the highlands of north Shewa, south Wello on Vertisols, Awi, East and West Gojam in Nitosols could be mentioned as an example. Gullies are also created along the animal tracks and footpaths.

Causes of soil erosion

The main causes of erosion in the Region are inappropriate farming practices without conservation measures (lack of crop rotation, planting crops down the contour instead of along it, frequency of tillage). Cultivation of very steep slopes due to population pressure, deforestation and/or burning of forests, bushes and shrubs, overgrazing and insecure land tenure are some of them.

As a result of increasing population pressure in the Region, the availability of suitable land for agriculture is shrinking. At the same time, the amount of land required for crop production is growing with population. Hence areas which are not suitable for agriculture (slopes even over 60%) are still under cultivation. The removal of vegetative cover for different uses (house construction, fuelwood, etc.) exposes the soil surface to direct impact by rain that leads to severe soil erosion. Overgrazing (free) causes a severe shortage of feed resource. This, in turn, lowers the productivity of the rangelands and pastures. High concentration of animals inhibits establishment or regeneration of woody vegetation and also distracts conservation structures.

Erosion varies widely with site physical conditions (soil characteristics, angle and length of slope, land cover, and soil conservation measures), with the nature of rainfall events, and their timing relative to prevailing land cover. Thus, even on the same site erosion rates may vary widely between years and different management practices. Areas severely affected by water erosion are located mainly in the north, northeastern and part of the central portion of the Region. However, in these areas erosion is probably so far advanced that active erosion is reduced (the soil is already shallow and exposed) and visible signs are limited,
while on the highland plains, there is still on-going active erosion and soil depth is not severely affected.

The Amhara Regional Conservation Strategy categorized the causes of soil erosion in the Region as being physical (natural), policy, socio-economic, institutional and technical factors. The result is low agricultural productivity, increased poverty and food insecurity for a large number of the population in the Region.

Severity and estimates of soil erosion

The highlands of the Amhara Region suffer from severe soil erosion and land degradation. There are considerable areas of cropland which are no longer able to provide reasonable crop production and some even having to be abandoned due to soil erosion. The national erosion hazard assessment reveals that 1.1 billion tons of soil (58% of the nation's total loss) are lost from the Region each year (1997). Table 3 shows that 42% of the soil loss in the Region was only from 10% of the regional area. As described in the foregoing paragraphs, the areas of very high erosion hazard are mainly located in the highlands of North and South Gondar, East and West Gojam, North and South Wello and Waghamra zones. The estimated soil loss rates due to sheet and rill erosion vary from 201 to over 300 tons/ha/yr. This indicates that an average of 2.5 cm thick soil is being taken away every year from a hectare of land. As it can be seen from Table 3, 70% of the Region's land suffers from high water erosion.

Table 3. Estimated erosion hazard classes (main groups) in the Amhara Region

<table>
<thead>
<tr>
<th>Erosion classes</th>
<th>Range of soil erosion</th>
<th>Area coverage (Ha, ‘000’)</th>
<th>(%)</th>
<th>Mass of soil loss to erosion (Ton/ha)</th>
<th>(% Total loss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
<td>201-300</td>
<td>1660</td>
<td>10</td>
<td>466914</td>
<td>42.3</td>
</tr>
<tr>
<td>High</td>
<td>51-200</td>
<td>4796</td>
<td>28</td>
<td>429598</td>
<td>38.9</td>
</tr>
<tr>
<td>Moderate</td>
<td>16-50</td>
<td>5599.2</td>
<td>33</td>
<td>191112</td>
<td>17.3</td>
</tr>
<tr>
<td>Non-slight</td>
<td>9-15</td>
<td>5020</td>
<td>29</td>
<td>16742</td>
<td>1.5</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
<td>17075</td>
<td>100</td>
<td>1104366</td>
<td>100</td>
</tr>
</tbody>
</table>


The Abbay River Basin Integrated Development Project (ARBIDP) study indicated that the plain areas of the highlands, in Gojam, Agew-Awi and in south-east of the highlands are all classified as having a moderate erosion hazard. These areas have deep soils (Nitosols, Alisols and Acrisols). Soils with moderately deep profiles are classified as severely eroded (severe erosion hazard) and occur in the middle of the Abbay gorge, in the northern lowlands, south and south-east of Lake Tana and in patches the eastern highlands.

The assessment of land degradation in Ethiopia was made by FAO. Ethiopian Highlands Reclamation Study (EHRS) in 1984 concluded that some...
1,900 million tons of soil were annually eroded from the highlands, equivalent to an average net soil loss of 100 tons/ha and an annual loss of 8 mm in soil depth. The variations range between 5 and 170 tons/ha depending on altitude and agro-ecological zone. The highest rates of erosion were found in Wello, Gondar, Gojam and Shewa. Differences in vegetative cover are responsible for much of the variation in erosion rates in the highlands. Although, quantitative data on soil losses are limited, Hurni (1988) estimated that average erosion rates on currently unproductive cropland and cropland planted to annual crops are 70 tons/ha/year and 42 tons/ha/year, respectively, while it averages 8 tons/ha/year on land planted to perennial crops and 5 tons/ha/year or less for all other land cover types.

One commonly used theoretical framework for estimating potential soil loss is the USLE model. The USLE was developed for a particular temperate zone situation. Therefore, it needs to be adapted to tropical and local situation. Thus, in the Abbay basin study, the application of this formula resulted in unreliable and unsatisfactory results. The quantitative estimates of erosion are surprisingly low, compared with all other data as reported above. The map produced using USLE estimate (1:2,000,000) scale should be considered only as indicative.

Results obtained from test plots at Andit-Tid (north Shewa) SCRP site indicated that soil loss under traditional soil management techniques averaged 152 tons/ha/year. While at Anjeni, west Gojam on experimental plot with different slopes and conservation practices, soil loss rates varied form 53 tons/ha/year to 161 tons/ha/year. In the same site soil loss is reduced by 32% with graded bunds, 54% with graded Fanya-juu, and 66% with grass strip.

The SCRP concluded that soil losses from croplands in the highlands were much less than those estimated by the EHRS. The NCSS also claims that soil losses may have been overestimated by the EHRS.

**Economic significance of soil erosion**

It is difficult and speculative to translate soil erosion losses into economic terms as the relationship between soil loss and productivity may not be linear (Abbay River Basin Study, 1998). The impacts of erosion on agricultural production may occur due to fertility losses by leaching or diversion of organic residues. Diversion of organic residues for other uses results in bad soil physical proportion such as bath soil structure in low water infiltration, storage and low nutrient holding capacity.

In terms of the economic hazards, the areas of Gojam, Agew-Awi and around Lake Tana are the most critical, where the hazard from erosion is most significant. These surplus producing areas are important at both regional and national levels (as maintained earlier). However, observation shows that these areas are under active erosion. Thus, the regional soil conservation programs should focus on these areas (BoA, 1999).

FAO (1986) that the average annual yield declines from 1 to 3% on cropland (averaging 2.2% for the highlands) and upto 1% on grassland. The
Degradation could cost Ethiopia 15,000 million Birr over the next 25 years or an average of ETB 600 million per year (14% of the agriculture contribution to GDP). About 80% of the losses would result from reduced crop production and the remaining 20% coming from reduced livestock production.

The National Conservation Strategy Secretariat, NCSS study of 1993 provides the quantitative and monetary impact of degradation on production and productivity in agriculture as follows:

- In 1990, loss of 3.5 mm or 8 mm soil depth, by erosion resulted in a loss of grain production, which was estimated to be between 57,000 and 128,000 tons. This loss also reflected on 1000 to 2500 km² of cropland that was gone out of cultivation because the soil depth fell below a minimum critical level. The foregone production in the livestock sector resulting from soil erosion was estimated to be between 35,000 and 78,000 TLU (Tropical livestock units). Together these losses represent financial losses of Birr 18,000 (at 3.5 mm soil loss) or Birr 40 million (at 8 mm soil loss), which was equivalent to 0.5% and 1.5%, of the 1990 agricultural GDP, respectively.

- The burning of dung and crop residues caused physical production losses estimated to be four (at 3.5 mm soil loss) to eight times (at 8 mm soil loss) greater than the production cost accounted by soil erosion. These losses amounted to 4 and 5% of the 1990 agricultural GDP, respectively.

As it could be seen from the Ethiopian Highland Reclamation Study (FAO, 1984; 1986), the findings seem to be an overestimate of losses. Based on the SCRP – Anjene research station data, Kefene Kejela (1992) reported that the costs of soil erosion will account for 15,000 million birr over the next 25 years with the annual reduction of crop yield by 1-2 percent.

Bojo and Cassells (1995) estimated in their study that gross annual financial losses were US$ 2 million due to soil erosion and roughly US$ 100 million (which is 50 times more than the physical soil loss) due to nutrient losses resulting from the removal of crop residues and dung from crop lands.

Soil and water conservation technologies

In the past, the soil conservation research project (SCRP) in Ethiopia had generated ample data on the effectiveness of the graded and level bunds in conserving soil and reducing runoff volumes. According to the objective of an area, graded or level bunds are used interchangeably. In soils that require drainage of excess water, graded structures are selectively used, whereas level bunds are preferable in soils/areas where drainage is not a problem (Table 4).
Table 4. Effect of the soil conservation techniques on soil loss and on crop production

<table>
<thead>
<tr>
<th>Conservation technique</th>
<th>Reduction in soil loss as compared to the control</th>
<th>Effect on grain yield as compared to the control plot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anjeni</td>
<td>Maybar</td>
</tr>
<tr>
<td></td>
<td>28% slope</td>
<td>28% slope</td>
</tr>
<tr>
<td>Level fanya juu</td>
<td>na</td>
<td>72</td>
</tr>
<tr>
<td>Graded Fanya juu</td>
<td>70.2</td>
<td>4</td>
</tr>
<tr>
<td>Level bund</td>
<td>na</td>
<td>37</td>
</tr>
<tr>
<td>Graded bund</td>
<td>68.3</td>
<td>na</td>
</tr>
<tr>
<td>Grass strip (level)</td>
<td>74.7</td>
<td>55</td>
</tr>
</tbody>
</table>

na: not available
Source: Lakew Desta (1998)

All the conservation structures tested in all the stations were significantly reduced soil loss over the control, whereas grain yield was affected in all the techniques except the use of graded Fanya juu at Anjeni. In another work at Anjeni (on 12% slope), the use of graded Fanya juu and grass strip techniques were increased grain yield by about 14%.

Gully stabilization techniques using physical structures and biological materials (multipurpose trees and grasses) showed promising results in controlling run-off erosion and restoring gullies (Birru Yitaferu, 1998 and Getachew Alemu, 1998). Tree species such as Acacia saligna at Srinka and Sesbania spp in the Adet areas are recommended for gully stabilization. Grasses such as Vetiver zizanoids and elephant grass (Pennisetum purpureum) are the selected species in rehabilitating gullies.

Soil moisture conservation and management is an essential practice in moisture stressed areas of the Region. As of Kidane and Rezene (cited in Wendimu Bayu and Getachew Alemu, 1998), have shown that the efficiency of tied-ridge, basins and furrow dikes has been tested for several years in Wollo in improving yields of different crops. A yield increase of 47, 127 and 66% in sorghum, maize and mung-bean, respectively, has been reported when using tied-ridging.

Adjusting plant population densities and spatial arrangement to the available soil moisture is one mechanism of managing soil moisture deficit. On the other hand, short maturing crop varieties are of vital importance for efficient moisture use and successful crop production. Early or dry planting was reported as giving higher yields in the Kobo area (Wendimu Bayu and Getachew Alemu, 1998).

Excess moisture is also a problem in areas that have high rainfall under Vertisol condition. Technologies that drain excess moisture from the farm have been tested and significant yield increases have been achieved. The use of broad
bed and furrow, camber bed and open ditches are recommended in the management of Vertisols.

Runoff and soil losses are significantly reduced by using cover crops and land uses along the various slope gradients (Asrat Abebe, 1992). Bare fallowed plots were reported in heavy soil erosion even when slope length was reduced to 10 m. On the other hand, natural grass resulted in almost no soil erosion at all. Thus, a series of grass strips across the slope combined with shortening the slope length is suggested to keep soil erosion within the allowable range for cultivated land. It is also repeatedly reported that growing small cereals such as teff and wheat are requiring fine seedbeds and their planting time is late in the rainy season. Soil erosion is very serious in these crop fields, especially, in the high potential cereal producing areas of Gojam and Gondar. The use of lupine and vetch species as cover crops and green manuring in the teff production system of Gojam is found effective in protecting the soil from rain at the start of the rainy season Lupine and Vetch species are also used to replenish soil fertility by replacing the chemical fertilizer requirements of the crop.

In combating the effect of soil erosion, various soil conservation structures and grass-strips were evaluated and about 14% yield increment was achieved. According to Solomon Abate (1994), it should be possible to sustain the stability of the soil, water and vegetation resources, even under intensive use by selecting appropriate land-use systems that match the site characteristics, and by using management systems that protect and enhance soil productivity.

**Indigenous SWC practices**

At the national level, about 38 different types of indigenous SWC practices have been identified (Lakew Desta, 1998). In an inventory work of indigenous SWC practices within the Region, since 1996, it had been possible to identify 27 types of practices (Lakew Desta, 1998; 1999). In places like Ankober and Debre Sina, north Shewa, level bunds that were built more than (100 years ago) which are developed into bench terraces are observed. A system of renewing stone and/or soil bund is also noticed to make use of the accumulated topsoil above the bund (traditionally it is known as 'erken meshar' in the Ankober areas).

Construction of traditional ditches in the highlands of East and West Gojam is known as 'fesses' and 'awra fesses', level bunds around Dessie, contour plowing of perennials around Bati, contour cultivation in many slopey agricultural areas of the region. Fallowing, crop rotation, managing scattered trees in the farmland, and others are the indigenous skills practised in the Region (Lakew Desta, 1998).

'Shilshalo' or making furrows in the established plants is an indigenous practice in conserving moisture in the drier areas of Wollo and some parts of north Shewa. The practice is important in loosening the compact soils and can aerate the rooting system of the crop and rainwater can be harvested in the furrow.
The system is widely practised for sorghum and maize crops production (Wendimu Bayu and Getachew Alemu, 1998).

Table 5. Indigenous soil conservation measures, benefits and problems, Tikurso, Ethiopia

<table>
<thead>
<tr>
<th>Indigenous SWC techniques</th>
<th>Benefits</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Kab’</td>
<td>Obstructing transportation of sediment and eroded soils</td>
<td>Non-continuity, Improper alignment, Frequent collapse due to plow interference, Harboring rodents, Being weed source</td>
</tr>
<tr>
<td>‘Dinber’</td>
<td>Obstructing eroded soils and transportation of sediment</td>
<td>Non-continuity, Improper alignment, Frequent collapse due to plow interference, Poor quality, Being weed source</td>
</tr>
<tr>
<td>‘Golenta’</td>
<td>Diverting excess water from flood source areas</td>
<td>Lack of mediator to negotiate amongst farmers to get proper route, Irregular and excessively steep gradient, Frequent collapse</td>
</tr>
<tr>
<td>‘Boi’</td>
<td>Draining without causing soil erosion</td>
<td>Gradient, Alignment</td>
</tr>
<tr>
<td>‘Fereka’</td>
<td>Improving soil fertility</td>
<td>Obstruction of growing the same high-value crop season after season</td>
</tr>
<tr>
<td>‘Fig’ or manure</td>
<td>Improving soil fertility</td>
<td>Decomposition, Far distances between site of origin (backyard) and site of application (farm)</td>
</tr>
<tr>
<td>‘Maker’</td>
<td>Improving soil fertility</td>
<td>Lack of seed and interference with major cropping</td>
</tr>
<tr>
<td>‘Ribrabo’ or mulch</td>
<td>Retaining moisture and increasing soil fertility</td>
<td>Decomposition, Lack of mulching material</td>
</tr>
<tr>
<td>‘Gorf mekelibesha’ or flood trap</td>
<td>Trapping sediment from floods</td>
<td>Fixation and size estimate</td>
</tr>
</tbody>
</table>

Source: Azene Bekele (1997)

The study in indigenous soil conservation skills of farmers revealed that there are a great number of technologies. Several indigenous soil conservation techniques are widely practised in the Amhara Region as mentioned in the work of Azene Bekele (1997), and the techniques are listed with their benefits and associated problems (Table 5).

Technology transfer

Improved soil conservation techniques have widely been used by farmers during the last 20 years through mass mobilization, Food for Work (FFW), the Community Forest and Soil Conservation Development Department (CFSCDD), and in the new extension program launched by the government.
In addition to the traditional soil conservation practices, improved techniques such as graded and level Fanya-juu and soil bunds, grass strips and agroforestry systems have been practised in the Amhara Region through various agents. The main agents in transferring the soil conservation technologies are the BoA, FFW program, NGOs (GTZ, Winrock International, Agriservice Ethiopia and others) Sida watershed management programs in East Gojam and South Wollo, research centers (Adet, Sheno and Sirinka) through their on-farm research programs and other.

Integrated watershed management practices using soil conservation structures, biological materials in stabilizing the bunds and improved farming practices are currently widespread in the Region. In spite of the development and expansion of the watershed management practices and their importance, farmers were rarely able to replicate the practice without assistance.

**Possible barriers for adoption of SWC technologies**

**Research approach**

The conventional top-down approach was one of the constraints in developing an effective SWC technique for proper lack of understanding of the research partners (among farmers, development workers and researchers). There was little attempt to increase the awareness of farmers regarding soil erosion and the shortcomings of the traditional practices vis-à-vis the newly introduced techniques. By far, the main actors in researching and utilizing the research results (development agents and farmers) are not consulted to share their experience and knowledge soil and water conservation technologies should also address immediate food demands.

**Land ownership**

In situations where farmers have no permanent title to land, there is a reluctance to adopt improved land management and conservation practices. Frequent distribution of land made farmers feel insecure about losing part of their farm. Therefore, farmers plan to invest for immediate needs than for long-term benefits out of their farm. Improving local control and strengthening local institutions would enable better SWC in insecure ownership conditions. The institutional issues concern poor integration of sectoral government agents arising from frequent restructuring and government change.

**Lack of appropriate land-use policy in practice**

Very steeply slope areas are cultivated for crop production. In such areas farmers could not afford the labor and cost of soil conservation structures since it requires frequent structures within a short vertical distance and frequent maintenance.
Livestock rearing system

Free grazing is common practice not only in the Amhara Region but in the rest of the country as well (except some coffee growing areas). This practice is disastrous to establish perennials and soil conservation practices on the farm.

Complexity of the SWC techniques

Soil conservation structures require knowledge to properly design and construct them so as to control runoff. Besides, there is need to organize farmers from upstream and downstream of the watershed.

Other complexities of the SWC techniques are:
- security of land ownership. Communal and state-owned areas are more degraded
- farmers have immediate food demands.
- very few demonstration sites to promote farmer to farmer extension.

Availability of alternative techniques

Generally, farmers may have similar agrarian and environmental problems. However, since they have differences in wealth their problems, goals, knowledge and aversion to risk may also vary. On the other hand, technologies should be recommended according to the physiography, rainfall characteristics and farming system of an area. Costly and heavy conservation structures may be recommended indiscriminately to those areas and communities that require lower options of these.

Lack of data in soil conservation requirement classes

Land classification is a basic tool for the field staff to understand the capability of the land in terms of sustainable production of major kinds of land use: crop production, grazing and forestry. The soil conservation requirement classes are the major category of the system. It is known that there are eight soil conservation requirement classes in which the risk of soil erosion increases through class-I to IV and VI to VIII, as well as the requirements of soil conservation practices and management.

Knowledge of available resources

Reliable data on land resources including soil, climate, vegetation and topography are needed if sound land use and conservation policies are to be developed. In addition, information is needed on the resources available to farmers (crop
residues, organic manures, fertilizers and draught power and labor) together with knowledge of how farmers manage these resources.

Institutional issues

Most small-scale farmers produce at subsistence level using very low inputs. Yields are often poor and farm incomes are too low to sustain the family, let alone to maintain the soil resource.

Gap analysis and research needs

In spite of the available technologies and the efforts to transfer them, many problem abound to get smallholder farmers to adopt them easily. These problems need research. There are various researchable themes in soil and water conservation that can bring changes to current production systems:

• Fine-tuning the techniques in the use of physical structures to the level that farmers can carry out the engineering work by themselves
• Integrating SWC structures with bund stabilizing biological materials, which can add value to the bund such as MPTs, fruit trees, fodder grasses, and so on
• Changing the research system from research-station-based and researcher-managed to on-farm and participatory/operational – research which can increase understanding about the technology among the research partners and reduce the time required to transfer and introduce the technology to the users
• Scaling-up the use of SWC technologies – by substantiating key parameters that can govern the benefits of the farmers. Designing and implementing outcome-oriented soil conservation research through increasing involvement of relevant stakeholders, and integration of disciplines to enhance the possibility of adoption
• Socio-economic and cultural constraints that barrier the diffusion of SWC technologies. Fore instance, labor is reported several times as it is a shortage in constructing and maintaining the structures, however, it is not labor that should be mentioned as a problem but the religion and cultural influences behind
• Putting options of the technologies for the various land types and land-use patterns, and by far for the capability of the users. Simple and cheap technologies should be developed for less erosion prone areas/land types and for those people that cannot afford costly conservation structures.
CONCLUSION

Land degradation due to soil erosion is a serious problem in the Amhara Region highlands. Production and productivity of the crop and the livestock sectors are declining while the population pressure is increasing. The land resource such as the soils, water and vegetation are dwindling due to mismanagement of agriculture. As a consequence, food and feed shortage is a common phenomenon for both the people and the livestock.

Of the limiting factors in agricultural production, soil erosion by water is the priority. Information on the characteristics of soil erosion in the Region such as types of soil erosion, causes, severity and the economic significance are studied and reported for any level of users. Alternative SWC technologies to the traditional ones were widely introduced and transferred into the farming community. However, due to the various bio-physical and technical problems, the rate of adoption remains minimal. Indigenous SWC practices are many; however, none of them were considered as a building block in designing the new ones. Planning and development of the technologies were without consulting the users and partners.

Scientists are exploring various options that would enable farmers to intensify agricultural production on tropical hillsides, while preserving fragile soils. Crop-pasture systems, particularly those including forage legumes and fodder grasses increase crop-livestock production while improving soil quality through enhanced biological activity and physical structure. Similarly, in areas where burning of dung and crop residue practices are prevalent, tree planting to produce fuelwood and efficiently use it might be more effective in arresting land degradation than the use of sole conservation measures designed to reduce soil erosion. Both biological and physical soil conservation measures should be considered for future SWC programs. Nevertheless, technologies and improved practices by themselves may not be solutions; rather these technical and biophysical factors should abide with the socio-economic, socio-cultural and political dimensions, which are key elements in establishing a sustainable development. Sorting and analyzing the barriers for adoption, fine-tuning fitness of the existing technologies and scaling-up the most feasible technologies are essential points to be considered to succeed in the soil and water conservation programs.

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Opportunities and Challenges in Reversing Land Degradation: The Regional Experience

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ABSTRACT

Land degradation is one of the major threats to food security and natural resource conservation in the Amhara region. As a consequence, a quarter of the farmlands have gone out of production in recent years. The traditional farming in the region, which is characterised by multiple and non-conservation tillage, cereal-dominated cropping and extensive livestock management is very erosive for soils and nutrients. Reversing the effect may demand a systems approach, whereby an investment in improvement of natural, human and social capitals would be used more efficiently. Addressing degradation of natural resources should combine local and scientific knowledge through farmer/community participation, capacity building of local actors and enhanced farmer innovation, and should be empowered by favourable policy. This approach requires the full involvement of stakeholders at different levels to facilitate and integrate system-compatible technological interventions to various social groups.

LAND DEGRADATION PARADIGM

Land resource degradation is considered to be one of the major threats to food security and natural resource conservation in the Amhara regional state. Hundreds of years of exploitive traditional land use, aggravated by high human and livestock population density lead to the extraction of the natural capital, mainly through farming of uncultivable sloppy lands and overexploitation of slowly renewable resources. The outcome is that a quarter of the highlands are seriously eroded, of which 15% are so seriously affected that it will be difficult to reverse them to be economically productive in the near future (SCRP, 1996).

Despite the current recognition of land degradation as a major bottleneck of agricultural productivity and natural resources management by farmers and policy makers, the issue of land degradation was not considered as a top priority in the national policy of poverty alleviation. Reversing land degradation in a short period requires a strong policy support through increasing credit access to farming communities and/or promoting cost sharing arrangements (Sanchez et al., 1997). Proposals for diversity of technologies and investment of time and resources by a wide range of governmental and non-governmental institutions to address land degradation continues to prove unsuccessful, and soil fertility decline in small scale farms remained to be an intransigent problem. The rural poor in the Amhara region are often trapped in this vicious poverty cycle between poor access to
resources (poverty), land degradation, and lack of relevant knowledge and/or appropriate technologies to generate adequate income and opportunities to overcome land degradation. The major knowledge gap is associated mainly with poor access to information for technologies and market. There is a direct link between land degradation and rural livelihood through three pathways. Firstly, decline in soil fertility as a result of land degradation decreases farm productivity and income. As crop/livestock production is the major source of household income in the highlands, decline in soil fertility, through nutrient depletion and poor soil water holding capacity affects the on-farm income significantly. Secondly decline in soil fertility affects productivity of labour; a degraded land requires much more labour per unit area than a well managed land. Operation related to soil and water conservation and soil fertility management may compete with off-farm labour thereby reduce an off-farm income of the household. Thirdly land degradation reduces the underground and above ground biodiversity of the system, which in turn, affects the biochemical process of the rhizosphere and the vegetation cover of the land.

In earlier days, natural fallows were used to restore soil fertility mainly in the cereal-based highlands of Wollo and Gonder. However, due to increasing demand for land as a result of population pressure, natural fallows with such a long duration are no longer viable option of improving soil fertility. It has been recognized that natural fallow requires longer time to achieve the required level of soil fertility that can lead to optimum crop yields (Jama et al., 1998). Short duration natural fallows are now becoming more appreciable though short-duration, natural, unmanaged fallows normally do not maintain soil fertility at levels similar to those achieved under long-duration natural fallows (Aweto et al., 1997), unless enriched by fast growing, N-fixing legumes. Short duration improved fallows consisting of planted and managed fast-growing species allow rapid replenishment of soil fertility. It has the advantage of in situ accumulation of biomass, optimising nutrient cycling through nutrient pumping from subsoil layers and litter falls, enhancing soil biological activities and maximize use efficiency of minimal external inputs (Sanchez et al, 1997). The ideal species in the improved fallow systems is, therefore, fast growing, N₂ fixing and efficient at nutrient capture and cycling (Jama et al., 1998). The most common herbaceous legumes growing in pasturelands in the upper cool highlands of the Amhara region are vetches and clovers, besides the commonly grown food legumes like lentils, faba bean, and pea and grass pea.

Since land degradation is a complex phenomena affected by biophysical and socioeconomic factors, it became relevant to understand its root causes, biophysical or socio-economic, that play the major role in aggravating/reversing the trend of soil fertility. This paper also suggests methods and approaches for enhanced integrated soil fertility management and community participation towards sustainable natural resource management.
UNDERSTANDING THE ROOT CAUSES OF LAND DEGRADATION

There are multiple factors that cause land degradation at short and long terms in the region. The major environmental factor that cause significant soil and nutrient loss in a short period of time is water erosion followed by wind erosion. In Sub Saharan Africa, the major agents of land degradation are water erosion, wind erosion, chemical degradation and others that affected soil loss by 47, 36, 12 and 3.5 %, respectively. Given the mountainous and commonly slopy landscape of the Amhara region, water erosion is expected to be the major environmental agent affecting land degradation. Most of the Wollo and Shewa highlands became erosion-prone due to high rainfall intensity accompanied by very steeply farmlands.

Although the degree of soil erosion is highly related to the interaction of Wischmeier factors, the type of land use and management may have played an important role in the highlands. The contribution of different management factors towards land degradation in Africa is estimated to be 49%, 24%, 14%, 13% and 2% for overgrazing, agricultural activities, deforestation, overexploitation and industrial activities (Vanlauwe et al, 2002). The livestock sector is a very important component of the system both as an economic buffer in times of crop failure and economic crisis and as a supportive enterprise for crop production. There is a considerable concern, however, that the number of animals per household is much higher than the carrying capacity of land resources. Overgrazing due to very high livestock population density in the Amhara region is expected to contribute most to land degradation. Another very important factor that aggravated land degradation in the Ethiopian highlands is deforestation. The forest cover declined from 40% at the beginning of this century to less than 3% at present. Deforestation accelerated land degradation in many ways. Firstly, deforested land is easily susceptible to erosion, both wind and water, and hence causes considerable nutrient movement. Secondly, the amount of litter that could have contributed towards maintaining the soil organic matter is considerably reduced. Thirdly, deforestation in the highlands caused lack of fuelwood, and hence farmers use manure and crop residue as cooking fuel, which otherwise could have been used for soil fertility replenishment.

Overexploitation of land resources without returning the basic nutrients to the soil is also an important factor that contributed most to soil fertility decline in the region. For instance, barley is the single dominant crop in the upper highlands of Wollo. This system has very low crop diversity with a legume component of less than 3%. The barley-dominated system receives external inputs very rarely with a fertilizer rate of less than 5 kg/ha (Quinones et al., 1997), and the practice of applying this limited amount of mineral fertilizer is a recent practice. Data from the region on the amount of nutrients returned to the soil in comparison to the nutrients lost through removal of crop harvest showed that only 18, 60 and 7 % of nitrogen, phosphorus and potassium is returned to the soil, respectively (Sanchez et al., 1997). Hence
there is an over extraction of nutrients from the same rhizosphere for years and years.

Another possible cause of land degradation is lack of early awareness about soil erosion and soil fertility decline by farmers. For instance in Uganda, McDonagh et al., (2001) reported that when farmers were asked to describe their indicators of soil erosion they stated gully/rill formation, exposed underground rocks, land slides, wash away of crops, shallowing of soils and siltation of the soil. These are soil traits that appear in a much later stage of soil degradation, after the soil organic matter and nutrients of the soil are removed. If farmers respond to soil erosion at this stage, the probability of reversing the fertility status to its earlier value would be difficult. Similarly farmers indicators of soil fertility decline include stunted crops, yellowing of crops, weed infestation, and change of soil color to red or grey, traits that appear at the later phase of soil fertility decline.

Lack of appropriate policy at local and national level is another factor affecting land degradation. Lack of appreciation of the dynamics and the threatening trends by policy makers is one major obstacle to creating government concern and concreted action (Kebede Tato and Hurni, 1992). The current land policy of Ethiopia (only the right to use and transfer to their children) is expected to affect long term investments including construction of conservation bunds, planting trees, short term fallowing and alike.

**TOWARDS INTEGRATED SOIL FERTILITY MANAGEMENT**

Traditionally, the major nutrient management strategy to increase crop yield and improve soil fertility was through application of mineral fertilizers. The 0.5 ha demonstration plots that have been advocated and practiced by FAO and the ministry of Agriculture for years is one example. As this mono-technology approach failed to address the problem of soil fertility an integrated nutrient management approach that suit local biophysical, social and economic realities should be promoted. Integrated nutrient management technologies can be nutrient saving, such as in controlling erosion and recycling of crop residues, manure and other biomass, or nutrient adding, such as in applying mineral fertilizers and importing feed stuffs for livestock (Smaling and Braun, 1996).

The traditional field operation in the Amhara highlands, which could be characterized by multiple tillage, cereal-dominated cropping and very few perennial components in the system, is very erosive for soils and nutrients. Continual farming in the highlands without considering conservation measures caused severe land degradation in the highlands. A FAO study in Zimbabwe showed that each hectare of well-managed maize growing land lost 10 tones of soil per hectare. Depleted soils commonly reduce payoffs to agricultural investments for various reasons. Degraded soils rarely respond to external inputs, such as mineral fertilizers, and hence reduce the efficiency and return of fertilizer use. Degraded soils have also very poor water-holding capacity partly because of low soil organic matter content that in turn reduce the
fertilizer use efficiency. Results from the dry regions of Niger, Sadore, showed that application of fertilizer increased the millet yield by 71% and also improved the water use efficiency by 70% (Bationo et al., 1993). Hence improved soil fertility enhances the water use efficiency of crops in drought prone areas. Low soil organic matter accompanied by low soil water content may also reduce the bio-chemical activity of the soil that may affect the above and below ground biodiversity of the system. Degraded soils have also low vegetative cover that may accelerate further soil loss and runoff. In Andit tid, the amount of soil loss due to water erosion was 230 t/ha/year under hacked plots. However, it was possible to reduce the soil loss to 30 t/ha or less under crop covers or fallow grass lands (SCRP, 1996).

The effect of soil fertility decline goes beyond nutrient and water losses. There are convincing results showing that the incidence of some pests and disease is strongly associated with decline in soil fertility. Results from the Amhara and Tigrai region showed that the effect of the notorious parasitic weed, striga, on maize and sorghum was severe in nutrient depleted soil (Esilaba et al, 2000). It was possible to decrease the population and the incidence of striga significantly by improving the fertility status of the soil through application of organic fertilizers. Similarly the incidence of root rots in beans, stem maggots in beans, take all in barely and wheat is associated with decline in soil fertility (Marschner, 1995). The positive effect of application of organic and inorganic fertilizer on the resistance of the host crop is mainly through improving the vigorosity of the plant at the early phonological stages.

Amede et al. (2001) outlined the need for a combination of measures to reverse the trend of soil fertility decline in the African highlands as presented in the following section.

**Participatory soil and water conservation measures**

Firstly, it is fundamental to minimize soil and nutrient loss through application of system compatible soil conservation measures. Research conducted in Andit tid and Gununo showed that increasing the vegetation cover of the soil could decreases soil loss and runoff significantly (SCRP, 1996). When a cropland covered by crops or grasslands is compared to a frequently hacked farmland, run-off was reduced by about 90 and 100% and soil loss by 68% respectively. Hence soil nutrient loss and runoff could be minimized through increasing the frequency of crop cover, especially by those crops with mulching habits and higher leaf area index to minimize the rainfall effects. Results from SCRP showed that perennial crops like enset and fruit trees or annuals with mulching and runner habits, like sweet potato, could reduce erosion effects significantly. Recent simulation studies in Northern Ethiopia showed that crop lands allocated for cereal crops like teff were found to be very prone to erosion and proposed that growing small seeded cereals, like teff, in sloppy farmlands should be discouraged.

Following the 1984/85 drought, there was a huge campaign in this part of the country on constructing terraces in sloppy lands for soil and water
conservation purposes, using the food for work scheme. However, the approach was top down and did not participate the local community during planning and implementation stages. The consequence was that farmers failed to maintain the terraces and in some case farmers have destroyed the terraces for various reasons. When farmers were asked to list the reasons for rejecting soil and water conservation technologies they listed five major driving forces (Amede, in press) namely, high labour cost, decrease in farm size, its inconvenience during farm operations especially for free movement of oxen plough, and multiplication of rats in the stone bunds. Moreover, investing in soil conservation technologies by small farmers very often fail owing to economic factors, land tenure problems, absence of techniques, or inappropriate extension system (Kebede Tato and Hurni, 1992). By considering those farmers criteria and by adopting participatory planning and implementation approaches farmers have adopted and disseminated soil conservation technologies in one the African Highlands Initiative benchmark sites, Areka (Amede et al, 2001). The major driving force for the adoption of the technology was its integration with high value crops (e.g. bananas, hops) and fast growing drought resistant feeds (e.g. elephant grass, pigeon pea) grown on the soil bunds. However, the sustainable integration soil and water conservation technologies depend heavily on the effectiveness of by-laws to limit free grazing and movement of animals during the dry spells. Hence there may be a need to reconsider the local policy so as to facilitate the integration of natural resource management technologies to local communities.

Integrated nutrient management

Building the organic matter of the soil and the nutrient stock in short period of time requires a systems approach. These include the combination of judicious use of mineral fertilizers, improved integration of crops and livestock, improved organic residue management through composting and application of farmyard manure, deliberate crop rotations, short term fallowing, cereal-legume intercropping and integration of green manures. Because of the inconsistent use of mineral fertilizers and the very limited returns of crop residues to the soil, most of the internal N cycling in small holder systems results from mineralization of soil organic N. Such process may contribute most of the N for the annual crops until the labile soil organic fraction (N-capital) are depleted (Sanchez et al., 1997).

Apart from the occasional application of small amounts of mineral fertilizers, all the other organic resources form the principal means of increasing soil nutrient stocks and hence soil fertility restorers in small-scale farms. If these approaches are used in combination and appropriately, they could reverse the trend and consequently increase crop yields and, thereby alleviate food insecurity. However, the continued low yields are an indication of insufficient inputs and/or inappropriate use of these technologies. The majority of small-scale farmers are still aggravating the soil/plant nutrient deficit through improper land management and over-exploitation of the nutrient pool. However, there is still an opportunity to replenish the soil
nutrient pool using integrated approaches depending on the degree of soil degradation, the production system and the type of nutrient in deficit.

One potential source of organic fertilizer is farmyard manure. There is a large number of livestock in the Amhara region that could produce a considerable amount of manure to be used for soil fertility replenishment. However, there is a strong competition for manure use between soil fertility and its use as a cooking fuel. Recent survey in the upper central highlands of Ethiopia showed that more than 80% of the manure is used as a source of fuel. Only farmers with access to fuel wood could apply manure for soil fertility replenishment. Experiences from Zimbabwe showed that most manures had very low nutrient content, N fertilizer equivalency values of less than 30%, sometimes with high initial quality that did not explain the quality of the manure at times of use (Murwira et al., 2002). This could be explained by the fact that most manures were not composed of pure dung but rather a mixture of dung and crop residues from the stall. Besides the quality the quantity of manure produced on-farm is limited. Sandford (1989) indicated that to produce sufficient manure for sustainable production of 1-3 tonnes/ha of maize it requires 10-40 ha of dry season grazing land and 3 to 10 of wet season Range land, which is beyond the accessibility of Ethiopian farmers due to land shortage. Moreover, the potential of manure to sustain soil fertility status and productivity of crops is affected by number and composition of animals, size and quality of the feed resources and manure management. Wet season manure has a higher nutrient content than dry season manure, and pit manure has a better quality than pilled manure. Similarly, Powell (1986) indicated that dry season manure had N-content of 6 g/kg compared with 18.9 g/kg for early rainy season manure when the feed quality is high.

Another potential organic source is crop residue. Returning crop residue to the soil, especially of legume origin, could replenish soil nutrients like nitrogen. However, there is strong tradeoff for use of crop residue between soil fertility, animal feed and cooking fuel. In the upper Ethiopian highlands crop residues are used as a major source for dry season feed and supplementary for wet season feed. Hence little is remaining as a crop aftermath to the soil. Although legumes are known to add nitrogen and improve soil fertility, the frequency of legumes in the crop sequence in the upper highlands is less than 10%, which implies that the probability of growing legume on the same land is once in ten years. The most reliable option to replenish soil fertility is, therefore, promoting integration of multipurpose legumes into the farming systems. Those legumes, especially those referred as legume cover crops, could produce up to 10 ton/ha dry matter within four months, and are also fixing up to 120 kg N per season (Giller, 2002). Those high quality legumes adapted to the Ethiopian highlands include tephrosia, mucuna, crotalaria, canavalia, and vetch (Amede and Kirkby, in press). However, despite a significant after effect of LCCs on the preceeding maize yield (up to 500% yield gain over the local management) farmers were reluctant to adopt the legume technology because of trade-off effects for food, feed and soil fertility purposes (Amede, unpublished data, 2002). In an attempt to understand factors affecting integration of soil
improving legumes in to the farming systems of southern Ethiopia, Amede and Kirkby (in press) identified the most important socio-economic criteria of farmers namely, land productivity, farm size, land ownership, access to market and need for livestock feed. By considering the decision-making criteria of farmers on which legumes to integrate into their temporal & spatial niches of the system, it was possible to integrate the technology to about 10% of the partner farmers in southern Ethiopia.

Although most farmers are convinced of using farm-based organic fertilisers, they are challenged by questions like which organic residue is good for soil fertility, on how to identify the quality of organic resource, how much to apply, when to apply, and what should be the ratio of organics to mineral fertilizers. This calls for development of decision support guides to support farmers’ decision on resource allocation and management. Scientists from Tropical Soils Biology and Fertility Institute of CIAT developed decision guide to identify the quality of organic fertilisers based on the polyphenol, lignin and nutrient content as potential indicators (Palm et al., 1997). As those parameters demand laboratory facilities and intensive knowledge, Giller (2000) simplified the guide by translating it to local knowledge as highly astrigent test (high polyphenol content), fibrous leaves and stems (high lignin content) and green leaf colour (high N content) to make the guides usable to farmers.

There is an increasing trend of mineral fertilizer use in the Ethiopian highlands over the past decades, as fertilizer imports into the country have increased from 47000 tonnes N and P in 1993 to 137000 tones in 1996 (Quinones et al., 1997) as a result of a strong campaign of Sasakawa-Global 2000 in collaboration with the Bureau of Agriculture. However, there is a declining trend in fertilizer use in 2001/2002 due to increasing cost of fertilizers, lack of credit opportunities to resource poor farmers and low income return due to market problems.

Organic resources may provide multiple benefits through improving the structure of the soil, soil water holding capacity, biological activity of the soil and extended nutrient release, but it could be unwise to expect the organics to fulfil the plant demand for all basic nutrients. Most organic fertilizers contain very small quantities of some nutrients (e.g. P and Zn) to cover the full demand of the crop, and hence mineral fertiliser should supplement it. Combined application of organic fertilizers with small amount of mineral fertilizers was found to be promising route to improve the efficiency of mineral fertilizers in small holder farms. For instance, organic resources enhanced the availability of P by a variety of mechanisms, including blocking of P-sorption sites and prevention of P fixation by stimulation of the microbial P uptake. Long term trials conducted in Kenya on organic and mineral fertiliser interaction also showed that maize grain yield was consistently higher for 20 years in plots fertilised with mineral NP combined with farmyard manure than plots with sole mineral NP or farmyard manure (S.M. Nandwa, Kenya Agricultural Research Institute, unpublished data, 1997).
Sustainable rural development and natural resource management in the region demands an investment in and improvement of the natural capital, human capital and social capital. As the natural capital in the region had multiple problems that needs multiple solutions, there is a strong need for holistic approach to deliver options for clients of various socio-economic category.

Given the complexity of the problem of land degradation, and its link to social, economical and policy dimensions, it requires a comprehensive approach that combines local and scientific knowledge through community participation, capacity building of the local actors through farmers participatory research and enhanced farmer innovation. This approach requires the full involvement of stakeholder at different levels to facilitate and integrate social, biophysical and policy components towards an improved natural resource management and sustainable livelihoods (Grourd, 2001). Watershed management as a unit of planning and change imposes the need for increased attention to issues of resource conservation and collective action by the community. The issues of land degradation may include afforestation of hillsides, water rehabilitation and/or harvesting and soil stabilization, soil fertility amendment through organic and mineral fertilizers and increasing vegetation cover by systematic use of the existing land and water resources. This could be achieved by working closely with communities and policy implementers in identifying and implementing possible solutions to address land degradation and other common landscape problems, like grazing land improvement, gully stabilization and by monitoring and documenting the processes for wider dissemination and coverage.

Some of the watershed conservation related solutions should be tried and implemented on specific test locations using farmers’ own contribution and the INRM team’s technical supervision. However, a wider application of these solutions to larger areas may require attracting additional funding investments from the district, donors or other NGOs in the area. The local village communities may also effect changes in the norms and rules governing the use of natural resources in their vicinity. Traditional rules and local by-laws (e.g. written and unwritten and called “afarsata” or awatcheyyache) regarding the use and sharing of resources exist in most villages and these need to be identified and studied with a view to effect reform or renew their emphasis in the community. Integration of Agroforestry technologies in the farming systems of the Ethiopian highlands failed because of absence of national and/or local policies /by-laws that prohibit free grazing and movement of animals in the dry season. Experiences from the 1980s campaign of ‘Green Campaign’ in Ethiopia also showed that it is almost impossible to address the issue of land degradation without the full involvement and commitment of the local community. The local by-laws in resource arrangement and use should be facilitated and supported, as the rules and regulations at the local level could be implemented effectively through elders and respected members of the community with tolerance and respect. There may be a church and/or witchcraft dimensions to these, and there may be
changes over time that might help to understand why people are doing what they are doing. In addition, the influence of national and regional policies on local resource management should be understood. These will form an important subject of community wide discussion and deliberation (Stroud, 2001).

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Opportunities and challenges in reversing land degradation


Policies for Sustainable Development in the Highlands of Amhara Region: Overview of Research Findings

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ABSTRACT

Reducing resource degradation, increasing agricultural productivity, and reducing poverty and food insecurity are major challenges in Ethiopia, where nearly 90% of people live in rural areas and depend on agriculture for their livelihoods. Since 1991, the federal and regional governments have focused on promoting conservation of natural resources and improving of agricultural productivity and welfare through a broad program of investment in infrastructure (roads, irrigation, etc.), agricultural extension and credit, education, and other services. Empirical evidence is needed of the impacts of these policies and programs. Using data from the highlands of Amhara region, this paper addresses the information gap. We find that the agricultural extension program and production of high-value crops have had substantial positive impacts on crop production and household incomes, and have contributed to improved land management and adoption of external inputs. Thus, continuing and expanding the extension approach appears well justified, and promoting production of high-value crops can help households escape the poverty trap. However, a key factor underlying these improvements is road development (i.e., better access to all-weather roads and markets). Population pressure was associated with lower crop production and incomes, as well as worsening of most resource and welfare conditions. Thus, family planning, education and other means of reducing population growth, as well as developing the non-farm sector, will be crucial in relieving the pressure on the land and raising incomes.

Keywords: Land degradation and management, agricultural productivity

INTRODUCTION

Reducing resource degradation, increasing agricultural productivity, reducing poverty, and achieving food security are major challenges in Ethiopia, where nearly 90% of people live in rural areas. The situation is more severe in the highlands,¹ which constitute about 45% of the total area, but is home to 80% of the human population and 75-80% of the cattle and sheep (Befekadu Degefe and Berhanu Nega, 2000). The farming situation in the highlands of Ethiopia is summarised as: over-populated and over-utilised; small farms of 1-

¹ The highlands are areas 1500 meters above sea level, with mean annual temperatures ranging form 7 to 29°C.
5 hectares (ha) and 4-5 cattle; cultivation of steep slopes and up to 300 tonnes/ha of soil loss annually; endemic food and feed shortages; low crop productivity (cereal yields average less than one ton ha\(^{-1}\) in many places); increasing competition for crop and grazing land; favourable temperate climate; cattle and oxen are sources of power, milk, meat and manure; draft power determines crop production; and low cattle productivity. For example, between 1995 and 2000, Ethiopia ranked 7th in the world in terms of cattle population, averaging 33 million, but ranked 184th in terms of productivity, averaging 109 kilogram (kg) per animal for meat (bases on FAO data: FAO (2000)). An estimated 31% of the population live on less than US$1 per day while 76% live on less than US$2 per day (World Bank, 2001), and 64% of the children are malnourished and micronutrient deficient due to insufficient meat and milk consumption causing blindness and limiting mental development (Befekadu Degefe and Berhanu Nega, 2000), severely compromising Ethiopia’s next generation.

The situation is no different in the highlands of Amhara region, which accounts for 13% of the total area and 25 and 35% of the human and livestock population, respectively. Average farmland holding is 1.7 ha, ranging from 0.7 ha in North and South Wello to 2.6 ha in West Gojjam (Larsen et al., 1996). Cultivation and grazing on steep hillsides is severe; annual soil loss of 200 tons ha\(^{-1}\) and more have been recorded (Kappel, 1996) and the region accounts for nearly 60% of the national soil loss rate (CEDEP, 1999). Cereal yields average 900 kg ha\(^{-1}\), with the leading cereal teff (30% of cereal area) yielding 600 kg ha\(^{-1}\) or less (BOPED, 1999a). Poverty, food insecurity and malnutrition are very severe, especially in the drought-prone lower agricultural potential parts of the region. Many households in the region (about 58%) face food shortages for 5 to 16 weeks of the year, while several of them (about 11%) do not have enough food for more than one-half of the year (UNECA, 1996). Although the region has a high population of livestock, average milk and meat consumption per capita are a low 9.1 kg and 3.2 kg, respectively, compared to national averages of 14 kg and 10 kg, respectively (BOA, 1999).

In recognition of these problems the federal and regional government has undertaken a massive program of investment and land conservation since 1991. The regional strategy of Conservation-based Agricultural Development-Led Industrialization has focused on promoting conservation of natural resources through community and individual participation and improvement of agricultural productivity and welfare through a broad program of investment in infrastructure (roads, irrigation, etc.), agricultural extension and credit, education, and other services. Empirical evidence is needed of the impacts of these policies and programs, and identification of specific problem areas to be addressed. Addressing this information need is the primary objective of this paper.
MATERIALS AND METHODS

This study presents an overview of the key findings (synthesis of several research papers) of the research project on Policies for Sustainable Land Management in the Highlands of Amhara Region that has been implemented jointly by the International Food Policy Research Institute (IFPRI), the International Livestock Research Institute (ILRI), and the Amhara National Regional State Bureau of Agriculture (ANRSBOA) since 1999. In this section we first present the goal, purpose and specific objectives of the research project. Then, we present the conceptual framework guiding the research, overview of activities, and study area and data collection.

Goal, purpose and objectives

The long-term goal of the research project is to contribute to improved livelihoods and land management in the East African highlands, in order to increase agricultural productivity, reduce poverty, and ensure sustainable use of natural resources, while the immediate purpose is to help policy makers identify and assess policy, institutional and technological strategies to improve land management in the Ethiopian highlands. The specific objectives are to:

- Identify the main factors affecting land management and its linkages to agricultural productivity, poverty, and sustainability;
- Identify the major current and potential pathways of development, their causes and implications;
- Identify and assess strategies to promote more productive, sustainable, and poverty-reducing pathways of development and improved land management;
- Strengthen the capacity of collaborators in the country to develop and implement such strategies, based upon policy research;
- Increase awareness of the underlying causes of land degradation and the promising strategies of pathways of development.

Conceptual framework

There are many factors potentially affecting farmers’ decisions about livelihood strategies and land management, and a complex set of linkages between government policies and programs and these decisions. The conceptual framework guiding the research (Figure 1) has been developed to address these challenges.

Land management is determined by private decisions that are made at the farm household level, as well as by collective decisions made at the group, village or higher levels. These household and collective decisions determine current agricultural productivity and affect the condition of land resources (thus influencing future agricultural productivity), which in turn affect the level of farm income and rural poverty.
Figure 1. Factors affecting livelihood strategies, land management, and their implications
It is important to emphasize that it is such outcomes (productivity, resource conditions, and household incomes), and not adoption of specific land management technologies \textit{per se}, that are likely to be of most concern to farm households and to policy makers. It is, thus, critical to consider the ultimate impacts of any policy or technology on these outcomes, and the extent to which there may be trade-offs or complementarities among them.

For example, a strict regulatory approach, e.g., prohibiting farmers from planting annual crops on steep lands, may be effective in reducing soil erosion, but may also have severe implications for agricultural production, food insecurity and poverty. On the other hand, there may be "win-win-win" strategies available that promote greater productivity and incomes as well as improved resource conditions. For example, promoting intensification of annual production on less steep lands and perennial production on steep lands may reduce land degradation, while increasing agricultural productivity and farm incomes.

Land management decisions are determined by many factors operating at different levels (plot, household, village, region, nation, and international). Many of these factors influence land management directly. Demographic and socio-economic factors (e.g. population density, access to markets, and the level of local prices) also influence land management. Some of these effects are direct, while others are indirect. For example, access to markets and local prices determine the profitability of alternative practices. On the other hand, population pressure leads to smaller farm sizes and often to more fragmented holdings, which may reduce farmers’ ability or incentive to fallow or undertake land-improving investments.

One important indirect way in which biophysical and socio-economic factors affect land management is by determining what livelihood strategies have comparative advantage in a particular location and for particular households. For example, in areas close to a major urban market and having high agricultural potential, farmers may be able to earn relatively high incomes from production of perishable cash crops (such as horticultural crops) or intensive dairy production. The land management problems, constraints and opportunities for improved land management in such a situation (e.g. declining soil fertility, potential for use of inorganic fertilizers or livestock manure, potential benefit of credit) are likely to be significantly different than in more remote areas where less intensive subsistence mixed crop-livestock production may predominate (e.g. opportunities for improved fallows, need for improved management of common grazing lands, appropriate technical assistance to improve both livestock and crops). The appropriate policy strategies for such situations are therefore also likely to differ.

The development of different livelihood strategies in a particular location may be influenced by many village level factors, such as agricultural potential, access to markets, population density, and presence of government programs and organizations. These factors largely determine the comparative advantage of a location by determining the costs and risks of producing different commodities, the costs and constraints to marketing, and the opportunities and returns to alternative activities, such as farming versus non-
farm employment. These factors may have generalized village level effects on livelihood strategies and land management, such as through their impact on village level prices of commodities or inputs, or they may affect farm household level factors, such as average farm size. Household level factors such as households’ endowments of “physical capital” (land, livestock), “human capital” (education, training, farming experience, household size and composition), “social capital” (participation in community organizations, leadership in community), “financial capital” (access to credit, savings), or “natural capital” (land quality, access to other resources) may also determine the livelihood strategy or land management practices chosen by particular households.

Government policies, programs and institutions may influence livelihood strategies and land management and their implications for productivity, sustainability, and household incomes at many levels. Macroeconomic, trade, and market liberalization policies will affect the relative prices of commodities and inputs in general throughout a nation. Agricultural research policies affect the types of technologies that are available and suitable to farmers in a particular agro-ecological region. Infrastructure development, agricultural extension, conservation technical assistance programs, land tenure policies and rural credit and savings programs affect awareness, opportunities, or constraints at the village or household level. Policies or programs may seek to promote particular livelihood strategies (e.g. food crop production), or may seek to address constraints arising within a given livelihood strategy (e.g. credit needs arising in cash crop production). Programs may attempt to address land management approaches directly, for example by promoting particular soil fertility management practices. Policies and programs may also be designed to affect development outcomes directly, through direct management of land by the government, or through nutrition or income enhancement programs.

Currently available information does not provide policy makers with much guidance as to which of these intervention points will be most effective in achieving better land management, improving agricultural productivity, and increasing incomes and food security. Much public action aimed at improving land management focuses on influencing household adoption of particular technologies. Yet this may be ineffective if the technologies are not suited to the livelihood strategies that have comparative advantage in a given location. It may be more effective in many cases to first focus on the larger development strategies for particular livelihood strategies, before focusing too much on particular land management technologies.

Activities

To achieve the goal and objectives of the research project, various activities have been undertaken including: characterization of the nature, extent, and causes of the land degradation problem in the highlands of the Amhara region, which led to the development of several hypotheses on "pathways of
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2 A pathway of development is a common pattern of change (or stagnation) in agriculture and livelihood strategies, associated with its causal and conditioning factors (Pender et al., 1999).

3 Weredas predominantly (more than 50% of total area) below 1500 m a.s.l. were excluded from the sample frame.

4 Irrigation projects were major ones (earth dams and river diversions) undertaken by the Commission for Sustainable Agriculture and Environmental Rehabilitation in Amhara Region (COSAERAR).
land, oxen, social network, savings, etc.), consumption and expenditure, plot characteristics (mode of acquisition, size, slope, quality, etc.), land investments and management practices, input use, and agricultural production in 1991 and 1999. Soil samples were also taken to test for level of nitrogen, phosphorus, potassium, organic matter and acidity and texture. The data are supplemented by secondary information on population from the 1994 population census, geo-referenced maps of the boundaries of each sample PA and geographic attributes, including altitude and climate. Figures 2 and 3 in the appendix show the stratification of the highlands of Amhara region and the geographic distribution of the selected PA's.

RESULTS AND DISCUSSION

The results presented here are a synthesis of many research papers (Benin and Pender, 2002; Benin, 2002; Pender, 2002; Benin et al., 2002; Benin and Pender, 2001; Pender, 2001; Lakew Desta et al., 2000) that have used any of the above data. First, we present descriptive statistics and general trends between 1991 and 1999 in key factors (population pressure, markets and infrastructure, and government policies and programs) and community and household productivity, resource and welfare outcomes. Then, we present key results of econometric analyses of the impacts of the above factors and household endowments on land management, productivity, incomes, and resource conditions. To focus the paper on the key findings, we will not discuss any methodological issues, including specific conceptual models and hypotheses, econometric models and estimations, and detailed description of the variables. However, it is good to know that all the statistical results have been corrected for stratification, weighting and clustering of the sample. Those interested in these details may refer to the above papers or contact the specific authors.

Trends since 1991

Population pressure

Population growth has been rapid in the region. The number of households per km\(^2\) increased from 35 in 1991 to 45 in 1999. This represents an average growth rate of 3.6% per annum. Population growth is more rapid in the high agricultural potential areas, due to immigration from the low agricultural potential areas. Using the 1994 population census data (BOPED, 1999b) we find that population density was 130 persons per km\(^2\) in the high potential areas, compared to 90 in the low potential areas.

Access to infrastructure and services

There has been limited improvement in access to infrastructure and some services between 1991 and 1999, and most communities are still far from
towns and roads, especially in the low potential areas. For example, average walking time to the nearest all-weather road or bus service for communities in low potential areas was more than 9 hours in 1999, while it was a little over 2 hours for communities in high potential areas. The average distance to the wereda market town is 27 km for communities in high potential areas, while it is about 53 km for those in low potential areas.

There have been substantial improvements in adult literacy and school attendance. The proportion of adult literates increased from 39% in 1991 to 53% in 1999, while the percent of children in school more than doubled, from 24% to 51%. Perceived availability of some services (e.g. health and education) has also improved, although the quality of these services and availability of others (e.g. transportation services and energy sources,) have declined.

The proportion of total land area that is irrigated has doubled, from a very low 0.1% in 1991 to 0.2% in 1999. The area irrigated is still very small compared to the potential of irrigation in the region, which is estimated at 195,440 ha (1.2% of the total land area or 4.5% of the total cultivated area in 1998).5

Market development

Significant development of input and output markets is occurring. On average, walking time to the nearest grain mill declined from about 3 hours in 1991 to 1.5 hours in 1999, although communities in high potential areas have better access (1 hour in 1999) compared to those in low potential areas (2.5 hours).

Use of purchased inputs has also increased. On average, the proportion of households using fertiliser more than doubled, from 25% in 1991 to 52% in 1999, while those using improved seed, pesticides, herbicides, purchased fodder and animal vaccines increased from 2 to 34%, 16 to 19%, 4 to 14%, 19 to 24%, and 33 to 55%, respectively. The most dramatic increases occurred with respect to use of fertiliser and improved seed in the low potential areas, where the proportion of households using these inputs in 1991 were almost zero but increased to 38% for fertiliser and 28% for improved seed. Use of purchased inputs (i.e. proportion of households using) was higher in communities in high potential areas, except for fodder, which was higher in low potential areas.

Agricultural extension and credit

The Bureau of Agriculture (BOA) is active in promoting the use of external inputs. The proportion of households participating in the BOA extension and credit program increased from 6% in 1991 to 25% in 1999. Participation in this program was higher in high potential areas (33% in 1999) than in low

5 Estimation of the potential irrigated area is based on estimates for large-scale irrigation potential (195,440 ha: BOA, 1997) and total area (17.5 million ha: CEDEP, 1999) and total cropped area in the main season in 1998 (4.3 million ha: BOPED, 1999a,b).
potential areas (15%). However, credit coverage of the Amhara Credit and Savings Institution (ACSI), which started operation in 1995, was equal in high and low potential areas in 1999 (9% of households).

There are other non-governmental organisations (NGOs) that are active in providing credit and extension. Their coverage increased from 1% of households in 1991 to 19% in 1999, though they were also more active in high potential areas.

**Land policies and tenure**

Land redistribution has been ongoing since 1974, when land transactions (sale, renting, sharecropping) were prohibited, and every community has had at least one since then. About 50% of the communities had a redistribution since 1991, mainly in the recent major land redistribution in 1997 and 1998. The average number of redistributions per community since 1991 is three. Land redistribution was much more common in high potential areas (occurring in about 73% of the communities) compared to low potential areas (15%).

On average, land tenure security has improved substantially, both where redistribution occurred and where it did not. The main reasons for the perceived improvement are land registration and the fact that redistribution has reduced landlessness. Among the few communities feeling reduced tenure security, the main reasons for the decline are fear of future redistribution, shortage of land, or poorly defined plot boundaries.

The regional government in 1991 lifted the ban on land leasing, although the ban on sale of land still remains. Since then, there has been substantial participation in temporary land leasing among farmers. Equ sharecropping (one-half of output to landowner) and fixed-fee rentals have increased and are the dominant forms land rentals, while siso sharecropping (one-third of output to landowner) and land borrowing have declined. About 11% of the plots operated in 1999 were rented, with slightly more rentals in high potential areas. The average contract length has not changed and is a little over one year. Sharing of fertilizer by the landowner under sharecropping arrangements is common and has increased, while sharing of labour and seed has declined.

**Community natural resource management**

The BOA and wereda and kebele administrations have been instrumental in promoting the establishment of community woodlots, restricted grazing areas, and area enclosures. Restricted grazing areas, natural forests and woodlots are more common in high potential areas, while area enclosures are only found in low potential areas. There are restrictions in the use of these resources, with area enclosures being the most restricted where grazing and cutting of trees and grasses are not allowed. Grazing and collection of fuelwood may be allowed in woodlots, but cutting of trees is subject to approval in many cases. Grazing areas may be restricted in the time of grazing and/or type of animals (e.g., oxen only during ploughing season).
Land investments and management practices

The BOA and NGOs are also active in promoting soil and water conservation (SWC) measures, some through mass mobilization and food-for-work programs, but mostly through encouragement of private initiatives. Up to 65% of the communities are involved with undertaking various SWC measures (mostly stone terraces) promoted by BOA. The proportion of households adopting particular measures or practices on their (private) land is also high.

The most common investments on private land are drainage and diversion ditches (undertaken by 78% of households), followed by grass strips (59%), live barriers (44%), stone terraces (39%), gully checks (27%), soil bunds (16%), and tree planting (10%). Stone terraces and gully checks are more common in low potential areas, while more vegetative measures such as grass strips, live fences and planting trees are more common in high potential areas.

With respect to management/cultural practices, burning (to prepare plot or soil burning), fallowing (traditional and improved) and intercropping have become less common. Changes in other practices are relatively small: contour ploughing, mulching, manuring, and composting increased, while ploughing in crop residues and reduced tillage declined.

Livelihood strategies and wealth

Cereal-livestock production activities continue to dominate livelihoods, although non-farm activities are becoming increasingly important, especially in low potential areas. There has been little change in cropland use; cereals take up 70% of the total cropped area. Among the cereals, teff continued to dominate (30% of cereal area in 1999; no change between 1991 and 1999), followed by barley and wheat (20% each; wheat increased but barley declined), and maize (12%; slight increase). Sorghum, finger millet, millet, and oats make up the remaining (18%; slight declines). The average land holding in 1999 was 1.7 ha per household, with slightly larger holdings in high potential areas.

Ownership of all types of livestock declined between 1991 and 1999. For example, the proportion of households owning oxen declined from 73% in 1991 to 59% in 1999, while ownership of cows declined from 46 to 30%. In terms of the percentage decrease, young cattle (bulls, heifers and calves) and small ruminants (sheep and goats) declined the most, especially in low potential areas. The main reason for the decline was a combination of loss to drought and diseases and sale of animals during crop failure. In 1999, the average number of oxen owned was 1.6 per household, while the number of tropical livestock units was 3.8.

In 1999, the average household size was 5.7 and 44% of household members were males. On average, the household head was 42 years old, had attended 2.5 years of formal education, and 95% were male. Involvement of household members in organisations was more common in low potential areas.
(including women's youth and savings and credit associations and service cooperatives), with the exception of input supply cooperatives, in which involvement was greater in high potential areas.

Productivity and incomes

There have been substantial changes in crop yields, land resource conditions, and several indicators of welfare between 1991 and 1999. Rainfed cereal yields are much higher and have increased substantially in high potential areas. Between 1991 and 1999 in high potential areas, average maize yields increased dramatically from 1500 to almost 2250 kg/ha, while wheat yields increased from a little over 1000 to about 1250 kg/ha. Within the same period, teff yields stagnated at 900 kg/ha, while barley yields declined from 1150 to 900 kg/ha. In low potential areas, on the other hand, maize yields increased slightly, while teff, barley and wheat yields declined. In 1999, maize yields averaged 750 kg/ha, while teff, barley and wheat yields were less than 500 kg/ha in low potential areas.

Incomes were estimated for 1999 only. Average total household income was about Birr 1700 (Birr 1900 and 1450 in high and low potential areas, respectively), and per capita income was Birr 300. Net income from crop production contributed the most to total income, followed by income from non-farm activities, other farm products, and livestock (which was negative for all types of livestock except poultry and beekeeping).

Resource and welfare outcomes

Land quality indicators show a perceived worsening situation. The number of gullies and severity of erosion of cultivated and grazing lands increased between 1991 and 1999, while the proportion of land perceived to have good soil declined. In addition, indicators of cropland quality (soil moisture, soil fertility, soil depth) also show a worsening situation. Perceived changes in other resource conditions are more mixed. For example, availability and quality of woodland and water have increased, while those of grazing lands have declined. In general, the situation is worse in low potential areas.

Several indicators of perceived changes in welfare (e.g. average wealth, availability of food, child nutrition, and ability to cope with drought) also show a worsening situation, especially in low potential areas. On the other hand, housing quality, as indicated by houses with a metal roof, has improved, especially in high potential areas.

Econometric findings and implications

Impacts of population pressure

Population pressure had mixed impacts on land management practices. Increased number of households per km² was associated with lower likelihood of fallowing, manuring and contour ploughing, but it was associated with
greater likelihood of ploughing in crop residues, using reduced tillage and crop rotation, and undertaking gully checks.

Increased population pressure was also associated with lower income (crop, total and per capita) per household. For example, 10 more persons per km² were associated with Birr 50 less crop income per household. Increased population pressure was also associated with reduced livestock ownership (especially the proportion of households owning more than two oxen and young cattle (heifers and bulls)), although it was associated with adoption of improved livestock breeds (measured by proportion of communities with some households adopting).

Increased population pressure was also associated with perceived worsening of many resource and welfare conditions (quality of cropland, soil fertility, availability and quality of grazing lands, average wealth, availability of food, and ability to cope with drought). Together, these results show that population pressure, contrary to the predictions of population-induced intensification hypothesized by Boserup (1965) and her followers (e.g., Tiffen et al., 1994), may be causing more degradation, reducing agricultural productivity and increasing the vulnerability of the people. However, further research using more objective indicators of land degradation (such as soil nutrient stocks and flows based on a panel of the soil samples collected by this project) may yield more definite conclusions between population pressure and land degradation.

Impacts of access to roads, transportation and markets

Better market access (i.e. being closer to an all weather road or market) promotes intensification of crop production, as it was associated with reduced fallowing, greater investments in live fences, ploughing in crop residues, composting, and use of manure and fertiliser. In addition, use of animal health services was also greater closer to the woreda town.

With respect to household livelihood strategies, production of cereals only, cereals-small ruminants, poultry and beekeeping were more important further away from towns. On the other hand, perennials (e.g., trees) and perishable annual crops and other non-farm activities were more important closer to an all-weather road. Market access had insignificant impact on crop income (controlling for other factors), although returns to livestock per household were greater closer to towns and all-weather roads, especially in low potential areas. Non-farm income per household was also greater with better access to towns (being closer to bus services). In general, total and per capita household incomes were greater closer to towns. On the average, being one hour walking distance closer to a town led to Birr 300 more total income.

Better market access also had substantial positive impacts on perceived changes in resource and welfare conditions. For example, being closer to an all-weather road or market/town was associated with better cropland quality, soil fertility and quality of grazing lands and increased average wealth, availability of food and ability to cope with drought.
Impacts of irrigation

Irrigation was associated with increased intensification through greater use of fertility-improving technologies (fertiliser and manure), other purchased inputs (improved seed and pesticides), labour and draught power. Although the increased use of inputs led to increased output (as we shall see later), irrigation had insignificant impact on crop productivity (i.e., output per unit of inputs). Thus, the main impacts of irrigation on crop production are by promoting increased intensity of farming, rather than increased productivity of farming practices. The latter may be due to irrigation management problems, which requires further study.

Increased irrigation also was associated with a reduction in ownership of some types of livestock (one ox only, goats and donkeys), but with increased adoption of improved breeds and use of animal health services and private pastures. These results suggest that with increased crop production (in addition to production of high-value crops) from irrigated plots and subsequent higher incomes, farmers can afford to replace part of their livestock with a smaller number of more productive breeds (with associated health services) and also release part of their cropland for private pasture development.

Together, these results suggest that irrigation can indirectly reduce the pressure on already degraded land resources. However, controlling for input use, management practices and other factors, irrigation had insignificant impacts on perceived land quality indicators examined (including soil fertility, cropland quality, and availability and quality of grazing lands).

Impacts of extension

Similar to irrigation, extension was associated with increased intensification of crop production. We find that contact with an extension agent was associated with greater investments in stone terraces and fences, ploughing in of crop residues, use of manure, fertilizer, improved seed, pesticide, and draught power.

Extension also has direct positive impacts on crop production and incomes (crop, total and per capita). The value of crop production (Birr/ha) was higher by 25% for households in contact with extension agent; and crop and total incomes were substantially larger by about Birr 700 and 630, respectively. Interestingly, the impact of extension was larger in low potential areas. Extension had no significant impact on livestock income, while the impact on non-farm income was negative (about Birr 170 less for households in contact with an extension agent), probably due to the crop bias of the extension system.

Thus, the message is clear that extension is having substantial positive impacts on crop production in the region, directly and indirectly. However, there are other important aspects of the entire extension system that this research has not looked at; such as whether or not the system is cost effective.
or how to make it more effective. An in-depth impact assessment is needed to answer these questions.

Impacts of credit

Credit (obtained from BOA, ACSI, NGO’s or local sources (e.g., equb)) was also associated with increased intensification of crop production through reduced fallow and more use of fertilizer, improved seed, manure, labour and draught power.

Unlike extension, credit use had no direct significant impacts on crop productivity. Although credit obtained from NGO’s was associated with increased ownership of oxen, credit obtained from ACSI was associated with reduced livestock ownership (proportion of households owning greater than two oxen, heifers and bulls) and livestock income (about Birr 220 less per household). This is probably due to sale of extra oxen and young stock to repay loans (for fertiliser and improved seed) in times of crop failure immediately following harvest. This issue needs to be researched further and, possibly, alternative approaches to credit delivery and collection considered. However, the finding that credit obtained from NGO’s was associated with increased ownership of oxen, suggests that the government credit system can adopt the management and delivery strategies of these NGO’s and have similar but farther reaching positive impacts on livestock productivity, since the government programme is implemented throughout the region.

Credit also had positive impacts on perceived changes (between 1991 and 1999) in resource and welfare conditions (including increased cropland quality, soil fertility and average wealth).

Impacts of land policy and tenure

Land redistribution had mixed impacts on land management practices and input use. Plots obtained through land redistribution since 1991 were associated with more use of fertilizer and reduced tillage, but lower use of fallow, manure, labour, and ploughing in of crop residues. These results suggest that younger households, who are the primary beneficiaries of land redistributions, may be more willing and able to use fertilizer, reducing the need for ploughing in crop residues or applying manure. The impact on fertilizer is consistent with the finding of Holden and Hailu Yohannes (2001) that land redistribution had a positive impact on use of purchased inputs in the Andit Tid area in the Amhara region. However, younger households may also face labour and oxen constraints (forcing them to plough their plots fewer number of times) and livestock constraints (reducing their manure supply).

Controlling for other factors, land redistribution had no consistent significant impact on crop production. Land redistribution was associated with increased ownership of livestock (proportion of households owning oxen, small ruminants and donkeys) and adoption of associated livestock technologies, although it contributed to reduced soil fertility and quality of grazing lands. It seems that access to one’s own land is a major driving force
for owning livestock (oxen for ploughing and donkeys for transportation of farm produce), although distributing traditional grazing areas (especially hillsides) for crop production is contributing to increased pressure on remaining grazing resources.

Land tenure (owner-cultivation vs. rental or sharecropping) had mixed impacts on use of land management practices and inputs. While owner-cultivated plots, compared to rented or sharecropped plots, were associated with greater investment in stone terraces and more use contour ploughing, crop rotation and manure, they were associated with lower use of fertiliser and improved seed. These results suggest that farmers choose technologies to fit their tenure status; i.e., management practices with long-term beneficial effects are preferred on more secure plots, while those with short-term benefits are preferred on less secure plots.

Controlling for management practices, inputs, and other factors there were no consistent significant differences in crop productivity between owner-cultivated and rented plots, suggesting efficiency of the land rental market in the region. This contrasts with findings from the Tigray region, where crop output per ha was lower on sharecropped plots than owner-cultivated plots (Pender et al., 2002). On the other hand, Holden et al. (2001) find that crop output per ha was higher on rented than owner-cultivated plots in the Andit Tid area. The reason for the inefficiency in Tigray may be due to restrictions on the length of leases not exceeding two years. As the Amhara regional government is in the process of developing its Land Use and Administration Policy (ANRSC, 2000), the message is to avoid such restrictions and allow the rental market to operate freely. In addition, the indication of ending future land redistribution is in the right direction (given that it is difficult to continue to use this to address landlessness because of the very small farm sizes), and will also help to strengthen the efficiency of the land rental market in the region.

Impacts of social capital

Social capital was measured by membership of a household member in different organizations, which had mixed impacts with respect to land management practices. Household membership in a service cooperative was associated with greater ploughing in of crop residues and use of fertilizer, but lower use of manure and contour ploughing.

Social capital had limited impacts on crop and livestock incomes, but substantial impacts on total and per capita household income, probably due to promotion by some organisations of more income diversification and increased income from non-farm sources. Households with a member of a women’s association earned more total income (about Birr 1340 more) in low potential areas, but earned less (about Birr 1000 less) in high potential areas. Furthermore, households with a member of savings and credit group earned higher per capita income (about Birr 300 more).
Impacts of livelihood strategies

Crop income was substantially less in low potential areas for households that did not rely on cereal production as the dominant activity, and livestock income was greater (or less negative) for farmers relying on poultry or beekeeping as important sources of income. Non-farm income was substantially greater for households relying on production of high value crops (perennials and perishables), off-farm employment, trading or other non-farm activities. In general, total and per capita incomes were highest for households producing high value crops.

Communities with more households relying on production of high value crops (perennials and perishables) as their secondary income source were associated with improved land quality and welfare conditions (including increased cropland quality, soil fertility, average wealth, availability of food, and ability to cope with drought).

Impacts of wealth (physical capital)

Households with larger cultivated area (owner-cultivated plus rented-in land) used less inputs (labour, draught power, seed and fertiliser) per hectare of land and were less likely to contour plough. In addition, controlling for inputs, land quality, and other factors, larger farms had lower value of crop output (Birr/ha). However, the amount of land "owned" (PA-allocated or inherited land) had no significant impact on crop income. These findings mean that although smaller farms are more efficient, the amount of land owned does not affect land productivity. The latter result suggests that the land rental market in the region is functioning well to equalize households' crop income (similar to the finding of Pender et al., (2002) in Tigray region). Households without PA-allocated land or having a smaller amount of land relative to other productive inputs are able to rent in land (about 11% of all plots in the sample were acquired through rental) to support their production activities. This lends support to the earlier finding of an efficient land rental market in the region, where the value of crop output on owner-cultivated vs. rented or sharecropped plots was not significantly different, strengthening the implication that further land redistribution is not necessary.

Households with more oxen or livestock in general are associated with more use of manure, fertiliser, improved seed and draught power per unit of land. Controlling for all other factors, one additional ox was associated with an increase in crop production by 393 Birr/ha. These results suggest that, unlike the land rental market, oxen lease arrangements are not well developed, and that households with more oxen (and livestock) are able to farm their lands more intensively and obtain substantially larger farm output. This result contrasts with findings from the Tigray region and the Andit Tid area, where oxen ownership had an insignificant impact on crop productivity and yields (Pender et al., 2002; Holden et al., 2001).

With respect to livestock income, land ownership had no significant impact. However, the average marginal return to livestock was negative (about
14% of the initial value of stock) and the loss was higher in low potential areas (about 24%). The losses on livestock were greatest for sheep, goats and poultry. The losses on livestock were largely due to drought in the preceding year and are not likely representative, though they indicate the risks associated with livestock production in drought-prone environments. With respect to non-farm incomes, larger land ownership was associated with less non-farm income, especially in high potential areas, while livestock ownership had no significant impacts.

Impacts of human capital and gender

Household structure and composition had mixed impacts on the nature of intensification of crop production and productivity. Households with older heads were associated with greater investments in fences and were more likely to use improved seed, although they were less likely to plough in crop residues and used less manure, fertilizer and labour per unit of land. Household heads with more education were less likely to plough in crop residues or use manure and contour plough, although they were more likely to use improved seeds. Larger households were more likely to plough in crop residues, but used less draught power and seed. However, controlling for inputs, management practices and other factors, age and education of household head and household size had no significant impact on crop production and income, although households with older heads and larger number of members were associated with more non-farm income in low potential areas, and larger households earned less per capita income (about 70 Birr/person less).

The main implication here is that labour markets seem to be functioning well in the region, allowing households with less labour to hire non-family farm labour to equalise crop output per ha and income. Although this contrasts finding of Pender et al. (2002) in Tigray, where labour use per ha was greater for larger households, it is consistent with another finding in the same study that household size had no impact on crop output per ha.

The gender composition of the household had mixed impacts on input use. Households with a larger proportion of females used more fertilizer and improved seed, although they used less manure and draught power. In addition, female-headed households used less draught power, probably for cultural reasons (i.e., a taboo against women ploughing), but they were more likely to use fertiliser and improved seed. However, controlling for input use, management practices and other factors, female-headed households earned much less crop income (about Birr 1700 less) and total income (especially in high potential areas, about Birr 2000 less) than male-headed households. Similar results were found in Tigray (Pender, et al. 2002). Therefore, poverty is a greater concern for female-headed households and they may be more vulnerable to shocks.

Household structure (age, education and sex of head, size, and gender composition) had no significant effect on livestock income, and the effects on resource and other welfare conditions have not been investigated.
Impacts of land management practices and purchased inputs

Returns to fertility-improving practices and use of purchased inputs were high. Plots on which fertiliser was used had higher crop output per ha (1167 Birr/ha more) than those on which fertiliser was not used. Crop output was higher by 575 and 290 Birr/ha on plots on which manure and improved seed were used, respectively.

CONCLUSIONS

The agricultural extension program has had a substantial positive impact on crop production and household incomes, especially in the low potential areas, and has contributed to improved land management and adoption of purchased inputs. Thus, continuing and expanding the extension approach in the region appears well justified. The lack of emphasis on livestock improvement in the extension system is an issue deserving of further consideration. Improving the credit system (delivery and collection) will enhance the impact of extension.

The production of high-value crops (perishable and annuals) can substantially increase incomes and help households escape the poverty trap. Production of high-value crops was also associated with better resource and welfare conditions. However, a key factor associated with production of these crops is better access to all-weather roads and markets. Thus, road development can contribute to reducing poverty and improving food security, by contributing to adoption of high-value crops.

Control of population growth should be of high priority to address problems of resource degradation and poverty. Population pressure was associated with lower crop production and total and per capita incomes, as well as worsening of most resource and welfare conditions. Although larger households earned comparable total incomes, they had lower per capita incomes, as larger households tend to have higher dependency ratios. Thus, family planning, education and other means of reducing population growth and dependency ratios could help reduce land degradation and increase crop production and per capita incomes.

Gender issues are important, given that female-headed households produced less crop output and earned much lower incomes than their male-headed counterparts. Efforts to address this disparity are needed.

The large negative returns to livestock in 1999 are also alarming. Although this may have been due to impacts of drought in the previous year, the ability of households to cope with weather shocks through livestock stocking and destocking is critical. Promotion of more diversified livestock into smaller livestock such as poultry and beekeeping may reduce the vulnerability of households to such shocks and increase their incomes, given that these enterprises performed better in 1999.

The insignificant effects of land ownership on production and incomes may be partly due to the recent land redistribution, although the land rental market also played an important part in equalising farmers' opportunities.
Thus, continuing to use land redistribution as a tool to address the increasing problem of landlessness may not be necessary, as long as the land rental market is allowed to operate freely and without restrictions. Furthermore, it is difficult to continue land redistribution given the very small farm sizes that exist in the region. Developing the non-farm sector is also crucial in relieving the pressure on land as well as increasing incomes, given that non-farm income was also greater for households relying on trading or other non-farm activities.

ACKNOWLEDGEMENTS

The authors acknowledge the Norwegian Ministry of Foreign Affairs for funding the research and the partnership of the Amhara National Regional State Bureau of Agriculture in implementing the project on “Policies for Sustainable Land Management in the Highlands of Amhara Region”. Our particular appreciation goes to the many officials, community leaders and farmers who graciously and patiently participated in the research and responded to our numerous questions.

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APPENDIX

Lowland Woredas are those with more than 50% of their total land area classified as Kolla, which is traditionally estimated at 500-1500 meters above sea level. Source of area data: Bureau of Agriculture, Basic Agricultural Data, Bahir Dar, 1999.

Agriculture Potential is based on Disaster Prevention and Preparedness Committee's (DPPC) classification of the region into drought-prone vs. non-drought prone woredas. High Agriculture Potential (HAP) refers to non-drought prone and Low Agriculture Potential (LAP) refers to drought prone.

Market Access is defined by the condition of the road (all weather vs. dry weather) that passes through and links woreda towns. High Market Access (HMA) implies all weather road and Low Market Access (LMA) implies dry or seasonal weather road. Source of road condition data: Ethiopian Map Authority, 1994.

Population Density is defined by the 1994 rural population/km² of total land area. High Population Density (HPD) is greater than 100 persons/km² and Low Population Density (LPD) is less than or equal to 100 persons/km². Source of data: Bureau of Planning and Economic Development, Statistical Bulletin for the Year 1993/94-1996/97, Bahir Dar, 1998.

Source: Land Use and Regulatory Team, Bureau of Agriculture, Bahir Dar.

Figure 2. Classification of the highlands of Amhara region
Figure 3. Selected Peasant Associations in the Amhara region highlands
NGOs in Helping Combat Natural Resources Degradation in the Amhara Regional State: An Overview

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ABSTRACT

NGO operation country wide has seen a gradual transformation from a mere self-operation to operation in partnership with government agencies and communities. Amhara region is not an exception to this. Likewise, NGO engagement in natural resources which started with self-operated physical and reforestation conservation activities has adopted the integrated approach. Based on lessons of the past, there is a collective will to assist communities to adopt sustainable natural resource management (NRM) interventions that contribute to poverty alleviation. NGOs feel that their focus on biannual and perennial crop production, where the agro-ecology allows, is more environment friendly and has to be mainstreamed and encouraged. The different demands and pressures on NGOs, to participate in annual, field and cereal crop production extension activities has to appreciate the other activities as well. Recently introduced regional policies in the Amhara Region appear to have promising provisions in favor of natural resources management interventions by NGOs. Even at this early stage of its operation the woreda decentralization drive is seen as a further opportunity for effective joint action. NGOs feel it is possible to make a positive impact on the natural resources management base of the Amhara region. Genuine commitment and effective coordination are vital prerequisites for this to happen.

INTRODUCTION

The institutional and operational recognition of the NGO sector in Ethiopia has a history attached to natural resource degradation (the subject of this Conference) in the Amhara Region as well. CRDA first came into being in South Wollo (Dessie) during the massive famine of the early 1970s'. The present scenario of NGO distribution in the region and programme makeup also has strong correlation to the situation of the natural resource base.

During the last three decades, NGOs have been one of the major actors in the area of natural resource management in Amhara. NGOs have continued to provide the facilitation services, creating awareness, providing basic skill/HRD, appropriate technologies, financial and material assistance needed for conservation as well as sustainable utilization of natural resources.

The work of NGOs has been influenced by a number of supportive policies. In the field of natural resource management, over the years NGOs see a
A number of NGOs serve as only donors of inputs for employment generation schemes (EGS). Others have initiated capacity building interventions for local authorities in the area of NRM. All of these are positive steps towards community self-management of environmental programmes.

Despite these efforts of NRM in Amhara, there is little documentation of effects and impacts of NGO work in the sector. Several factors contribute to this dilemma. As a result of the learning process in the NGO sector and stability in the operational environment, a substantial improvement along this line is expected.

This paper presents the general overview of NGO participation natural resource management in the Amhara region. The paper is divided into two broad parts: (1) relief and development phases and (2) operational recommendations for future effective NRM in the region.

NGO of Natural Resource Management engagement in the relief and rehabilitation phases

The eastern half of the Amhara region has remained home to a substantial proportion of structural food-deficit population. Even in ‘good’ years, production is not enough to feed all the population. Because of this, NGOs have been collaborating with government in bridging the deficit.

In order to lessen the dependency effect of free handouts, relief supply, where possible, has been linked to some development work in return. The area of NRM is the only sector where the rural labor force was deployed in great numbers as part of the NGO response to the humanitarian needs. During the Derg regime, a number of international NGOs managed extensive projects of food for work in the Region. Even at present, close to 20 NGOs are involved in the implementation of EGS programmes. Over the last three decades, through the FFW arrangement and the EGS windows (for localized short-term emergency response) varieties of NRM components, including hillside terracing, tree planting, access road construction and small-scale water resources development works are accomplished, mostly in the food-insecure parts of the region.

As it stands now, NGO participation in the initiation as well as implementation of EGS programmes is strictly guided by the National Disaster Prevention Policy. The different stages of undertakings are handled in partnership with local authorities. Targeting of beneficiaries and planning of development activities is mostly handled by local authorities. NGOs participate by providing the necessary input (food or cash). Besides this, building the capacity of local authorities to manage such programmes in the most efficient and effective manner is emerging as a major role of NGOs.
THE PERFORMANCE AND POTENTIALS OF EGS FOR NRM IN THE AMHARA

1 Contacted field staff of NGOs have mixed feeling on the above aspect. Some are pessimistic, while others are optimistic. The pessimists assert that EGS has a 'big' humanitarian objective, which makes it difficult to undertake a serious task with at average efficiency. What matters most is not the end result but the delivery of the assistance to those who deserve it. They point that there is no strong monitoring and enforcement mechanism in EGS (in NRM). Localities for undertaking EGS are not chosen on the basis of conservation need. Consequently, the few contacted field staff foresee limited potential in the current EGS schemes in terms of reversing the rapid natural resources degradation.

The optimists, appreciate that the EGS are indeed effective in arresting the rapid natural resources degradation. Securing commitments of local authorities, particularly those at woreda level is noted as a vital aspect of ensuring success. With the provision of capacity building supports to woredas, proper planning and execution of projects is said to have enabled attainment of relatively sustainable schemes. The various policy provisions enacted recently and their operational guidelines are also expected to support the optimistic thinking framework.

As noted earlier, there is a marked improvement in the joint government NGO operation in the region. A good example to be cited is the Bort-NGO joint regional workshop organized at work Wollo Woldia focussing on some aspects of agriculture, natural resources development and networking. This trend is going to be further reinforced by the on-going Woreda decentralization process. It is an opportunity both for NGOs as well as the government. Both parties need to display genuine commitments to work together and make a difference in the lives and natural resource base of their constituency.

Development phase of NGO operation in natural resource management

Most NGO programmes implemented in rural areas of the Amhara Region can be described as conservation-based interventions. Each project has the two complementary sides: a larger share for conservation and with a smaller component of resource exploitation. Because of the excessive land resource degradation, it is still necessary to invest more on the reclamation side than on the exploitation.

The agricultural interventions of NGOs aim at enhancing productivity while managing the natural resource base. It is about improving the current and future productivity of the fragile and scarce soil and water resources. The major
components of agricultural programmes as they relate to natural resource management are the following:

**Small-scale irrigation**

As water/moisture availability/conservation is the major factor limiting agricultural intensification and income diversification, a number of NGOs have been implementing small-scale irrigation programmes in the Amhara Region. As capital-intensive ventures, small-scale irrigation schemes should be able to serve as many vulnerable households as possible. As it stands now, the issue of irrigated land redistribution is not resolved. Only those land owners on the command line benefit from projects. NGOs feel that because of this issue, maximum use of the irrigation potential with equitable allocations is not possible. Reallocation of some irrigated plots can ease the pressure on conservation reserve exploitation. Practitioners hope that the recently introduced regional Land-use and Administration Proclamation may solve this.

**Fruit and vegetables production - diversification**

The major thrust of diversification being the adaptation of better performing local and improved varieties, environmental compatibility has been as well a criteria of introduction. Field observations indicate that, in addition to the high value crops (vegetables), NGOs have given more emphasis to perennial crops than to annuals. Fruits and vegetables, in addition to the relatively better market values, have a higher productivity per unit area. Particularly fruit trees as such do not require seasonal manipulation of the soil and rather provide protection from erosion. Some NGOs have also succeeded in introducing some temperate fruits. A recent assessment of World Vision operation in the Amhara Region shows that because of the interventions of World Vision, a backyard agricultural intensification process is gradually taking over the field-based cereal production system. For a number of natural resources-based advantages and other considerations, this lesson of NGOs should be scaled-up and streamlined into the regional government extension system.

**Livestock development**

This intervention has concentrated mainly on improving the veterinary service and forage development along with the vegetative soil conservation measure. Truly speaking, both the government and NGOs have done little in the area of making livestock production compatible to the needs of natural resource

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3 Field level discussion with LWF staff
management. Overgrazing has continued to be a serious problem in nearly all parts of the region. Interventions that boost productivity while limiting stock size and management are vital.

The management of the Commons

Much of the natural resource conservation work of earlier NGOs and even the government as well has been done on the communal reserve areas. Over the years, these areas were considered as no-man’s-lands. Protection of conservation structures and assets created were destroyed. One of the factors contributing to the current level of performance of NGO’s conservation efforts is associated to this. At the moment, based on the recently issued regional "private use-right on communal lands" regulation, a number of NGOs have embarked on a capacity building support to collective, as well as individual, resource management efforts. Much optimism is seen in this line, and local authorities should be enabled to build confidence of the participants.

RECOMMENDATIONS FOR ENHANCING EFFECTIVENESS IN NRM EFFORTS

Absence of institutional arrangements

The absence of a separate bureau for NRM is not considered a major factor affecting performance in the sector. Nonetheless, some field staff feel that there is no strong governmental institution for testing/reviewing and facilitation of technology transfer in the natural resources field. Because of this gap, at times failures have been repeated. NGOs point that the regional agricultural research institute, the Bureau of Agriculture, (BoA) have to do much along this line.

Coordination of efforts

NGO programmes, the development as well as the EGS components facilitate work in NRM. Since the two components have different objective and output frameworks, NGOs face a challenge of making one complementary to the other. On the other hand, local authorities in the region coordinate the mobilization operation which also has a major NRM task. Field staff feel the appropriate synergy in these efforts is missing. Future strategy should ensure that the different actors are well coordinated so as to ensure collective effectiveness.

Community participation

NGOs still feel that community participation in the different stages of a project cycle is vital for success. Interventions should be designed by taking into account the traditional skills and present needs of farmers. There is an increasing need to
work with individual and smaller groups of farmers than the conventional mass mobilization. Likewise, technical staff at field level attach little significance to incentives for accomplishing NRM interventions at household level.

Resource base of NGOs for NRM

The major sources of funding for NGO programmes in the Amhara Region apparently comes from EU and USAID outlets. Experience so far shows that these agencies are more willing to respond to the emergency component of operation. Some NGOs express that the dependency on these sources and the standardization of support is making it difficult to pilot new projects and expand scope of operation. NGOs understand that there is much opportunity for tapping resources from some of the regional and global environmental support programmes. The Global Environmental Facility (GEF) and the Nile Basin Initiative are some examples. Government support and facilitation for NGOs to make maximum use of such opportunities has to be strengthened.

Annex 1

NGO's engaged in natural resources management in Amhara Regional State

<table>
<thead>
<tr>
<th>Zone</th>
<th>No of NGOs</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Wollo</td>
<td>11</td>
<td>26</td>
</tr>
<tr>
<td>North Shoa</td>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>South Wollo</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>South Gonder</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>North Gonder</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Waag Heemra</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>West Gojam</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Awi</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>East Gojam</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Oromiya Zone</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12 International NGOs</td>
<td>21 projects</td>
<td></td>
</tr>
<tr>
<td>7 National NGOs</td>
<td>21 projects</td>
<td></td>
</tr>
</tbody>
</table>
Participatory Assessment of Forest Resources in Limalimo Forest

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ABSTRACT

The different forest ecosystems of Ethiopia are under severing pressure as consequences of high population growth and inhabitants' need for agricultural and pastoral land. The long lasted civil war, forest fire, mobilizing a large population to new area without their consent and forced villigaziation programs launched during the military regime are also blamed to the shrinkage of the forest resources. At present, huge investments also poses threat on the remaining forest resources. Therefore, to lay the ground for the conservation of the forest genetic resources of Ethiopia a socio-economic survey parallel to the woody plant inventory diversity study are being conducted in selected forests. The objectives of this socio-economic survey are to investigate the major cause of forest destruction, people's priority species, actual uses and threats posed on tree/shrub species, prevailing farming systems and gender issues. And finally the survey aimed to assess appropriate and feasible traditional and formal institutions that can be involve in implementation of species level conservation (in situ and ex situ). PRA (Participatory Rural Appraisal), and other PR tools were used. Pair- wise ranking exercises that were conducted in Limalimo forest to identify the most threatened species revealed that "qulqual", Olea europaea, Juniperus procera and Hagenia abyssinica are the most endangered species. Furthermore, Scheffera abyssinica, Acacia spp, "Lelcha" and "Koya" are identified as threatened species. The triangulation exercises made by the researcher are also confirmed that the mentioned species are depleting at an alarming rate. Therefore, conservation efforts for these species are recommended.

INTRODUCTION

Ethiopia is endowed with rich flora and fauna due to its' physico-climatic diversity. The total number of vascular plants is believed to be more than 7000 species out of which an estimated 10 to 20 % are endemic. The number of woody plants is said to be around 1,000, out of which about 300 are tree species, (EFAP, 1994; EPA, 1997). In the beginning of 19th century, it is evidenced that about 35-40% of the total landmass was covered with high forests. Latest projections suggest that closed forests cover less than 2.5% of the total landmass. Estimate for the deforestation ranges from 150,000 to 200,000 ha per year, (EFAP, 1994).
Every day forests equalling the size of 500 football pitches are being destroyed, and if this trend continues high forest might be gone within 10-15 years time. The ever-increasing pressure on the remaining forest of Ethiopia calls for an integrated approach to combat the depletion of the forest resources and taking of appropriate action towards sustainable utilization. Therefore, the Ethiopian Government requested the German Government for technical cooperation, which finally led to the establishment of the Forest Genetic Resources Conservation Project. IBCR, in collaboration with GTZ, launched the above-mentioned project in July 1998.

Wood and non-wood products for household consumption and income generation were extracted from Limalimo forest, since the establishment of villages around the forest. The Italian military camp was established in 1935 in Limalimo forest to facilitate invasion of the rest of the country. Likewise, during the war between the Derg and the current government a military compound was built around Limalimo forest (1976-92), and therefore trees/shrubs were aggressively cut down to supply the camp with fuelwood and construction materials. Furthermore, the forest has lost its indigenous tree cover due to intensive cutting down of trees to supply a sawmill, established by two Italian owners immediately after the Italian invasions. The ever-increasing expansion of farmlands from Haile Sellassie's time to Derg and from Derg to the current government at the expense of the forest area, especially during the transition periods, has contributed a lot to the depletion of the forest. The forceful villagization program carried out in four localities through clearing of the forest and/or on the cultivable land occupied by the farmers has also contributed to the depletion of the forest. Inhabitants of the area utilize the wood and non-wood products throughout the year. Women in Debir Kebelc collect fuelwood every day. Therefore, the rapidly increasing populations in the localities have extracted fuelwood for household consumption and income generation.

MATERIALS AND METHODS

This socio-economic survey was carried out in December 2001. The survey crew comprised two researchers (Agricultural Economist and Sociologist) and two rapporteurs and guides. The site where this survey was conducted was Debir Kebele, Debark Wereda. Debark Wereda is located some 847 kms north of Addis Ababa, capital city of Ethiopia bordering Tigray region. A total of 21 participants (15 males and 6 females) were involved in the study. The methodology employed to conduct the survey was PRA (Participatory Rural Appraisal) and parallel to it relevant information was gathered from the secondary sources to enrich the finding and the whole exercise took five days.

The selections of the assessment area were carried out as per the objectives of the survey and altitude variation that certainly resulted in vegetation
variability. Woody plant Inventory and Socio-economic Team members jointly carried out the reconnaissance survey. Transect lines were laid down using the topomap of the forest on different aspects. Following that the socio-economic team selected a kebele that is closest to the transect lines selected for the biodiversity inventory.

The team initially contacted the development agents and chairpersons of the kebele and relevant information was gathered. Pertinent participants of the PRA discussions were identified and a tentative schedule was set. Elders, key informants, voluntarily farmers, who scratch their living directly or indirectly from forest products, landless and knowledgeable farmers, from both sexes were identified for group and focus group discussions, among others. Attention was also given to include different age groups. Arrangements were made and the selected villagers were invited through village leaders or through sending messages. Then the themes of the survey were introduced to avoid unnecessary expectation, and the eagerness of the mission to know more about people-forest interaction was explained. Whenever necessary energizers were deployed to stimulate/encourage participants.

RESULTS AND DISCUSSION

Farming systems and their effect on forest resources

Crop production

The major crops grown in the locality include barley, wheat, bean, chickpea and linseed. Inhabitants are also engaged in the production of teff, millet and maize in small amounts. The average productivity for the first two major crops (barley and wheat) is 11 and 12 quintals per ha, respectively. The recent stable crop in the locality is wheat and the preference of the inhabitants shifted to this crop from barley due to the decline of barley production. Land productivity used to be very high some 20 years ago as people used fallowing and shifting cultivation. Currently, both are not practised anymore due to limited farmland, which gives little chance to spare for fallowing and due to restriction of shifting cultivation. Household food security is very low with almost all households having enough food for only six months (MoA/GTZ, 1999). The remaining months' food requirement is met through hunting and gathering of wild fruits, selling of fuelwood (eucalyptus) and charcoal, minimizing consumption level and foregoing a meal or two per day, seasonal migration for job searching to other areas and selling of live animals. In the worst case, the coping mechanisms will include selling of necklace, earrings, rings and poles by demolishing their residences. Besides, to bridge this gap, farmers engaged in ruthless cutting of trees from
natural forests to produce timber and poles. Therefore, illegal involvement of the inhabitants in harvesting wood products, especially during months of food shortage, contributes much to the shrinkage of the forest.

Animal husbandry

The livestock population in the wereda is estimated at 77,922 cattle, 87,741 sheep and goats, 19,748 equines and 81,786 poultry (Debark Wereda Department of Agriculture). Most of the country’s endemic animals are found in and at close proximity of the forest. (Walia ibex, Siemen-wolf and the Gelada baboon). However, these animals are endangered. The main purposes of keeping livestock are for draught power and transportation. Horses are favored for draught power with age-old traditional tools unlike other highlands, where oxen are the major traction power. Farmers also emphasized on the owning of livestock to fulfill government commitment, such as fertilizer and improved seed debits and land tax. Farmers are also engaged in rearing animals for production of milk and meat for consumption and sales, and hide and skin for bedding and mattress, and to accumulate capital. The herds are also used to insure against risk. The livestock in the localities run free and subsist largely on natural vegetation on common grazing lands, when farm fields are free from crops. Cut and carry grass and storage for fodder-deficit periods are the usual practice. Inhabitants cut grass from October to November and feed it to their livestock from January to June. Furthermore, farmers of the localities feed livestock with weeds from their fields and crop residues are also used as a source of feed. However, currently the extension agents introduced forage plants such as “gwaya” and other leguminous plants. Therefore feeding livestock on forage plants has started. Keeping cattle in the forest both for grazing and to afford shade during the dry period is a common phenomenon, especially from January to May. The leaves of Dombeya torrida, Pittosporum viridiflorum, Nuxia congesta, Hypericum revolutum, Discopodium abyssinica, Bersama abyssinica, Erica spp and "Koya" are recognized as livestock feed, among others. Therefore, animals are let in the forest-affected regeneration.

Apiculture

Limalimo forest has a high potential for bee-keeping. The forest provides bee forage, nesting habitat for bees and materials to make beehives. Honey production is a traditional activity around the forest and honey is collected, both from fixed beehives and hollow trees. Hence, people in the assessment area produce honey for consumption and income generation. Tree species that were recognized by farmers for making beehives are Myrsine africana, Dombeya torrida, Hypericum revolutum, "leleha" and "dengay seber", among others. Farmers prefer these
species, for the fact that bees was attracted by the inherent attractive smell of the upper mentioned species and beehives made out of these species maintained favorable temperature for bees. Honey is extracted through smoking out the bees from the beehives. Therefore, the fire is set for the extraction of honey, and there is a real danger in that the fire, if not managed well, could burn the forest. On the other hand, as discussed earlier, beehives are produced using the stem of the selected trees and the practice poses a threat to the species mentioned.

Non-farm activities

There are non-farm activities that are occasionally practised, in close proximity of Limalimo forest: activities like iron-shaping, pottery-making and weaving. Professionals engaged in these occupations are looked down by non-producers and also considered impure. They are restricted to marry with persons from non-producer class. Furthermore, inhabitants scratch their living through extracting wood products for construction, farm implements, planks, fuelwood and charcoal, among others. Besides, farmers practiced woodcarving and petty trading for their livelihood and also utilized non-wood products such as leaves and fruits.

THE FOREST AND ITS RESOURCES

Household energy

Limalimo forest is endowed with a rich diversity of tree/shrub species and farmers are proud of the natural resources extracted and utilized. The survey results of the PRA conducted in Debir kebele has identified about 53 tree and shrub species. In Ethiopia the daily per capita fuelwood consumption is about 1.2 kg in arid areas, 2.1 kg in highland plateaux, and 2.7 kg in the southwest (one of the highest rates in Africa). The rural households derive about 95% of the domestic energy from biomass fuel. Based on the assumption (rate of 2.1 kg per day), current requirements of Debark Wereda is 2.1 kg/day*365 days*21,439 households=164 tons per annum. The pattern of fuelwood demand has been showing an increasing trend parallel to the population growth. Farmers prefer tree/shrub species for household energy, if they burn well, generate more heat as compared to others, easily splitting and flammable and serve for a long time with little smoke. Therefore, farmers exploited species mentioned in Table 1 for household energy sources.
Construction, timber and farm implements

The total population size of the Debark wereda is about 126,688 and the recent population size shows a 5% increment compared to the 1994 population census conducted by CSA (Central Statistics Office). The frequency of felling trees for construction purposes is increasing due to rapid population growth and associated demand to construct new residences and for renovation of the existing traditional tukuls. Besides, during the conflict (1976-91), the Derg soldiers harvested much wood for the establishment of military camp and to construct barricades. On the other hand, the rising demand of timber for construction of farmers' residences coupled with the attractive price of the timber made out of the species that are stipulated in Table 1 have contributed much to the creaming of the mentioned species. Farmers prefer to construct residences with these species due to the fact that these species are durable and long lasting. They also resist termite attack, do not easily decompose, grow straight and are easy to be chopped or split.

Farmers prefer tree species for making farm implements, if they are suitable for making various traditional farm implements, strong, abundantly available, durable, and have a capacity to resist termite attack.

Table 1. Preference ranking of tree species for various purposes

<table>
<thead>
<tr>
<th>Rank</th>
<th>Local construction</th>
<th>Farm implements</th>
<th>Fuelwood (female group)</th>
<th>Fuelwood (male group)</th>
<th>Wood - carving</th>
<th>Timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OLEEU</td>
<td>OLEEU</td>
<td>OLEEU</td>
<td>OLEEU</td>
<td>'Koya'</td>
<td>JUNPR</td>
</tr>
<tr>
<td>2</td>
<td>JUNPR</td>
<td>RHUGL</td>
<td>Acacia spp</td>
<td>Acacia spp</td>
<td>HAGAB</td>
<td>HAGAB</td>
</tr>
<tr>
<td>3</td>
<td>'Leleha'</td>
<td>DOMTO</td>
<td>JUNPR</td>
<td>APODI</td>
<td>OLEEU</td>
<td>'Leleha'</td>
</tr>
<tr>
<td>4</td>
<td>DOMTO</td>
<td>'Gejemo seber'</td>
<td>BUDPO</td>
<td>OLECA</td>
<td>SCHVO</td>
<td></td>
</tr>
</tbody>
</table>

Source: PRA participants in Debir Kebele

Ownership and access rights of the communities

During the assessment farmers declared that access to natural forest resources are restricted, except putting beehives. Therefore, farmers are expected to appeal to the Kebele officials and representatives of the Department of Agriculture even to cut a single tree for personal consumption. They are not entitled to get official benefit from the forest resources conserved. Recently, they observed that
Assessment of forest resources

Eucalyptus plantation adjacent to Limalimo forest were sold and used without their consent. They were also not involved in planning and decision-making of the forest resources utilization. Therefore, their sense of ownership disappeared.

Major causes for forest depletion

Farmers extract most of their basic needs from the natural forest resources. Therefore, villagers and other users pose threats to some species. This is for subsistence and to generate additional income. Expansion of farmlands is the major cause for the depletion of indigenous forest cover (Table 2). Moreover, natural forests shrink not only due to consumption but also due to lack of investment on it. Similar to other forest areas in the country, growth of agricultural production could not cope with the population growth. Young people (newly married couples), displaced ex-soldiers and other landless are lacking access to land and clear the forestland.

Table 2. Priority setting exercise made in Debir Kebele

<table>
<thead>
<tr>
<th>Causes for destruction of the forest</th>
<th>Number of respondents</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuelwood and charcoal</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>Expansion of farm land</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>Establishment of military camp sites</td>
<td>10</td>
<td>3</td>
</tr>
</tbody>
</table>

Source: PRA participants in Debir Kebele

Threatened woody species

Preference ranking was undertaken to identify species for house construction, farm implements, wood-carving, fuelwood (by both sex groups) and charcoal production. The ranking revealed that Olea europaea is the most favored species. Forest dwellers preferred Juniperus procera for house construction, household energy sources (female group) and timber production. The inhabitants for local construction, fuelwood (male group), woodcarving and timber production also prefer Hagenia abyssinica (Table 1). “Qulqual” is also preferred for house construction and timber. Therefore, the facts mentioned in previous pages coupled with the exercise to identify threatened species (Table 3) attested that “qulqual”, Olea europaea, Junipers procera and Hagenia abyssinica are the most threatened species. The triangulation exercises made by the researcher are also confirmed that the mentioned species are depleting at an alarming rate.
Table 3. Ranking of the most threatened species

<table>
<thead>
<tr>
<th>Tree codes</th>
<th>OLEEU</th>
<th>JUNPR</th>
<th>DOMTO</th>
<th>HAGAB</th>
<th>Leleha</th>
<th>Acacia sp</th>
<th>Koya</th>
<th>Quulqual</th>
<th>SCHVO</th>
<th>RHUGL</th>
<th>Gejemo seber</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLEEU</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>JUNPR</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>DOMTO</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gejemo seber</td>
<td>3</td>
</tr>
<tr>
<td>HAGAB</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>Quulqual</td>
<td></td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Leleha</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Leleha</td>
<td>4</td>
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<tr>
<td>Acacia spp</td>
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<td>X</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Acacia spp</td>
<td>3</td>
</tr>
<tr>
<td>Koya</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Leleha</td>
<td>2</td>
</tr>
<tr>
<td>Quulqual</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quulqual</td>
<td>3</td>
</tr>
<tr>
<td>SCHVO</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quulqual</td>
<td></td>
<td></td>
<td>SCHVO</td>
<td>2</td>
</tr>
<tr>
<td>RHUGL</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>RHUGL</td>
<td>1</td>
</tr>
<tr>
<td>Gejemo seber</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Score: PRA participants in Debir Kebcle

<table>
<thead>
<tr>
<th>Code</th>
<th>Scientific name</th>
<th>Vernacular name</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLEEU</td>
<td>Olea europaea</td>
<td>Leleha</td>
</tr>
<tr>
<td>JUNPR</td>
<td>Juniperus procera</td>
<td>Koya</td>
</tr>
<tr>
<td>DOMTO</td>
<td>Dombeya torrida</td>
<td>Quulqual</td>
</tr>
<tr>
<td>HAGAB</td>
<td>Hagenia abyssinica</td>
<td>Gejemo seber</td>
</tr>
<tr>
<td>SCHVO</td>
<td>Schefflera volkensii</td>
<td></td>
</tr>
<tr>
<td>RHUGL</td>
<td>Rhus glutinosa</td>
<td></td>
</tr>
</tbody>
</table>

Leleha
Koya
Quulqual
Gejemo seber

Shiferaw Dessie
COMMUNITY ORGANIZATIONS AND THEIR POTENTIALS AS PARTNERS FOR CONSERVATION MEASURES

Traditional organizations

Elders

A group of people that includes husband, wife, children and sometimes relatives who live together under a single roof and are sharing resources commonly forms a family. This is the first/lowest social institution in which conflict within the homestead is resolved. Beyond the level of household, people are associated together as neighbours and this is the next administrative unit in which disputes that could not be tackled by the family would be settled. Elders are also recognized to resolve quarrels between the family and neighbours, and cases beyond the neighbourhood will be referred to elders for mediation. Both parties choose two to three elders on their behalf, chosen elders identify the root cause of the conflict between the applicants and resolve the case. Empowering elders who won the trust of the communities were recognized as a relevant resource to attain the envisaged species level conservation. The information obtained during the PRA assessments revealed that elders have been involved in advising farmers not to cut trees excessively. They are also elected by the villagers to participate in the forest protection committee established in the Kebele. They have also been engaged in resolving conflict arising between the farmers, for instance when one puts beehives on the tree that was acquired/claimed by somebody else. Therefore, considering their experience in forest resource conservation, the trust developed and the respect of the community elders are recommended for conservation efforts.

Idir/Rike

The Idir is an informal social structure and its origin is traced to urban areas. Recently, the institution has been imported to the rural areas, disseminated and adopted on a larger scale. Farmers are eligible to be members of an idir, if they have paid a registration and a contribution fee. Men and women residing in one kebele at close proximity organize the Idir jointly. The Idir is permanent by its nature and governed by democratically elected leadership and established regulations. The major function of the idir is to assist during funeral ceremonies. The structure has a potential to raise the awareness level of the farmers, towards sustainable utilization of the forest resources, if members are convinced to incorporate the issue in their bylaws and if the local and government policy is going to be supportive. Therefore, the researcher favors the structure due to its
permanence, inherent democratic nature, and social bond created among members, trust and respect given by the community.

Orthodox Church

Trees and shrubs found on the premises of the Orthodox Church in the north of the country have been protected for a century and more due to the fact that the Orthodox faithful consider cutting trees/shrubs from a Church compound a curse. Hence, fear to cut trees, unless authorized by the leader of the church to remove old tree/shrub species for the consumption of the church helps to protect excessive cutting. Priests also participated in raising the awareness level of the believers towards conservation and believers refrained from creaming good-looking tree. Therefore, it is the conviction of the researcher that the Church can contribute a lot to attain the envisaged species level of conservation. The researcher also takes this opportunity to appreciate the effort made by other churches and mosques to conserve the forest resources in the country, and recommends further involvement of religious institutions in the awareness raising programs towards conservation, and negotiation with the church and mosque leaders and mobilization of the community to plant endangered species in their respective compounds.

Task-oriented structures

Debeyat and Webera

Debeyat and Webera are task-oriented traditional structures that are organized to pool labor for various activities that might be difficult to be managed privately. The former is organized among relatives and/or neighbors and relatively small (does not exceed seven persons) and the latter embraces 15-20 members, who come together to perform the intended activities. Every member of the community organizes Debeyat and Webera upon his request and invites colleagues to participate in the task that, he/she finds difficult to implement alone on time. The organizer of the Debeyat and Webera provides local beer and boiled/roasted grain to the participants of the work, and both are reciprocal in nature. Unlike formal organizations, these organizations are more grassroot-oriented and flexible, and likely more accountable to their members Therefore, the social bond created by task-oriented arrangements is strong and is anticipated to serve as a good forum for promoting sustainable utilization of the forest natural resources.
GENDER ISSUES

Division of labor

Almost all agricultural activities like land clearing, ploughing, seeding, harvesting, threshing, and transporting grain and straw are male domains. However, land preparation, weeding and crop protection is shared by both sexes, even if the male group largely performs the activities. Furthermore, construction of fences, maintenance of houses and building of additional or new houses are the job of men with little support by female. Livestock feeding, poultry keeping, cleaning of stable/barn are largely performed by women and men participate less in these jobs, milking cows are entirely women’s responsibility, but are also shared by men, when women get sick and during the delivery period of the mothers. Furthermore, wood products such as wood-carving, timber and pole production are men’s duties. Among the non-farm activities, the male group seldom practises iron-shaping. Nourishing the family and rearing children are major responsibilities of the women. Therefore, preparing meals and boiling water for various purposes, distilling local beverage and preparing honey wine are activities carried out by female, as well as grinding and fetching water. Women collect fuelwood and dung. Production of dung cakes, and its storage is fully women responsibility. Men do production of charcoal for commercial purposes. Men also do the wood cutting and chopping. Women are responsible for setting aside adequate amount of seed from all grain types for the planting seasons, even amidst food shortage. Failing to do so will entail beating by the husband and even divorce. This is also an agreed norm by the society in North Gondar (MoA/GTZ, 1999). Men take care of selling and buying agricultural produce especially when it is marketed in bulk and when cattle, sheep and goats are involved. Women do minor sales and purchase food items. Buying clothes and farm inputs are the responsibility of men. Therefore, marketing is shared between men and women (MoA/GTZ, 1999).

Timber production, wood-carving, producing poles and fuelwood making (cooking, distilling, heating, boiling and light generation) have contributed to the shrinkage of forest resources. Iron-shaping is an activity that requires heat energy from wood and PRA participants reported that four farmers perform the activity on a small scale, so its impact on forest resource depletion seems insignificant. On the other hand, non-farm activities that include pottery, weaving, iron-shaping and petty trading have played a potential role in reducing pressure on forest, through generating additional income.
Access and control profile

Men have ready access and control of various resources such as land, capital, tools and other production inputs, while women have low access to capital and production inputs. Furthermore, as women groups report, they acquired access to land but they are not provided with access to tools. Furthermore, they are not empowered to control capital, tools and production inputs, except land. On the other hand, both sexes lack access to employment opportunity provided by government and private employers. Men have access to information, education and training but low access to public services. On the other hand, women have access only to education and low access to information, training and public services. Men are empowered to control information exchange processes.

Participation profile

Both sex groups are eligible to be members of the kebele administration, service cooperatives, idirs and equips, if they comply with the rules and regulations of the mentioned structures. However, women groups were not qualified to be members of forest conservation committees and they are not eligible to become traditional elders, to resolve conflicts and to mediate between neighbors. Furthermore, men are the chairpersons and entire members of the executive board for all structures mentioned above. Men are also qualified to mediate and resolve conflicts in the locality, while women have responsibility to lead only women's association. Women take part in discussions and sometimes make suggestions. However, they never chair meetings, elect elders, make decisions or give lectures. On the other hand, decision on productive activities, education, health care and family planning are the responsibility of both sexes, and decision on daily expense and investment in consumer goods are women's domain.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Evidently, community-based conservation could contribute much to natural resources conservation due to the fact that the system involves the community in planning, monitoring and evaluation, decision-making and benefit-sharing. This author proposes that community-based institutions for the conservation of the species mentioned be given due consideration. The fact that they are organized on voluntarily basis, are democratic and grassroot-oriented, permanent in nature,
flexible, trustworthy and have the respect of the communities are all points worth supporting.

RECOMMENDATIONS

1. In order to save the Limalimo natural forest, increasing agricultural productivity and introducing alternative income generating activities are recommended.

2. Out-migration with genuine community participation is also recommended to ensure household food security.

3. Limalimo forest is the wealth of the international communities. Therefore, the initiation of feasible projects and securing fund from the international communities to boost production of the farmers are recommended.

4. Raising the awareness level of farmers through intensive extension and arranging benefit-sharing mechanisms are expected to play a great role to conserve the remaining forest resources. Therefore, community-based training that would be able to mould the attitude of the farmers towards sustainable utilization and conservation is recommended.

5. 'Qulqual', *Olea europaea*, *Juniperus procera*, *Hagenia abyssinica*, *Schefflera abyssinica*, *Acacia spp*, 'leleha' and 'koya' are recommended to be conserved.

6. Transparency and genuine stakeholders' involvement beginning with concept development up to implementation of species level conservation (*In situ* or *Ex situ*) in planning, decision-making and benefit sharing are recommended.

7. Honey production is environmentally and economically sound activity, requires low external input and seems sustainable. Therefore, this researcher recommends the promotion of this activity through introducing improved honey production and collection practices.

8. Introduction of fast growing tree species that enables farmers to become self-sufficient in household energy sources, and improved biomass stoves are also recommended to minimize the burden placed on Limalimo natural forest.

9. Limalimo natural forest is recognized as a home for wild animals, especially the Walia Ibex and Siemien fox, which are endemic to Ethiopia, and currently these species are rarely seen in and around the forest. Therefore, this researcher recommends the placement of appropriate measures to change this situation.

ACKNOWLEDGEMENTS

The author would like to thank participants of the PRA discussion in Debir Kebele and workers of Debark Wereda Department of Agriculture for the support
they have provided during the survey. The researcher would like to express sincere appreciation for the survey crew. The writer is also grateful to Ato Taye Bekele and Mr. Gunther Hasse for their valuable comments during the write up of this manuscript. The study was realized through the financial and technical support of GTZ and IBCR.

REFERENCES


Soil and Water Resources in the Amhara Region: Potentials and Constraints

TESHALE ADGO
Bureau of Agriculture, P.O. Box 437, Bahir Dar, Ethiopia

INTRODUCTION

The Amhara Region is located at the north-western part of the country between 9° and 13° 45' North Latitude and 36° to 40° 30' East Longitude. The land area covers approximately 170,752 km². It is bordered by Afar in the East, Benishangul in the south western, Oromiya in the south and south western, Tigray in the north and in the west with Sudan.

It is broadly viewed as being topographically the most diverse and complex region, characterized by rugged mountains, extensive plateaux and scattered plains separated by deeply cut gorges, steep slopes and cliffs which make movement over them very difficult.

The mean annual rainfall varies between 300 and 2000 mm, with the major rain falling between June and September. The western part of the region is characterized as a high rain fall areas exceeding 1200 mm annually, while the low rain fall areas are found experience in North Wollo and Waghamra (specifically Harbo and kobo). Not only the amount of rainfall but length of the rainy season also decreases north and north-eastwards from the south-western corner of the region.

It is characterized by diversified elevation, namely the lowest point at the north-west part [Metema and Matebia woreda] at about 600m elevation, while the highest is the top of Ras Dashen Mountain, which is about 4620m. It has 10 major agro-ecological zones.

The climate, terrain and population are the main factors that have influenced both use of the land and the natural vegetation cover. The major land use covers cultivated land (53%), Afro-alpine or sub-afro-alpine vegetation, forest land, Wood land, riparian wood land or bush land, bush land, shrub Land (18%), grass Land (16%), wet land, Bare land and Water bodies.

At present where the pressure on land is higher than ever due to accelerated growth of human population, a better understanding of the potential and limitations of soil resources among others, is necessary to boost production per unit area.

The geomorphology could be classified into eight broad major geomorphic units namely; The highland plateau (part of Gojam, wello and northern Shewa), The eastern escarpments (Debre Sina to Alamata), The eastern
lowland plains (bordering Afar region), the western lowland plains (bordering Sudan), the Abay gorge, the Tekezze gorge, the Tana plains, the afro-alpine mountains (Ras Dashen, Choke, Abune Yosef, Amba Farit, Guna and Adama).

There are 17 dominant soil types (Table 1). The distribution and type of soils have strong correlation with physiography, geology and climate.

The depressions and flat plains are most commonly covered by black clay soils (vertisols), while the undulating to gently rolling well drained highland areas are characterized by dark reddish to brown coloured deep soils (Luvisols, Nitosols and Acrisols). The mountainous and degraded landscapes of wello and North Gonder are of shallow and stony soils (Lithosols). The major alluvial plains in the east are predominantly Fluvisols and Vertisols with saline sodic phases. The young and shallow soils are found on the mountainous and degraded landscape of the Region. The deep and relatively fertile soils are found on the flat plains.

Table 1. Distribution of the major soil types in the Region

<table>
<thead>
<tr>
<th>No.</th>
<th>Soil type</th>
<th>Total Area (ha)</th>
<th>Percentage</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vertisols</td>
<td>1,773,161.1</td>
<td>10.38</td>
<td>Gojjam, Shewa</td>
</tr>
<tr>
<td>2</td>
<td>Luvisols</td>
<td>1,193,473.8</td>
<td>6.99</td>
<td>Chilga, Armacuiho</td>
</tr>
<tr>
<td>3</td>
<td>Nitosols</td>
<td>2,233,501</td>
<td>13.08</td>
<td>Mecha</td>
</tr>
<tr>
<td>4</td>
<td>Acrisols</td>
<td>426,240.64</td>
<td>2.5</td>
<td>Highlands sekela, Banja</td>
</tr>
<tr>
<td>5</td>
<td>Cambisols</td>
<td>170,496.26</td>
<td>1.0</td>
<td>Throughout the Region</td>
</tr>
<tr>
<td>6</td>
<td>Regosols</td>
<td>578,578.49</td>
<td>3.39</td>
<td>North Wello</td>
</tr>
<tr>
<td>7</td>
<td>Arenosols</td>
<td>596,736.9</td>
<td>3.49</td>
<td>Sekota, Abay gorge</td>
</tr>
<tr>
<td>8</td>
<td>Phaeozomes</td>
<td>3,239,428.9</td>
<td>18.97</td>
<td>Gondar, Wello, Shewa</td>
</tr>
<tr>
<td>9</td>
<td>Leptosols</td>
<td>2,335,887.4</td>
<td>13.68</td>
<td>Steep slopes &amp; lime stome area</td>
</tr>
<tr>
<td>10</td>
<td>Andisols</td>
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<td>0.4</td>
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<tr>
<td>11</td>
<td>Solonchaks</td>
<td>409,804.8</td>
<td>2.4</td>
<td>Borkena, Cheffia area</td>
</tr>
<tr>
<td>12</td>
<td>Fluvisols</td>
<td>102,511.2</td>
<td>0.6</td>
<td>Kobo, Habro</td>
</tr>
<tr>
<td>13</td>
<td>Lixisols</td>
<td>2,335,798.8</td>
<td>13.68</td>
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<td>0.6</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Histosols</td>
<td>34,150.4</td>
<td>0.2</td>
<td></td>
</tr>
</tbody>
</table>

In terms of land use about 340,960 ha is water bodies (2%). By improving drainage, Vertisols and Gleysols which cover 11% of the area can become more productive. Soils with low fertility status cover 12.9%, while shallow depth soil covers 13.7%.
POTENTIALS AND CONSTRAINTS OF THE SOIL RESOURCES

The eastern escarpments and lowlands

These border the Afar region, and are characterized by steep escarpment and flat lowlands. The steep escarpment extends all along the road from Debresina to Dessie. The escarpment at the margin of the plateau resulted from the major rift system. Due to the steepness of the slope and relatively scarce vegetation cover, it covered with shallow and stony soils (Leptosols). In some localized gently sloping table-lands, moderately deep organic matter rich dark coloured but stony soils / Phaeozomes/ occur. Except the limited gently sloping areas where the soil is moderately deep, the escarpments have no importance for crop cultivation in view of being degraded.

The flat low lands are prominently in cheffa and Borkena in the south, and kobo to the North. Due to the lower physiographic position and high runoff in the escarpments and plateau, the low lands receives fresh sediments regularly and suffer from frequent seasonal flooding and waterlogging. The southern part of the unit characterized by few perennial streams and hot springs, while north part of kobo and surrounding, by seasonal flood streams. Although drier as they are in the rain shadow of the high lands, there is good potential for development under irrigation.

The major soils in the unit are the Vertisols, Fluvisols, Solonchaks and Gleysols.

a. Vertisols occur on gently sloping parts. They are characterized by high clay content, dark colour with drainage and workability problems. Some have high exchangeable sodium in lower parts. They are mainly used for crop production.

b. Solonchaks. They are highly salt affected soils, and not suited for cultivation of major crops.

c. Fluvisols are sandy textured stratified soils derived from the escarpments and plateaux by alluvium. Fluvisols have no salinity and sodicity problems except when there is moisture stress during dry spells. Mainly short seasoned and/or drought resistant crops grow here. Kobo and Alamata area good examples where such crops grow.

d. Gleysols are waterlogged soils found around cheffa and Borkena. Due to high water table and prolonged water saturation throughout the year, they are not used for crop cultivation, but mainly for grazing land.
The North Wello and Gondar degraded area

These units are the most severely dissected parts with high concentration of steep lands. One of such degraded steep lands is Sekota area. Due to the steepness of the slope, clearance of the vegetation during land periods of human occupation, relatively heavy rainfall and severe erosion hazards, domination of shallow and stony soils. (Leptosols and Regosols). These are areas where land resource conservation activities should be directed instead of agriculture. Degradation of soils in North Shewa areas are also included in this unit.

There are some flat plains, streams and valleys of considerable importance (the Metema plain and the fringes of Humera plain), which are characterized by predominance of flat or gently undulating terrain. Vertisols are the dominant soil type which are dark heavy clay soils in association with dark reddish colored sandy loam soils (Luvisols). Both soils are reported to have high pH and low available phosphorus constant. Because of relatively higher moisture retention capacity, the Vertisol area is under cultivation despite its workability problem. Due to the lower moisture-holding capacity of the coarse textured soils, plants fail to grow well mainly because they fail to meet the higher crop evapotranspiration demand. Large scale irrigated agriculture is not practiced in the area probably due scarcity of water during dry season and high investment cost.

The Gojam plateau

It is the region's potential agricultural land known for its topography, climate and soil conditions. It occupies the major arable lands, which are characterized by vast flat to very gently undulating plains and high volcanic mountains. Except the foot slopes and continued flat tops, almost all mountains are virtually covered with shallow and/or stony soils. In some localities moderately deep organic matter, rich dark colored but stony soils do occur. Owing to the steepness of the mountains and severe erosion problems, soil depth is shallow.

The plateau

From a soil management point of view, major soils of the plateau landscape can be groped into three: Vertisols, Acrisols, Luvisols and Nitosol.

The Vertisols commonly occur in poorly drained lower topographic position and are heavy clay and dark coloured, soils while Acrisols, Luvisols and Nitosols occur on better drained physiography and are dark reddish to brown coloured. Acrisols are poorer in chemical fertility as compared to Luvisols and Nitosols. If managed properly and applied with necessary fertilizers and inputs, this is one of the areas where yield per unit area could be maximized. The plateau is endowed both with perennial and seasonal streams. Some could be used for irrigation so as to ensure double cropping in one year.
Soil and water resources in the Amhara Region

The Tana plain

It occupies the flat and depressions around Lake Tana. The Fogera plain to the east and the Dembia plain to the north of the lake are rich agricultural areas. The major soil types of the unit are Vertisols and Luvisols. The inherent soil physico-chemical properties of these soils are similar to that of soils of Gojam plateau. The major difference is that they are flooded seasonally (during the rainy season). They are water-saturated (logged) due to a high water table. As a result of drainage problem, a vast portion of the unit is put to grazing. On the higher slopes, cultivation is practised during dry spells using residual moisture.

Due to the difficulties in improving the drainage conditions, it would be better to put it to grazing land and to vegetable production which require more water.

The Abay gorge and Tekeze valley

The Abay Gorge is characterized by deep and steep incision of the river throughout the course in the region. The exception is the outlet near Bahir Dar.

The dominant soil type is Leptosols which are very shallow and stony in association with phaeozems. The presence of Arenosols where the sandstone formation is close to the surface. Due to the steepness, shallow soils and stoniness of the landscape, agriculture could not be more than subsistent and is unsustainable. The limestone and gypsum rock outcrops need further studies for economic viability.

The Tekeze valley differs from the Abay gorge by dominant soil types and topography. The valley has some flat terrain along the riverbank. The Luvisols are the dominant soils in the southern part and Arenosols in the north.

Due to the drier climate and erratic rainfall rain-fed agriculture can not be encouraged.

Water resource potential

The Region comprises of four basins. Three of them are river basins and one is a drainage basin. The upland plateau and the mountain ranges commonly drain westward in the north and southward direction to the great Blue Nile and in the north direction to the Tekeze River, respectively. The areas south-east of the plateau and mountain ranges drain through the lowland plain into the Awash river and the Afar (Dankil) depression, respectively. Some studies indicate that the surface water potential of the region is estimated to be 35 billion m$^3$ per annum. The groundwater potential for the country is not yet studied, but groundwater extraction for irrigation has started in the Kobo-Girana valley development.
Potential of Irrigation

Different sources state that the overall potential for irrigated agriculture in the Region is enormous. Primary surveys and master plan studies carried out to date on the major river system indicate that a total of around 650,000 hectares of land is available for surface irrigation. About 420,000 ha is shown to be medium to large scale irrigation project and is found in the Blue Nile basin. About 30,000 ha is estimated to be potentially irrigable in the Tekeze river basin. The remaining irrigable land is found in the Awash River and Afar drainage basins.

RECOMMENDATION

Highly degraded areas mainly in the south-eastern and north-eastern and other parts of the Region (which have the least vegetation cover and effective soil depth) should be reclaimed through area closure, integrated watershed and conservation-based protection approach, agroforestry/or multipurpose tree planting for fodder, fuelwood, etc. Medium priority can be given to arable lands on relatively low slopes highly degraded areas.

If managed properly and applied with necessary fertilizers and inputs, soils of the Gojjam plateau are areas where yield per unit area could be maximized.

Due to the difficulties in improving the drainage condition, waterlogged areas should be considered for improving grazing land and crops that require more water for their production. In general, due to drier climate and erratic nature of rainfall, rain-fed agriculture could not be encouraged in areas like Abay gorge, Tekeze valley and the like. Therefore, the possibility of irrigated agriculture should be considered.
INTRODUCTION

According to proclamation No 7/1992, Ethiopia is administratively divided in to nine National Regional states of which, the Amhara National Regional state (ANRS) is one of the regions with 11 zones (including one special zone, i.e. Bahir Dar), 113 woredas and 3051 kebeles. The Region is the second largest region in the country, next to oromya, in terms of area and population. With wide range of Agro-ecological Zonation conducive for different kind of fauna and flora.

Agriculture is the principal source of livelihood for about 89% of the population and accounts on the average for about 69.2 percent of the regional gross domestic product in real terms. This is more than two-thirds of the total. Crop and livestock activities contribute the greater share (61.1%) of RGDP grass domestic product for the period of 1993/94-1996/97. The region's economy is based on agriculture and the sole source of livelihood for the majority of the population, which is known for its traditional and subsistence type of farming system. The sector is highly dependent on natural factors. The variability in rainfall contributes to the largest part of the region to be more vulnerable to famine and food insecurity problem.

However, in areas with good rainfall, the agricultural extension program has shown great improvement in crop productivity and area coverage due to intensification practices. In the program, the share of land and production under selected food crops, namely maize, wheat, teff, barely and sorghum, has shown an average growth of respectively. The package diversity has reached some 75 types. The average productivity of the reported crops was above 25 quintals. The number of participant farmers at the start was 9.1 thousands and has reached to over 1168 thousands. At the start of the program, the diversity of package was very limited. Hence it was through time that the involvement of farmers in different packages began to materialize.

About Amhara region

The land use of the region
Total land = 17075200 ha
Land under cultivation =4.7 million ha=27.2%
• Meher = 4.3 million ha (91%)
- Belg = 0.3 million ha (6%)
- Irrigation = 0.75 million ha (3%)
- Agricultural density = 3.5 person/ha
- Per capita = 0.29
- Average land holding per household = 0.5-1.41

Pasture land = 30%
Forest and bush land = 19.7%
Residence = 5.3%
Water bodies = 0.7 million ha = 3.8%
Waste land = 14%

**Soil types by percentage**

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>30.4%</td>
</tr>
<tr>
<td>Brown</td>
<td>24.9%</td>
</tr>
<tr>
<td>Black</td>
<td>32.5%</td>
</tr>
<tr>
<td>Gray</td>
<td>11.2%</td>
</tr>
<tr>
<td>Other</td>
<td>0.84%</td>
</tr>
</tbody>
</table>

**Major Crop types and their percentage coverage**

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>74%</td>
</tr>
<tr>
<td>Pulses</td>
<td>14%</td>
</tr>
<tr>
<td>Oil crops</td>
<td>7%</td>
</tr>
<tr>
<td>Others</td>
<td>5%</td>
</tr>
</tbody>
</table>

**There are four climate zones**

- Kolla (<1500 m asl) 31.2%
- Dega (2500-3500 m asl) 20.5%
- Woyena dega (1500-2500 m asl) 44.3%
- Wurch (>3500 m asl) 4%

**There are nine agro-ecology zones**

<table>
<thead>
<tr>
<th>Zone Description</th>
<th>km²</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hot to warm semi-arid</td>
<td>34</td>
<td>0.02</td>
</tr>
<tr>
<td>2. Hot to warm sub-moist</td>
<td>18740</td>
<td>1.1</td>
</tr>
<tr>
<td>3. Tepid to cool sub-moist</td>
<td>38772</td>
<td>22.8</td>
</tr>
<tr>
<td>4. Cold to very cold sub-moist</td>
<td>2891</td>
<td>1.7</td>
</tr>
<tr>
<td>5. Hot to warm-moist</td>
<td>24828</td>
<td>14.6</td>
</tr>
<tr>
<td>6. Tepid to cool-moist</td>
<td>69311</td>
<td>40.6</td>
</tr>
<tr>
<td>7. Cold to very cold-moist</td>
<td>7992</td>
<td>4.6</td>
</tr>
<tr>
<td>8. Hot to warm sub-humid</td>
<td>2742</td>
<td>1.6</td>
</tr>
<tr>
<td>9. Tepid to cool sub-humid</td>
<td>5442</td>
<td>3.1</td>
</tr>
</tbody>
</table>
Temperature

- Mean high > 26°C
- Mean low < 11°C

Rainfall

- Lowest 5000-700 mm/annum
- highest > 1400 mm /annum

Population = 16.79 million (1/4 of the country’s population)

2.7% annual population growth
2nd most densely populated (100p/km²)
89% rural
11% urban
About 3 million households
Consists 11 adm.zones, 113 woredas, 3224 kebeles
94% Amhara
6% Agew, Hemera and Oromo
18-20% of the population critically is food insecure
Rural road density = 13.8 km/1000km²

Education coverage/primary/ = 43.4%
Health coverage = 42.9%

Potential and gaps. Meher crop production and input utilisation rate (1990/91-1993/94EC)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cereals</td>
<td>Qt</td>
<td>34475068</td>
<td>36465322</td>
<td>36350212</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Pulses</td>
<td>Qt</td>
<td>5208059</td>
<td>4377316</td>
<td>4603704</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Oilseed</td>
<td>Qt</td>
<td>1194731</td>
<td>1154387</td>
<td>1196592</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Vegetables</td>
<td>Qt</td>
<td>3204754</td>
<td>4319204</td>
<td>4337817</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Spices</td>
<td>Qt</td>
<td>268482</td>
<td>314467</td>
<td>274910</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Others</td>
<td>Qt</td>
<td>241976</td>
<td>261145</td>
<td>349974</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Qt</td>
<td>44593070</td>
<td>46891841</td>
<td>47113209</td>
<td>48991264</td>
</tr>
</tbody>
</table>

Remark: Only cereals are taken for the calculation of food balance sheet
Irrigation potential

Three major river basins i.e. Abay, Tekeze and Awash
Water resource = about 35 billion cubic meter (32% of the nation's water resource)
Irrigable area 500000 ha
Developed = 75900 ha (traditional small scale) which is 10%
To be developed + 424100 ha

Coffee production potential

Suitable land for coffee = 1555160 ha
Developed = 13846 ha
To be developed = 1541314 ha

Livestock and poultry potential

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>In &quot;000&quot;</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cattle</td>
<td>8936.98</td>
<td>(30% of the national)</td>
</tr>
<tr>
<td>2</td>
<td>Sheep</td>
<td>3825.56</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Goats</td>
<td>3700.11</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Horses</td>
<td>241.04</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Asses</td>
<td>1072.74</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mules</td>
<td>83.85</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Camel</td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Poultry</td>
<td>9067.2</td>
<td></td>
</tr>
</tbody>
</table>

Note: The region has also the Fogera breeds of cattle and the North Shewa sheep is also another area of potential
Skin and hides supply to the central market

<table>
<thead>
<tr>
<th>No.</th>
<th>Year</th>
<th>Skin</th>
<th>Hide</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1989</td>
<td>35000</td>
<td>4831960</td>
</tr>
<tr>
<td>2</td>
<td>1990</td>
<td>18880</td>
<td>4798800</td>
</tr>
<tr>
<td>3</td>
<td>1991</td>
<td>45580</td>
<td>4585200</td>
</tr>
<tr>
<td>4</td>
<td>1992</td>
<td>60550</td>
<td>3739400</td>
</tr>
<tr>
<td>5</td>
<td>1993</td>
<td>80000</td>
<td>2851000</td>
</tr>
<tr>
<td>6</td>
<td>Total</td>
<td>240010</td>
<td>20806360</td>
</tr>
</tbody>
</table>

Honey production

The region has high potential for this sub sector
- Traditional beehive = 683990 prodn. 5-10kg/hive
- Transitional beehive = 8081 prodn. 10-15 kg/yr/hive
- Modern beehive = 1664 prodn. 20-25 kg/yr/hive

Fish potential

There are about 11 water bodies
- Fish spps, namely
  - Tilapia,
  - Barb us,
  - Catfish,
  - Bezo,
  - Carp,

The production potential /yr is 16200 tone, while the actual production is 1205 tone.

Incense and gum potential

<table>
<thead>
<tr>
<th>Zone</th>
<th>No of</th>
<th>Area coverage ha</th>
<th>Potential of production (qt)</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Incense</td>
</tr>
<tr>
<td>North Gonder</td>
<td>9</td>
<td>419246</td>
<td>1173000</td>
</tr>
<tr>
<td>South Gonder</td>
<td>5</td>
<td>4504</td>
<td>8400</td>
</tr>
<tr>
<td>West Gojjam</td>
<td>3</td>
<td>22093</td>
<td>39000</td>
</tr>
<tr>
<td>East Gojjam</td>
<td>4</td>
<td>34806</td>
<td>82000</td>
</tr>
<tr>
<td>North Wollow</td>
<td>2</td>
<td>1450</td>
<td>6400</td>
</tr>
<tr>
<td>North Shewa</td>
<td>2</td>
<td>400</td>
<td>4300</td>
</tr>
<tr>
<td>Awi</td>
<td>2</td>
<td>31590</td>
<td>6500</td>
</tr>
<tr>
<td>Waghemera</td>
<td>2</td>
<td>3900</td>
<td>22000</td>
</tr>
<tr>
<td>South Wollow</td>
<td>5</td>
<td>86393</td>
<td>713000</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>604382</td>
<td>2054600</td>
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</table>
### Forest cover of the region

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Unit</th>
<th>Amount</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Dense natural forest</td>
<td>ha</td>
<td>81047</td>
</tr>
<tr>
<td>2</td>
<td>Woodland</td>
<td>ha</td>
<td>716915</td>
</tr>
<tr>
<td>3</td>
<td>Bushland</td>
<td>ha</td>
<td>1986870</td>
</tr>
<tr>
<td>4</td>
<td>Skrubland</td>
<td>ha</td>
<td>3396870</td>
</tr>
<tr>
<td>5</td>
<td>Artificial forest</td>
<td>ha</td>
<td>32213</td>
</tr>
<tr>
<td>6</td>
<td>Private forest</td>
<td>ha</td>
<td>71175</td>
</tr>
<tr>
<td>7</td>
<td>Total</td>
<td>ha</td>
<td>6285090</td>
</tr>
</tbody>
</table>

Major agricultural extension program activities, Amhara Region, 1995-2000

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Crop dev't package</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Demonstration farmers</td>
<td>No</td>
<td>4279</td>
<td>75754</td>
<td>73696</td>
<td>195277</td>
<td>280490</td>
</tr>
<tr>
<td></td>
<td>Copier from demonstration</td>
<td>No</td>
<td>128</td>
<td>41618</td>
<td>22785</td>
<td>397972</td>
<td>566036</td>
</tr>
<tr>
<td></td>
<td>Self-sustained farmers</td>
<td>No</td>
<td>4110</td>
<td>695</td>
<td>17127</td>
<td>75785</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Copier from self-sustained farmers</td>
<td>No</td>
<td></td>
<td></td>
<td>6360</td>
<td>33143</td>
<td>79206</td>
</tr>
<tr>
<td>2</td>
<td>Cultivated land</td>
<td>Ha</td>
<td>1932.8</td>
<td>18909.5</td>
<td>36403.1</td>
<td>168751.6</td>
<td>191284.7</td>
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<tr>
<td>3</td>
<td>Demonstration plots</td>
<td>No</td>
<td>4647.5</td>
<td>51738.6</td>
<td>85029.8</td>
<td>355137.1</td>
<td>525453.7</td>
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<tr>
<td>4</td>
<td>Feed development</td>
<td>No</td>
<td>51</td>
<td>8</td>
<td></td>
<td>480</td>
<td>389</td>
</tr>
<tr>
<td>5</td>
<td>Natural resource dev't</td>
<td>No</td>
<td>262</td>
<td>1942</td>
<td>9574</td>
<td>21755</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Demonstration farmers</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td>14959</td>
<td>38951</td>
</tr>
<tr>
<td></td>
<td>Self-sustained farmers</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td>389</td>
<td>1921</td>
</tr>
<tr>
<td>6</td>
<td>Post harvest loss</td>
<td>No</td>
<td>45</td>
<td>257</td>
<td>96</td>
<td>646</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Animal packages</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Demonstration farmers</td>
<td>No</td>
<td>490</td>
<td>1549</td>
<td>10531</td>
<td>20741</td>
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</tr>
<tr>
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<td>Copier from demonstration</td>
<td>No</td>
<td>1795</td>
<td>11453</td>
<td>28668</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-sustained farmers</td>
<td>No</td>
<td>224</td>
<td>712</td>
<td>3206</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Copier from self-sustained farmers</td>
<td>No</td>
<td></td>
<td></td>
<td>286</td>
<td>296</td>
<td></td>
</tr>
</tbody>
</table>

Total participant farmers No 4407 122285 109099 692160 1118090

Source: compiled from wereda Agricultural Development offices

Remark: In areas with abundant rainfall the program has shown improvement in productivity in selected crops like maize, wheat, teff barley and sorghum with an average productivity of 25 qt. The package diversity has also reached to about 75. However, amongst many problems of the program, concentrating only on crops and focusing less on other disciplines was the prominent one.
Manpower of the Bureau of Agriculture

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PhD</td>
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<td>2</td>
<td>1</td>
<td>2</td>
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</tr>
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<td>2</td>
<td>DVM</td>
<td>75</td>
<td>87</td>
<td>105</td>
<td>116</td>
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</tr>
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<td>3</td>
<td>MSc</td>
<td>89</td>
<td>129</td>
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<td>4</td>
<td>BSc</td>
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<td>343</td>
<td>446</td>
<td>536</td>
<td>627</td>
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<tr>
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<td>Diploma</td>
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<td>1624</td>
<td>1750</td>
<td>2013</td>
<td>1948</td>
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<tr>
<td>6</td>
<td>Certificate</td>
<td>883</td>
<td>1377</td>
<td>1632</td>
<td>3886</td>
<td>5335</td>
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<td>7</td>
<td>Others</td>
<td>1302</td>
<td>1865</td>
<td>2999</td>
<td>3814</td>
<td>3172</td>
</tr>
<tr>
<td>8</td>
<td>Total</td>
<td>3944</td>
<td>5427</td>
<td>7077</td>
<td>10531</td>
<td>11380</td>
</tr>
</tbody>
</table>

However due to the new restructuring the manpower and positions are obviously expected to change therefore:

Total positions allowed currently = 4907
  Bureau level = 184
  Zonal level = 33
  Potential woredas = 46 * 49 = 2254
  Drought prone woredas = 44 * 53 = 2332
  Investment woredas = 26 * 4 = 104

The structure of the organization consists of:

- Bureau head
- Two bureau heads
- Crop Production and Protection department
- Natural Resource Development and Protection Department
- Livestock development department
- Planning and Agricultural Information department

Personnel Adm. Service
Financial Adm. Service
Training and Human Resource development Service
Agricultural Extension Policy and Strategies in the ANRS

AYNALEM GEZAHEGN
Bureau of Agriculture, P. O. Box 437, Bahir Dar, Ethiopia

INTRODUCTION

As we know, the Ethiopian economy is dependent on agriculture which, in turn, is dominated by traditional small-scale farmers. Since 1908, the government has been trying to promote extension services to enhance the productivity of small farmers. The year 1908 can be said to be the first time agriculture got recognition. An agricultural office called “Yersha Mesriabet” was established and had the following objectives:

1. Advisory service and monitoring of both crop and livestock production
2. Animal health service
3. Forestry development and conservation

In 1931, “Yersha Mesriabet” was restructured through proclamation and its name was changed to Ministry of Agriculture. Upto 1953, however, the agricultural extension service was not properly organized due to unclear objectives, unclear targeting of beneficiary farmers, unclear extension methods to be followed, and lack of proper organization and definition.

From 1953 to 1987, the government launched a restructured full fledged extension intervention program or as pilot projects. Most of the programmes and projects had the following common characteristics:

- The impact of all of these development interventions was not that much significant in terms of improving the life of the rural population and the mode of farming and productivity, in particular.
- There were only few changes made such as the introduction of artificial fertilizer and the use of improved seeds and animals
- In general, productivity per unit area did not significantly improve over the traditional method.

Since 1994/5 (1987E.C), the Ethiopian Government designed a new extension approach known as participatory demonstration and training extension system (PADETS). Which is a development intervention with the ultimate goal of increasing productivity. This extension approach covers the whole country. The PADETS approach in ANRS involved demonstrating agricultural activities on farmers’ field, providing training and visiting service for both development agents and farmers, facilitating input and credit supply, etc.
PADETS improvements over previous approaches

It enhanced package approach and increased productivity /production. Also, it brought about behavioural change, such as Whanging farming practices /row planting of maize. Different varieties of improved seeds, were used. Commercial fertilizer consumption increased.

Table 1. Fertilizer and improved seed consumption trend

<table>
<thead>
<tr>
<th>Cropping year</th>
<th>Fertilizer consumption</th>
<th>Improved seed consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988/89</td>
<td>616680</td>
<td>13614</td>
</tr>
<tr>
<td>89/90</td>
<td>557203</td>
<td>25857</td>
</tr>
<tr>
<td>90/91</td>
<td>721851</td>
<td>25283</td>
</tr>
<tr>
<td>91/92</td>
<td>740445</td>
<td>99498</td>
</tr>
<tr>
<td>92/93</td>
<td>829524</td>
<td></td>
</tr>
<tr>
<td>93/94</td>
<td>726653</td>
<td></td>
</tr>
</tbody>
</table>

PADETS improvements included increased participation by beneficiaries. In 1987, four packages were used on 8099 demonstration fields; in 1993/94 cropping calendar, the packages increased to 85 conducted in 1527243 demonstration fields with 1224429 fanners participating. (Table 2). The number of development agents increased. Improved linkages among different stakeholders which participated in the system directly or indirectly.

Table 2. Number of participants and demonstration trend

<table>
<thead>
<tr>
<th>Cropping calendar</th>
<th>No of participants</th>
<th>No of demonstrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987/88</td>
<td>8099</td>
<td>8099</td>
</tr>
<tr>
<td>88/89</td>
<td>83645</td>
<td>87535</td>
</tr>
<tr>
<td>89/90</td>
<td>278367</td>
<td>149501</td>
</tr>
<tr>
<td>90/91</td>
<td>938500</td>
<td>982231</td>
</tr>
<tr>
<td>91/92</td>
<td>1197100</td>
<td>1315598</td>
</tr>
<tr>
<td>92/93</td>
<td>1182673</td>
<td>1495807</td>
</tr>
<tr>
<td>93/94</td>
<td>1224429</td>
<td>1527243</td>
</tr>
</tbody>
</table>

Weaknesses of PADETS

PADETS focused only on production extension. There was no marketing extension. It also focussed on the number of demonstrations irrespective of this quality. The target group identification did not address all groups of the community living in a given area. The production did not target local and foreign markets. There was clear lack of technology which suited all agroecologes.

To improve these drawbacks, the ANRS designed a new agricultural extension system in 1994 named the "Training and Advisory Services".
Training and Advisory Services extension system

The system has objectives, target groups, contents and organizational structure. The main objective of the system was to enhance effective use of natural and human resources to produce quality and marketable products both on local and foreign markets in order to increase the household income. Specific objectives were (1) Production of good quality produces which can compete on the world market; (2) Promoting different technologies which suit farmers conditions; (3) Enhancing food-processing technologies in areas where surplus production is available; and (4) Enhancing natural resource development, conservation and efficient use of these resources.

Target groups /beneficiaries
Farmers living in the region do not all have the same economic status, farming practices, culture and religion. They live in different environments. Stratifying them to different groups is important to know their felt needs and develop technologies. The target groups identified were: Farmers living in areas with adequate rain fall, farmers living in erratic rainfull areas, women farmers, farmers living in and working around investment areas, farmers using irrigation, those farmers whose livelihood mostly depends on livestock production but who carry on some crop production (pasturalists), voluntary settler farmers, farmers which participate in specialized farming activities, school dropout (youth) farmers.

Major strategies of the system were:
Strategies involved mobilizing and motivating the community through awareness creation. It included motivating farmers to make good decisions, educating them to better understand new technologies, aim for internal motivation which leads to attitudinal change and action, to adopt new technologies.

Major strategies included organizing farmers. After creating motivation and awareness, extension agents organize the farmers into small groups based on their needs by village, farmland, farmers who have similar activities and belong to service cooperatives. Organizing farmers is useful to save time, labour and money, share experiences among farmers, find common solution for problems.

Mobilization and organizing farmers are based on package approach to give advisory and training service on the following agricultural activities, namely: crop production development, livestock production development, natural resource development, water-harvesting technology, family planning and home economics, as well as promoting market information.

Training components of the system
Training is given for both staff members and farmers. The staff members training includes short and long-term training conducted in local institutions
some of which are in overseas colleges and universities. Farmer training takes place in the farmer training centres established in each PAs. The duration of training depends on the type of module. The maximum training period is six months. The syllabus is structured for 80% practice and 20% theory.

Communication methods of the system

The extension method considers, the size and educational level of the target group, the level of trust between the target group and extension agents, the extension agent skills, manpower and resources available, type of objectives/goals. A further selection includes individual method, group method and mass method.

Organisational structures

To achieve the stated objectives and organization of the extension program, the ANRS Bureau of Agriculture organized four technical departments: Crop production and protection technology promotion, Animal fish resource development and veterinary service, Natural resource development and conservation technology promotion, and Agriculture Extension. Major activities of these four departments are:

- formulation of policy directives,
- preparing training and workshops,
- identifying and collecting technologies from both local and abroad sources,
- conducting case studies and conducting field supervision.

The woreda level agricultural office has four technical desks, namely crop production and protection technology promotion, animal and fish resource development and veterinary service natural resource development and protection extension and home economics. Major responsibilities of the four desks were to lead the agricultural activities, give training to developing agents and to select, appropriate technologies suitable to the woreda condition and collecting statistical data.

At the kebele level, three specialized development agents for a group of farmers 1000 will be assigned (at each development centre). The major activities of DAs are to give advisory service, arrange demonstrations, provide market information, collect agricultural statistical data, coordinate input supply, give training for farmers, give information about the availability of credit and other inputs, assess training needs of the farmers.

Linkage: This issue concerns creating suitable cooperation and collaboration among different stakeholders who can contribute to the system for the achievement of the stated objectives. The following institutions are the stakeholders: BoA staff at all levels and farmers are main actors in the system, credit institutions, input supply institutions, research institutions, administrative institutions, cooperatives, among others involved in the extension system. Therefore, creating a smooth relationship with different actors is very important for any development intervention.
Forest and Wildlife Resources in the Amhara Region: 
Potentials and Constraints

TESHOME TESEMA
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ABSTRACT

The Amhara region have been endowed with various natural resources such as forests and wildlife. But, the ever growing population demand more land for cultivation and hence forests are subjected to encroachments and poaching. As a result forest coverage is shricked to patches and disappearing from the landscape paying a way to land degradation, environmental deterioration, and created a wide gap between wood supply and demand. Although a remarkable effort to revert the prevailing condition is on the way, it needs to be supported by strong forestry policy and research backstopping. State and commercial investments in the area of forestry and wildlife should be encouraged. We cannot even think about agricultural production and economic growth unless and otherwise we conserve and develop our natural resource base such as forests and wildlife.
An Overview of the Research Master Plan in ANRS and the Status of its Implementation in the Short Term Period

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ABSTRACT

Agricultural research Ethiopia started about 50 years ago with its up and down phases and develop to what is now Ethiopian Agricultural Research Organization (EARO). The Ethiopian Agricultural research system currently encompasses EARO, Regional Research Institutes. Many technologies were developed in the past by the research system and some of them have been extended successfully to users. However, for more successful research in the short and long term the Regional Agricultural Research Master plan (RARMP) was prepared and approved for 20 years encompassing research approaches, the research foci and targets, major thematic research areas identification agriculturally important agro-ecological zones in the region, and preparation of action plan, particularly of the short term. The status of the RARMP implementation by ARARI in the short term was in areas of establishing new center, strengthening of the existing center, execution of research programs, linkages, human resources development, and documentation. Finally, conclusion and recommendation to realize the remaining part of RARMP was made.
During the last day of the workshop, participants decided to form three groups, so as to analyse the contributions and recommendations of the presentations. It was also to consolidate the acquired technical and policy intervention for possible implementation by ANRS authorities. The three themes were: Natural Resource development & conservation, Research & extension approaches, and Networking / linkages and partnership. The summary of the presentations is presented here under.

Group I presentation by Dr. Eylachew Zewdie

Natural Resource Development and Conservation Issues

- Natural Resources include soil, water, natural vegetation, wildlife, livestock and crops

A. Constraints / limitations to natural resource conservation in ANRS

1. Approach / Technology - related constraints

   - Limited to low bio-mass production of the system
   - Current crop biased extension facilitation
   - Weak water harvesting, utilization and management experiences
   - Up-trend accountability
   - Unitary and top-down approach in policy development and implementation
   - Too hierarchal facilitation system
   - Lack of planting materials of forages and trees
   - Limited women empowerment in NRM
   - Fragmented development and conservation approach
   - Accessibility problems in technological and market options, mainly related to poor road facilities
   - Inadequate utilization of indigenous knowledge/resource
   - Heavy dependence on external sources for inputs and food aid
   - Food aid dependence for natural resource conservation activities

2. Policy/Incentives affecting NRM in ANRs

   - Excessive dependence on bio-mass energy and limited attempt to replace the biomass
   - Scarcity of livestock feed resources
   - Weak capacity and linkage between relevant institutes involved in NRM
   - Inadequate participation of the grass root actors on NRM policy development, monitoring and evaluation
• Lack of incentive for economically non-viable and non-accessible regions
• Absence of policy back-up on committed conservation and protection effort towards bio-diversity resources
• Biased towards crop production centered food security strategy
• Extremely high cost of agricultural inputs, mainly inorganic fertilizers and improved seeds
• Single lined agricultural development, which did not follow holistic approach
• Limited role of government in joint forest management and community action
• Absence of regional policy on food aid centered NRM activities

3. Lack of competence/capacity in terms of designing and implementation of viable NRM projects

• Lack of educational, organizational and technological competence to support local institutions
• Lack of awareness of grass root actors towards wise utilization of resources and development interventions
• Limited capacity of facilitators and farmers in up-scaling of successful NRM intervention

B. Solutions / recommendation to be considered by researchers and policy makers

1. Approach and Technologies to be considered for future NRM interventions

• Encourage increased bio-mass production of individual households to be self-sufficient in their requirement for energy, feed, construction and compost preparation
• Sloppy lands and abandoned lands to be distributed to individual, and groups for afforestation, to increase bio-mass production
• Energy efficient stoves usage be expanded
• Government should reduce tariff on substitute energy and construction materials
• Institutions should provide appropriate incentive for self sufficient individual in their bio-mass requirement
• The focus to crop biased technologies be replaced by holistic approach including training and human resource deployment
• Water harvesting, utilization and management interventions be encouraged both at community and farmer level
• Private entrepreneurship on river basin who focused on water harvesting and utilization for agricultural production should be encouraged
• Accountability be made two-way (both bottom-up and top-down)
• Wereda centered development approach appreciated; however a participatory monitoring and evaluation system by which policy implementation can be evaluated be devised
• Integrated watershed/catchment development approach that consider components should be promoted by all relevant institutions. The watershed approach should integrate local knowledge and collective action with imported technologies.

• Failure and success in integrated watershade management be documented and the lessons used to develop pilot water shade management sites.

• Commitment and competence in technology transfer and dissemination should be improved.

• There should be a clear strategy on improvement and use of locally available resource.

2. Policy recommendations

• Regional policy on food aid centered activities implementation should be revisited.

• Modern energy usage policy should be facilitated at various levels.

• Capacity building and linkages among various actors and implementers be enforced by policy.

• Farmers of the future should be integrated to regional schemes capacity building.

• Monitoring and evaluation should be farmer participatory, quality and impact focused.

• There shall be policy on law enforcement on the rationale utilization of NR resources eg. forest, water.

• Food security strategy should focus on income and diversified asset creation.

• There shall be pilot sites specializing in conservation of bio-diversity in the region.

• Private and group nurseries for afforestation be given highest priority.

• Net working to sources of high value planting materials should be established.

• Women be empowered in planning, implementation, resource ownership and use of NR.
Group II  Presentation by Dr. Belay Simane

Research and Extension Approaches

In the ANRs region
• Research and extension did not bring the expected out puts todate in Natural Resource Management (NRM), as priority was given mainly to crops sector

On the other hand, NRM research is complex and capital knowledge and labour intensive.

The major NRM problems of the ANRS system are
• Water and soil erosion, associated with sloppy landscapes
• Deforstation, mainly as a source of cooking fuel
• Overgrazing, associated with overstocking and limited feed resources
• Mismatch of technologies in NRM with physical and socio-economic situations

1. Current research frame work of ANRS
• Research master plan recently prepared, intending to promote better technology integration
  • System problems identified and prioritized
  • Implementation mechanism suggested and planned for implementation
• Suggestion from the group towards improving the research frame work
  • Inventory of resources in the region
  • Inventory of technologies, approaches and methodologies
  • Task sharing (ARARI should identify stakeholders and coordinate responsibilities) among various implementing institution

1.1 Methodologies for NRM interventions
• Define the possible clients (farmers, policy makers, investors, extension, NGOs...)
• Develop intervention matrix that are required for implementation
  Problem-Resource Inventory, available technologies, methods, approaches, responsible institutions
• Promote multidisciplinarity and holistic approach
• Shift from conventional to integrated watershed approach towards addressing system problems
• Consider farmers/community participation as a prerequisite
• Synthesis of indigenous knowledge and using it as an entry point
• Distribute summary of research master plan in local languages, and to all stakeholders

1.2 Forest Resources Management and Recommendation
• Resource degradation in the region is high
• Little contribution from research todate, although there are shelved technologies
• Training be considered as one basic ingredient for success
  • Improved productivity of systems through integration of multipurpose trees
  • Share costs and benefits with local communities
  • Strategic planning with local actors

2. Current Research –Extension-Farmer Linkage could be characterised as follows:
• NRM not favored and the institutional support is weak
• Little understanding of dissemination processes and dissemination channels
• Poor policy support

Suggestion for improvement

a. Favoritism towards NRM should be encouraged
b. Develop effective technology promotion strategies at all level

2.1 Capacity Building
• Bringing researchers and extension workers to the same wave length. In this case, short term training may be required
• Local, national and international tours may help
• Recognize the current institutional arrangements in rural development and link with federal institutions may facilitate the process

2.2 Coordination
• Different institutions used to be involved and yet there was no adequate coordination & implementation
• Strategies are available but too theoretical

Suggestion

• A need for annual forum, where actors should exchange information
• Improve relation with higher learning institutions and with researchers from outside the region/country

2.3 Agroecological Zonation
• Need fin tuning
• EAROs effort should be integrated

2.4 On technology transfer
• Shift to T & A and farmers training
• State of the art technologies should be made available
• Networking across actors and institutions be improved
• Entry points towards collective action should be identified
• Incentives at various levels should be considered
• Local institutions/policies should be strengthened
• Farmer-to- Farmer training should be promoted
• Technological options would be more acceptable by end users than packages.
Group III Presentation by Ato Yitayew Abebe

Networking / Linkage partnership

Forum for Natural Resources Management and Conservation within ANRS

1. Preamble

In ANRS there are,
- Diversified actors
- Different interests and
- Different level of capacity

2. Problems

- Lack of coordination across different levels, institutions and themes
  - Duplication of activities, which costs time and money have been observed
  - Woreda level decentralization may have its own effects
  - Low level of data / information flow was recognized as a constraint
  - Weak research extension system, which created
    - poor communication among actors and
    - Limited client – oriented research outputs delivered

3. Existing potential resources (Networking)

- Woreda level development committee
- BOPED – on going networking initiative
  - Extension basic agriculture inform.
- Go/NGO forum
- Establishment of ARARI
- Newsletters & journals of sector bureaus

4. Objectives of Networking

4.1 Encourage stakeholders to systematically document available natural resources data, and in the long term formulate regional level NR Data base center

4.1.1 Strategies

- Create collaborative working atmosphere among stakeholders
- Encourage stakeholders to properly compile their available data in a user friendly format
- Creation of discussion / daily forum for fine tuning.
4.2 Design information flow strategies among stakeholders

4.2.1 Strategies suggested

- Use all available media including electronic means
- Work towards publication and dissemination of IEC materials to stakeholders and general public
- Use public fora including traditional ones.
- Create enabling environment to the formation of interactive public fora

4.3 Create awareness and sensitize the public on status risk & conservation of NR in the region.

4.3.1 Strategies

- Encourage formation of environmental groups / clubs in schools, CBOs, etc. including those: environmental and tree planting days
- Encourage the private sectors in awareness creation campaigns.
- Strengthen the existing school curriculum with environmental issues
- Promote information flow within the community on alternative energy technologies
- Document success stories on NR and establish rewarding systems
- Lobby for the exemption of fees for promotion of NR conservation and environmental protection.

4.4 Create public dialog fora on NR policy review and follow-up

4.4.1 Strategies

- Consolidation of existing NR related policies
- Initiate / organize public dialog fora on draft NR policies
- Create conducive environment which enables all citizens to express their concern on risks & illegal usage

5. Stakeholders that should be in the forefront of the implementation

- Rural development bureau
  - ARARI
  - BoA
  - EPLAUA
  - COSERAR
  - Wat. Min. & Energy
  - BOPED

- Federal
• All corresponding government bodies
• Ethiopian Agricultural Research Organization
• Ethiopian Science and Technology Commission Etc.

• Civic. societies
• NGO
• Professional societies
• Religious org.
• Bi & Multi-lateral agencies (USAID, GTZ, etc.)

6. Recommendation

• ARARI & EPLAUA to play the leading sole
• Network forum to be established in three months of time
• Each stakeholders should realize the urgently of NR status and its required collaboration action.
DISCUSSIONS HIGHLIGHT

Q1: How stable is agro-climatic classification? Also, what is the practical implication of agro-climatic classification and crop production? We need to establish relationship.

A1: This classification is based on climatic data of several years. It shows the climatic potentials of the region for determining land-use and long-term agricultural planning. However, climate has interannual variability. Climate variability helps planning agricultural activities of that particular year. The practical applications of these zones for crop monitoring require the application of crop water balance model in each agroclimatic zone. This would help in determining the crop water requirement.

Q2: The year with LGS of below 90 days was declared a drought year. Does this also include parameters such as soil texture with respect to retaining soil, water, or evapotranspiration rate, etc? Otherwise, don't you think this classification could oversimplify the definition of a drought year?

A2: In determining the LCP, I used a water balance approach which incorporates soil moisture and water holding capacity of the soil. Therefore the soil factor has also been taken into consideration when determining the LGS and drought condition.

Q3: I know that each agroclimatic zone has its own complement of crop varieties adapted to it. Sorghum may take any length of time between 10 and 3 months depending on the variety. Tef also takes 1½ - 6 months. I think it would be an over-simplification to define a single length of rainfall duration to be used across agroclimatic regions as constituting a drought. I believe that each agroclimatic zone, with its complement of particularly adapted farmers' varieties of crops, has its own particular length of rainy season that is the threshold of drought.

A3: As I said in my presentation, there are some pulses and very low yielding teff and wheat varieties and wheat that require below 90 days of LGS. But most crops grown in the country require above 90 days of growing season to give a reasonable production.

Q4: Land management is one of the critical factors affecting policy decisions in rural development. What is the practical implication (of the soil classification you presented) and what recommendations. Did you have for decision-makers at higher level?

A4: Highly degraded areas mainly the south eastern, north eastern and other degraded parts of the region (which have least vegetation cover and effective soil depth)
Discussions

should be reclaimed through area closure integrated water shed management and conservation based protection approach.

Q5. What are the real problems / constraints behind the poor integration of trees and tree crops?

A5: The delay of the implementation of landuse policy, free grazing, lack of tree seeds, marketing etc. can be mentioned.

Q6: What are the tangible steps taken by ANRS towards encouraging private investment in the foresting sector.

A6: The government has prepared a forest investment policy which makes investors free from taxation up to 25 years. But you don't see people investing in this area. The problem may be associated with the minimum size of the plot suggested by the policy maker, which was about 10 ha. you can not get 10 ha of bare land. What is available is between ½ and 1 ha of land.

Q7: Conservation is a cross cutting issue and should not focus only in low potential areas. All development ventures (agriculture, water, irrigation, dam, etc) should be conservation based if sustainable development is going to be achieved.

A7: I didn't say that conservation is not needed for high potential areas. However, I tried to focus on specific approaches to tackle root causes of poverty in the so-called high Vs low potential areas. To speed up development for high potential areas, we have to increase production through increased supply of input and proper management practices.

Q8: The land use plan of ANRS prohibits further land redistribution without community consensus. This is a good start but does not go far enough to address low productivity. There should be provisions for individuals to consolidate land and resource to build wealth and increase productivity within rural settings.

A8: Redistribution has been thoroughly discussed by the regional policy makers. In tomorrow's session that will be presented and discussed.

Q9: Eucalyptus improves income generation and meeting needs of wood for fuel and construction, but eucalyptus is hard on the soil, suppresses other plants and crops, exploits too much water and soil nutrients. So, eucalyptus has both problem and benefits; how can we compromise this.

A9: Farmers in the ANRS and in Oromiya now establish eucalyptus in thier croplands. They produce agricultural crops during the first and 2nd year they act as nurse crops to eucalyptus and allow it to grow fast and thus escape damage from domestic animals. This method of eucalyptus establishment minimizes competition with food crops and greatly reduces tree plantation establishment & (direct) costs. But once established (after 18-24 months) eucalyptus will begin to
feed and draw water from lower soil depths and does not compete with agriculture crops which are confined to soil depths not exceeding 30-40cm. This cry of water and nutrient depletion from agricultural lands is not quite correct. Eucalyptus only uses lost soils nutrients and moisture.

Q10 / comment: You make it sound that eucalyptus is the most environment friendly of trees. But:-

1. Even if its water consumption per unit biomass is low, it grows throughout the year thus drying up the soil. That is why we have many reports of springs drying up upon planting with Eucalyptus.
2. The leaf shape of Eucalyptus enlarges even small drops of rain. And because it is a tall tree, the drops have a serious erosion impact on the soil.

Considering all these, it is best to treat Eucalyptus not as an environment-friendly tree, but as a crop whose negative impacts we have to ameliorate.

Q11: In your presentation you have indicated major constraints of technology transfer, which could be classified as constraints related to technology development and socio-economic status of the people (farmers). Which one is the most important constraint and what will be the means to overcome?

A11: I can agree with the comment on the categorization of the adoption barriers into technical and social factors with equal priority. However, much is done on the technical aspect relative to the social constraints. Therefore, in the future research efforts more attentions should be given to the social and the policy issues.

Q12: SWC technologies do not produce a positive impact or yield. The SCRP had all along argued that the SWC technologies that it had introduced (Fanya Juu, gtered bunds, etc.) were the most appropriate technologies to the farmer. Is it therefore surprising that the farmers are reluctant to adopt soil conservation technologies?

A12: The SWC structures are very important in reducing run-off volumes and sediment loss, however, yield loss was observed due to physical land lost because of the structures. As to the farmers, unless these structures are integrated with improved practices and inputes that increase productivity, one should not expect adoption using only physical structures.

Q13: 1. Most of the researches in ARARI are young and need to benefit from advice and guidance from experienced researchers available at EARO. Please comment on the issue of strengthening linkage between ARARI and EARO with a special focus on capacity building.
2. The linkage between research and extension in Ethiopia has not been strong. What strategies are planned in the ANRS to strengthen linkage between Research and Extension?

A13: As it has been mentioned most researchers are
1. young but energetic to work, some of the senior researchers are on study leave. Generally ARARI researchers are benefiting from EARO senior researchers during research program review and also by arranging short term training on identified topics.
2. in fact in ANRS the research - Extension - farmers linkage is growing compared to previous exercises. There is good working relation of ARARI and BoA, we work together in on farm research especially in two zones and this involvement will increase. There is also an evaluation of the on farm research work together on the field and select the best technology together.

Q14: Although the formulation of the land use policy is a great landmark in the history of natural resources management, the main question implementation. What strategies you have designed on to implement on?

A14: The authority's effort will greatly depend on its capacity. At the moment it has about 20 technical staff at the head office. The 13 positions are approved for Woreda desk. Hoping that the Woreda Desk will be have enough saturated with personnel, the authority has planned (annual plan) to:
- Certifying land (titling land)
- Preparing EIA guideline and
- Piloting land administration

Q15: The multidisciplinary group suggested for watershed management is deficient in biodiversity other than forests and the environment. It should not focus only on agriculture, it should include other biological disciplines and environmental disciplines.

A15: It would be an advantage to include other biological and environmental disciplines in the group. However, one has to note that the more the group members, it will be difficult to organize the field work. A good agronomist is assumed to look into these issues.

Q16: have never met an Ethiopian farmer who does not use the market "small holder farmer" but not subsistence farmer describes the Ethiopian farmer accurately. If the Ethiopian farmer is backward, what direction are we considering? "Backward" and "forward" are relative. I do not believe that industrial agriculture takes us forward.

A16: A farmer that doesn't use improved technology, highly dependent on natural resource like rainfall, who doesn't produce sufficient food for his family and is found under absolute poverty. Is for me considered as a backward farmer.
However, this doesn't mean that farmers in the region have no indigenous knowledge.

Q17: The issue is how can we link farming system with marketing and finance, agroprocessing and storage, and alternative job appropriations?

A17: I see the cause & effect relationship of the above facts. However the regional BoA have designed strategy to treat the issues of marketing by: establishing marketing structure and to create market information network in the extension system. The other area of intervention is to link local industries with farmer in a mode of "out grower" arrangement to facilitate back and forth linkage. Great emphasis is given for post harvest packaging especially for surplus producing areas.

Q18: They findings and the policy implications in terms of "More people, less erosion" abandon of land redistribution and increased rental. Could you comment?

A18: What theory has to say about population pressure causing more or less erosion is controversial with regards to our study, the results confirm that population pressure is contributing to the land degradation problems. Clarifying the policy implications: land distribution, as a tool to solve the problem of landlessness in the Amhara highlands is unnecessary given a situation where the land lease market is allowed to operate freely and without restrictions. In addition, encouraging longer leases may have more impact on addressing the land degradation problem by encouraging investments in land improvement.

Q19: It is good to learn that the extension system is moving from PADETS to training and advisory system. In relation to the current policy of Woreda based development program, there will be three extension Agents (natural resource, livestock and crop based) stationed at the Keble level. What is happening to the home agents program as this is important in terms of addressing post harvest, food utilization and gender related (nutrition, family planning, etc.) issues.

A19: In relation to the current policy of Worda based development program, the organizational structure of Worda includes four Desks namely-Crop production and protection desk Animal & Fish resource development & Veternor, NRD desk, Extention and home economics disk. About 21 - 45 experts at Worda level and 3 development agents at Kebele / PA level are assigned.

Q20: What about the food habits / acceptance of triticale by local people. Triticale seems to have lots of potential.

A20: We have tested it with households and workers they fully accepted taste. We are quite confident that there is a wide acceptance.
Q21: Free grazing was mentioned as a hindrance to most biological conservation measures. How do you tackled / solved this problem in your project.

A21: Free grazing is a fact, we cannot do much against at present. But we can convince the community, as we do in South Gonder to keep animals out of the fields for some time until plants are established.

Q22: How much regional conservation strategy is different from National conservation strategy?

A22: While national conservation strategy was formulated it was proposed that each region should formulate regional conservation strategy according to their situation. Accordingly regions have prepared strategy based on national conservation strategy to their own context.
CLOSING SPEECH

YOSEF RETTA
President, Amhara National Regional State

Dear conference participants and invited guests

I am extremely happy to be present at the final session of your conference, the first of its kind to be held in the region. I have observed your deliberations on developing strategies for the utilisation, management and conservation of natural resources concluding with key and essential recommendations.

During my long tenure in the region, this is the first occasion for professional associations like yours to gather together from various corners and convene a conference on the region’s problems and present recommendations for consideration and implementation by the relevant policy and decision makers. I should like to assure you of the full-hearted support the regional government will give to such fora at any time. It should continue at large in the future.

Honourable conference participants and invited guests

Implementing drafted polices in full, capacity building at bureau level, raising the awareness level of people on protecting as well as utilising their natural resources in a sustainable manner, and providing additional professional assistance from various intelligentsia in the country — these are areas that the region should focus upon, I assure you.

Dear conference participants and invited guests

The source of the problem with our natural resources is poverty and the outdated traditional ploughing culture. So also is lack of capacity building and coordinated progress of the people vis-à-vis professionals in the field.

Participants have taken a realistic view of the constraints involved and have contributed immensely towards finding ways of alleviating them. I certainly hope that this kind of assistance will continue unabated in future.

From the coordinators of this conference and this last session I have observed the debate on important issues. In your deliberations, you looked at the region’s natural resource deposits, management technique of these resources together with the constraints involved. Your discussions focused on the steps being taken to draft policies and strategies for properly maintaining in the region’s natural resources. Also, progress made in implementing the policies and
establishing bureaux for this purpose have been discussed. Evaluation of the implementation process including future prospects was reviewed.

Your discussion on the creation and proper maintenance of a database for use now and in the future is a matter of priority. Needless to say, any effort towards this end will have the full backing of the regional government.

**Honourable conference participants and invited guests**

One sees a good beginning where people have started to act, to participate, to protect and develop their natural resources towards the ultimate goal of being able to move out from the shackles of poverty. Undeniably, a great deal of work awaits us in this direction, we know.

The recommendations made at this conference will strengthen the results of our programme underway. I take this opportunity to assure you on my own behalf and that of the regional government, that we will do all we can to implement your recommendations. Our professional association has successfully coordinated government institutions, NGOs and donor agencies to hold this conference. I believe that this commendable endeavour of holding consulatious on regional issues, present and future, should be strongly encouraged and continue. After all, it is only when we unite all our efforts and strength that we can arrive at our target. Coordinated effort in the right direction yields encouraging results. To this end, we are doing all we can to make our region exemplary. I anticipate to see you at our side in our future endeavours as you have done now.

And finally, may I state to all of you who came from other parts of the world and from our country that when the outcome of your convention shows positive results, that will be the day that the sweet fruits of your labour will be realised. On my own behalf and that of the regional government, I express our deep gratitude to our regional bureaux who participated in the preparation of this conference and to the Ethiopian Society of Soil Science for steps taken and will be taken. I now declare this meeting closed.

Thank you.

Translated by
Ato Asrat Wendem-Ageñehu
“Natural Resources Degradation and Environmental Concerns in the Amhara National Regional State: Impact on food Security”

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