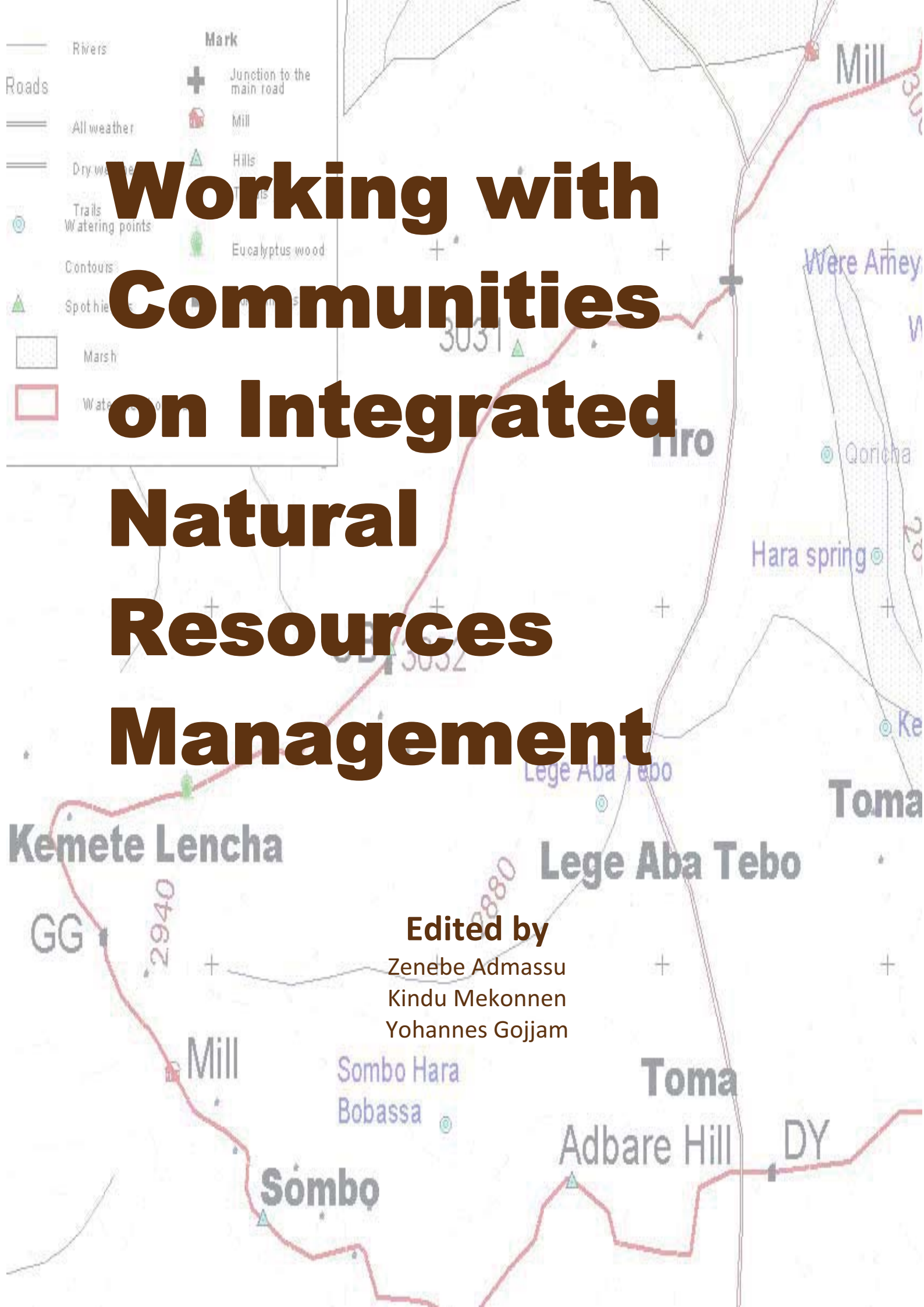

Working with Communities on Integrated Natural Resources Management

Edited by

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Working with Communities on Integrated Natural Resources Management

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Preface

This publication is the result of integrated watershed management research conducted at Galessa watershed in central highlands of Ethiopia. A workshop entitled 'Working with Rural Community for Integrated Natural Resources Management' was held at Holetta Research Center on 28-29 February 2008 to present and discuss research results. Participants of the Workshop included farmers, wereda and zonal agricultural and rural bureaus experts, researchers, NGOs and policymakers.

It is my belief that this publication is important source of information on integrated watershed management in Ethiopia and serves as reference for development, research, and education and training purposes.

Numerous individuals and groups have been instrumental in the conduct of the research and making the results ready for use. First of all, I would like to acknowledge farmers and development agents of the Galessa watershed who made the research to bear fruit. Their participation, hospitality and tolerance during different stages of watershed management processes are gratefully acknowledged. I will also like to extend my sincere thanks to the different offices in West Shewa Zone and Dendi Wereda, particularly the office of agriculture and rural development and office of rural water development. My thanks also go to all researchers who participated in this research. Special recognition is given to Dr. Kindu Mekonnen, Dr.Adugna Wakjira, Ato Yohannes Gojjam, Ato Birhanu Bekele and Ato Fekede Feyissa for organizing the Workshop and critically reviewing the papers.

I am deeply indebted of the financial support the Ethiopian Institute of Agricultural Research and African Highlands Initiative project.

Zenebe Admassu
Project Coordinator, AHI, Ginchi Benchmark Site
July 2008

Opening Address

Solomon Assefa
Director General, Ethiopian Institute of Agricultural Research

On behalf of the Ethiopian Institute of Agricultural Research and me, it is my pleasure and honor to address this Workshop of 'Working with Rural Community for INRM: experiences from participatory integrated watershed management at Galessa.'

Ethiopian agriculture is mainly concentrated in the highlands, which contain nearly 85 percent of the population, 95 percent of the cultivated land, and 80 percent of cattle, which form a critical part of Ethiopia's ox-plow cultivation system. Ethiopian highlands are the major sources of staple crop production, which is dominated by cereals, though *enset* is an important staple in the southern parts makes up 65 percent of the total agricultural value-added with livestock production.

Land degradation, especially soil erosion, declining soil fertility, deforestation, poor land management cultivation practices, increasing number of population, and the load of poverty on environment deterioration, are the main features observed in the Ethiopian agricultural sector in particular and the sub-Saharan countries in general. For instance, 2/3 of the population of Africa is affected by land degradation. In Ethiopian highlands, soil erosion on cropland averages 42 tons per hectare per year and it is much higher on steeper slopes. If this soil erosion rate continues, more than 6 million hectares of additional crop and pastureland will become unusable. The gross discounted cumulative cost of erosion in Ethiopia has been estimated to be as high as $1.25 billion/year.

It is also well known that the Ethiopian highlands account for nearly half of the African highlands. The Galessa highland which is part of the central highlands of Ethiopia in which the benchmark site of AHI project is located has the following major features:

- Loss of soil, water, nutrient, and seed as a result of soil erosion;
- Loss of indigenous trees;
- Poor and declining soil fertility;
- Low crop productivity and diversity;
- Poor quality and quantity of water resources;

- Lack of feed resources and low productivity livestock; and
- Lack of collective action on NRM.

Any intervention by governmental or NGOs to improve the above situations should focus on maximizing growth in agricultural production and minimizing natural resource degradation.

Having policies, institutions and technologies as the conditioning factors for influencing farmers in their decision on the use of natural resources are also critical areas to be addressed. Any of these efforts should be in line with the developmental policies of the Government of Ethiopia.

Moreover, for concrete, targeted and mission-based approaches we need to think differently about dissemination of technology, knowledge and information. This is the task ahead of us. This is the current agenda we are dealing with in our business process reengineering activity: aiming at changing our research process to be cost-effective, client-oriented and capable of producing quality products and services, and letting clients to have technological options to change their activities and lives.

The Holetta Research Center has been conducting research on integrated natural resources management using participatory integrated watershed management and its approach is found to be encouraging since its efforts are in line with the development policies and strategies of the Government of Ethiopia. Thus, Government of Ethiopia expects more feasible results from the HRC/AHI developmental research efforts at Galessa watershed and hopes that the experience from this site will be scaled up to other similar areas as fast as possible.

Wishing you very successful deliberations in the two days, I declared this workshop officially opened.

I thank you!

African Highlands Initiative Project in Galessa

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Ethiopian Institute of Agricultural Research
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Introduction

African Highlands Initiative (AHI) is an eco-regional research program that brings together national and international research expertise, local government representatives, and development partners that strongly share a commitment to work with local communities to improve their livelihoods while reversing natural resource degradation. AHI is hosted by the National Agricultural Research Institutes (NARIs) in pilot countries who are members of the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA). The research agenda of the AHI is implemented through a collaborative arrangement involving EIAR and other institutions in east African countries. The research activities at Galessa and other AHI sites are conducted in an integrated way through action and formal research to find approaches for systems intensification and watershed management, institutional innovations for research and development (R&D), developing and disseminating approaches for sustainable livelihoods, and advancing impact.

This paper highlights the evolution of the AHI project and its research and development achievements at Galessa and surrounding areas, challenges, constraints, and limitation for the project activities

Evolution of the Project

AHI was initiated in 1995 in five countries (Kenya, Ethiopia, Madagascar, Uganda, and Tanzania). The project started at Galessa areas of Dendi Wereda, Oromiya Region in 1997. AHI works in highland areas that are densely populated, have poor or declining natural resource endowments and, due to unsuitable management practices and limited levels of investment, have reached the point where people and

landscapes can no longer provide livelihood needs. The project aims at contributing towards food security by improving Natural Resources Management (NRM) and agricultural productivity in the highlands of East African countries. The AHI project has been operational at Ginchi/Galessa with four consecutive phases.

The first phase (1995-1997)

In this initial period, research was conducted with small grants, geographically scattered and having disciplinary research oriented agenda.

The second phase (1999-2000)

In this phase, research was geographically aligned and team-based. Improving income and investment through diversification and intensification, soil conservation and fertility maintenance and improvement, and integrated pest management were major taskforces during the second phase. Entry points were considered as strategies to work with farmers.

The third phase (2002-2004)

AHI concentrated in selected watersheds focussing on development approaches and Integrated Natural Resources Management (INRM). In the third phase, social issues and process documentation received much attention. The approaches in phase three were highly participatory and interdisciplinary.

The fourth phase (2005-2007)

The focuses of the fourth phase were scaling up of technologies and knowledge, institutionalizing the concepts of integrated watershed management and strengthening of local institutions and bylaws. Leaflets, posters, discussion forums, publications, web sites, trainings and cross site visits were the most important tools to achieve the scaling out and up efforts.

Achievements

The AHI project in collaboration with the Holetta Research Center of EIAR has enormous achievements in terms of resources assessment, technology development and promotion, capacity building and production of various publications (Kindu *et al*., 2002; Kindu *et al*.,

2006; Yohannes *et al*., 2006). The following are some of the achievements or findings of the project:

Resource characterization

The following were the major achievements registered on assessing resources in the different sites of the Project

- Characterization of the farming systems, identification and prioritization of major problems and development of interventions plans executed at Galessa Qota Gisher Kebele;
- Indigenous *Rhizobia* for legume vetch evaluated in fallow lands;
- Herbage dry matter productivity of seasonally waterlogged communal grazing land, forest margin and short arable fallow lands assessed;
- A potato leaf disease such as late blight identified as the major production constraint;
- Livestock production systems and development opportunities studied at Galessa;
- Agroforestry potentials and opportunities identified both in the watershed and the surrounding areas;
- Availability and consumption of woody and non-woody biomass as source of fuel studied; and
- Biophysical, socioeconomic, institutional and other issues explored at Galessa watershed.

On-farm research

- Five released varieties of potatoes were introduced as entry point and evaluated for their performance. Out of which three have been found promising for further production and utilization;
- Five improved barley varieties were introduced to Galessa and evaluated on different farmers' fields. Among the varieties DIMTU, ARDU 12-60B and HB42 were promising for dissemination;
- More than 10 multipurpose tree (MPTs) and shrub species were introduced and evaluated for their adaptability and growth around homesteads and open fields. Five of the species adapted more than the others;
- Loose-rock check dam and brush wood-check dam combined with *Erytherina* spp (Korch) and *Hagenia abyssinica* (Koso) for gully stabilization were evaluated. From this experiment, Korch combined with temporary structures found to be more effective;
- The use of biomass transfer of live-fence leguminous shrubs for soil fertility management and yield of barley were evaluated, and three species identified as potential sources of plant nutrients;

- The possibility of potato production with the application of compost was tested in comparison to the application of other plant nutrient sources. The combined use of compost and inorganic fertilizer has been identified better than the other options in terms of various indictors;
- Fifty forage accessions and species were introduced and evaluated for their adaptation and forage production. Out of which Oats (1693, D-27 and A-20) and Hairy vetch (2438, 2437, and 2465) reported to be better in terms of their adaptability and biomass production;
- Conventional and improved bacterial wilt management packages were tested on six infested farms. The percent incidence of the bacterial wilt was lower for the improved than the conventional management packages;
- Two improved Triticale varieties were introduced and their performance evaluated. Out of which, Mayne performed better than the other varieties;
- Introduction and performance evaluation of six different Apple varieties were carried out. Royal Galla, Winter banana and Jonago red were found to be good in terms of different growth parameters;
- Improved linseed varieties were evaluated. Variety CI-1652x Omega/23/A was better than the other varieties;
- Evaluation of field pea as a break crop for barely fallow production was tested. Out of which Holetta performed well in terms of yield (1.6 t ha^{-1}); and
- Run-off, soil and nutrient losses from the different land use systems have been assessed. The control plots (without soil bund) had the highest soil loss (40 t ha^{-1} per season).

Scaling out

- Improved linseed varieties disseminated through informal seed multiplication. More than 130 households have benefited from this technology promotion activity;
- Four improved food barley varieties such as HB 42, ARDU 1260B, HB1307 and Shegie promoted on 15 farmers fields;
- Informal potato seed multiplication has been conducted through six farmer research groups (FRGs). Almost all the watershed inhabitants have benefited from this seed multiplication scheme; and
- More than 150,000 MPTs seedlings have been planted in and outside the watershed.

Capacity building

- Trainings were provided for researchers, development agents, farmers and other stakeholders in Ethiopia, Uganda, Tanzania and Kenya;
- Cross-site visits were organized for researchers, farmers and agricultural experts in Areka, Konso, Derashe and Ankober;
- Field days have been organized for researchers, farmers and other stakeholders to visit on-farm research activities and exchange experiences; and
- Workshops were organized in and outside the county to share successes and failures.

The capacity building activities of the project helped to built thrust between farmers and researchers; created awareness and demand on crop, livestock, NRM related technologies; and improved farmers' knowledge on locally available resources.

In addition to these the following achievements were recorded

- Three springs developed through collective action and negotiation;
- Mini-weather station established in the watershed;
- Community based nursery established in the watershed;
- Seven diffuse light stores constructed for better management of the potato seeds;
- Twelve energy saving stoves introduced and demonstrated to the farmers; and
- Three crossbred cows were introduced.

Publications

The lessons from the research, development, and capacity building efforts of the project were published and publicized to the users through various information dissemination mechanisms. The publications include reports, proceedings, working papers, policy briefs, farmers' products (posters and leaflets) and peer reviewed journals. The targets of these publications include research organizations at national and international level; development and extension organizations and practitioners with an interest in conceptual synthesis of "good practice"; and policy-makers interested in more widespread application of lessons and successes.

Constraints

- Ambitious plan with low resource provision;
- Unplanned shift from one phase to the other, which has resulted in suspension of ongoing research activities;
- Inadequate budget and vehicle allocation;
- Late release of funds;
- Absence of clear terms of references (TOR) for team members;
- High turnover of team members, site coordinators and steering committee members;
- Lack of incentive for team members; and
- Authorship related problems mainly created from the regional office.

Conclusions and Recommendations

The Project should be able to device intervention mechanisms for the aforementioned constraints. Similarly, the project should assess itself to provide answers for the following queries:

- Could the project able to apply the principles of participatory research and integrated/holistic approach in its research system at Galessa?
- Has the project managed to develop approaches and methods for INRM?
- Has the project brought a significant impact on the life of farmers and the management of natural resources? and
- Has the project attempted to replicate its successes and lessons in similar areas of the highlands?

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Participatory Integrated Watershed Management: Lessons from the central highlands of Ethiopia

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Introduction

Integrated watershed management (IWM) is a process of formulating and carrying out a course of action to managing human activities in an area defined by watershed boundaries in order to protect and rehabilitate land and water, and associated aquatic and terrestrial resources, while recognizing the benefits of orderly growth and development. It is an integrated and holistic approach to the development of an area with the ultimate objective of improving the quality of the live of the people who dwell within it (FAO, 2000).

It is not different within the watershed domain where multiple actors see in the approach a means to accomplish disparate objectives. This has resulted in multiple visions among different professionals of the "watershed approach". Among agronomists, watershed approach is seen as a means of scaling out technologies, primarily those for soil and water conservation or generally for environmental protection (Hinchcliffe *et al.,* 1995). For the water resource sector and policy-makers, it is seen as a means for enhancing environmental services and public goods emanating from upper catchments for the society at large (FAO, 2000). Conservationists view it as a framework for enabling trans-boundary natural resource management (NRM) in which livelihood concerns are often addressed only to the extent that they help to further conservation goals (van der Linde *et al.,* 2001). Yet among social scientists and others, watershed management is seen as a framework for enhancing

collective action and equity in natural resource access and governance, or livelihood problems that can't be solved at farm or household level (Meinzen-Dick *et al.*, 2002).

The principal factors influencing watershed operations are physiographic, edaphic, climatic and socio-economic. The sever degradation of natural resources is a challenge to the developing countries in their poverty reduction and sustainable development strategies. It also worsens the poverty situation and affects livelihood, infrastructure, asset building and overall economic growth.

Choosing the approach

Due to demographic pressure the average landholding in the Ethiopian watersheds is often fragmented and less than one ha (Zenebe, 2005). The fragmented landholding (3-5 parcels) coupled with the improper land-use system, nutrient depletion, drought and drainage problem, low crop and livestock productivity worsened the situation. Deforestation for cultivation, wood for fuel and construction, overgrazing, conversion of marginal lands to agriculture is escalating the problem of soil erosion and land degradation than ever. Although substantial efforts have been made to halt the problem, the achievements are far below satisfactory.

The lack of integration from the different disciplines, sectors and limited level of participation of the stakeholders are among the limiting factors contributed to low level of success. Farmers' involvement in problem identification, priority setting, planning and implementation of the programs has been minimal. This calls for a concerted effort of farmers, researchers of various disciplines, other organizations and institutions on NRM for conservation, enhancement and efficient utilization of the resource base aimed at increased productivity with the end goal of rural poverty alleviation.

The conventional fragmented and linear research approach has been weak to address the overall viability of the agricultural system due to the complexity of the NRM problems and the need for collective action in addition to individual solutions. Thus, there is a need for the interaction between social, technological, economic and policy dimensions; an interdisciplinary approach to problem identification, planning, implementation and participatory monitoring and evaluation; and full participation of all stakeholders.

Participation and integration in watershed management

In PIWM, the approach can be qualified through two aims. First, the process must be participatory in terms of the particular issues to be worked on, and how related activities are carried out (Hinchcliffe *et al*., 1995; Rhoades, 2000). "Participation" means different things to different people. All too often, however, it is taken to mean mere turn-out at community fora, undermining true participation in decision-making and benefits. Throughout the diverse stages of watershed management, we have experimented with diverse forms of participation, from equity to representation to negotiation. This is simply involvement of all stakeholders in problem definition, planning, implementation and monitoring and evaluations. Second, the process must be integrated. While different people may define integration differently, a common approach is to emphasize the integration of disciplines (technical, social and institutional dimensions) (Bellamy *et al.*, 1998; FAO, 1977; Reddy, 2000) or objectives (conservation, food security, income generation) (Shah, 1998). While it is increasingly clear that the success of watershed management programs rests on the integration of conservation with livelihood goals and technical with institutional interventions (Reddy, 2000; Shah, 1998). Few programs have effectively achieved such integration (Rhoades, 2000; Shah, 1998). It is therefore essential that any approach at integration integrate an understanding of the principles operating within natural and social systems (Meinzen-Dick *et al.,* 2002; Reddy, 2000).

Site Selection and Delineation

Site selection

Watershed management was initiated by the Ethiopian Institute of Agricultural Research (EIAR). A multidisciplinary team composed of different disciplines from different research centers was formed. The team selected three watersheds for the aforementioned purpose. The team used secondary data (topographic map) to identify the candidate watersheds. Initially, seven candidate watersheds were selected. The team categorized the seven watershed sites into three main agro-ecologies, namely high, intermediate and low rainfall. Galessa and Garie Arera (West Shewa Zone) and Tumano Abdie (North Shewa Zone) were classified under $M_{2\text{-}5}$ sub-agroecology and selected to represent high altitude and high rainfall areas.

The intra-group comparison was made with the help of weighted values attached to each criterion in the group. The criteria include agro-ecological representation, prevalence of resource management and land degradation problems, distinct outlet and hydrologic boundary. The team also considered that the watershed falls within the same social and administrative boundary, diversity in the current and potential land-use systems, presence of inhabitants within the watershed, absence of intensive interventions by other government and NGOs. The size should also be large enough to accommodate potential challenges and small enough to be manageable with the existing resources and measure the impacts. The watershed should not be far from the implementing research center and all weather roads. Based on those criteria, Galessa watershed was selected to represent the highlands and high rainfall areas. It is after that the implementation mandate was given to Holetta Research Center (HRC).

Delineation

A multidisciplinary site team composed of researchers from HRC and Dendi district agricultural office was formed. Based on the preliminary outlet identified during the site selection process, the watershed boundary was delineated using primary data (GPS readings), secondary data (topographic map) and in consultation with the local community. After delineation, the Digital Elevation Model was derived (figure 1). Although, watershed boundary delineation was flexible, final delineation showed that the total area of the watershed was about 340 ha. Administratively, the watershed is found in Dendi wereda, West Shewa Zone of the Oromiya Regional State. Most areas of the watershed are found inside the Galessa Qoftu Kebele and some portion of Toma village is within the Galessa Qotagisher Kebele. The altitude of the watershed ranges from 2820 to 3100 m and located at 09^{o}06'54"N to 09^{o}07'52"N and 37^{o} 07'16"E to 37^{o}08'54"E. Some areas of the watershed around the primary school were excluded. This is because the team felt that inclusion of the areas around the primary school could make the watershed unmanageable. On the contrary, the team decided to include some areas around Tiro. That means the delineation did not strictly follow a hydrological boundary.

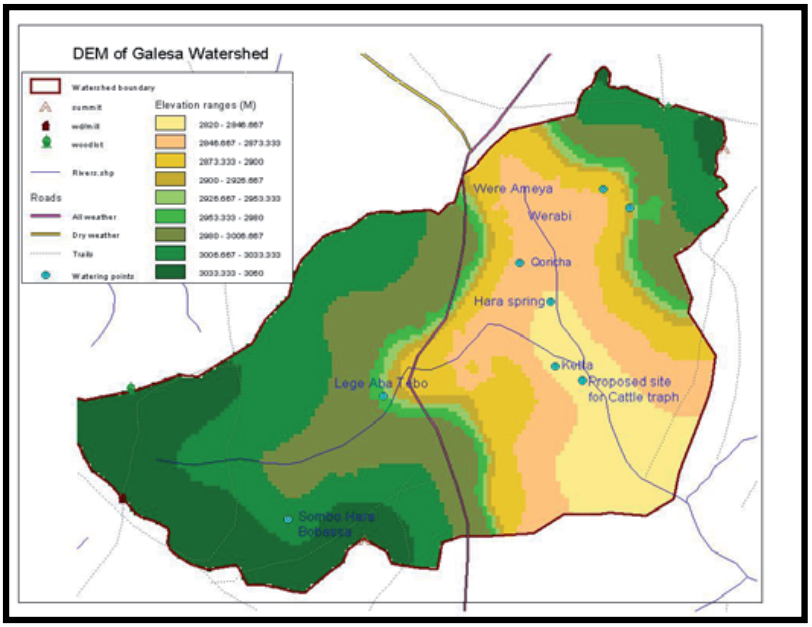

Figure 1. The digital elevation model of Galessa watershed

Diagnosing NRM Problems

The focus of diagnosis was to characterize, identify and prioritize watershed problems. The main procedures involved include: establishment of a community entry protocols, identifying watershed issues, generating consolidated list of watershed issues and participatory ranking of identified watershed issues.

Community entry protocols

Social protocols are crucial when entering to a community to initiate collective actions. This involves contacting different parties including community leaders, local elders, religious leader and local government. Accordingly, this was done through informal visits and scheduled meetings, consultation of local residents on the protocol for handling such initiations. The local leaderships were informed about the project's aims. Owing to the already existing collaboration of farmers with HRC, entry for watershed activities was not difficult. However, the procedure for community entry was followed and different stakeholders (local government at different levels, local institutions, community leaders and influential people) were consulted both informally and formally.

Identifying watershed issues

Tools for participatory problem diagnosis must enable the identification of constraints from farms to 'neighborhoods' to landscapes and even the administrative units that govern certain dimensions of land use within these biophysical units (German *et al*., 2006). It must also retain a flexible interpretation of watershed boundaries and processes. In other words, problems identified by farmers that manifest themselves beyond the boundaries of the watershed, i.e., resource conflicts with non-watershed residents or do not easily conform to our notions of a watershed problem should not be ignored due to our own rigid conceptions or interests. They often hold the key to solutions or may hinder our efforts when left unaddressed.

The case of flexible boundaries can be illustrated by the Galessa watershed, where farmers residing outside the watershed have access to water supplies and grazing land at the watershed. Unless the management issue of these resources brought into decision-making, innovations will be made difficult. The impact can be manifested either through failure to cooperate; for example, controlling livestock movement or from unequal contributions to maintaining a shared resource, which will undermine community enthusiasm for future investments. This methodology enables diverse social groups residing within the watershed to be systematically consulted when identifying and prioritizing watershed issues (German *et al*., 2006). A set of variables likely to influence the relative priority given to watershed issues is used to select interviewees for participatory watershed diagnosis. These include wealth (wealthier and poorer households), gender (male and female), age (elders and youth) and – in watersheds where the location of landholdings differs greatly by household, and may influence the extent to which natural resource degradation influences livelihoods – landscape location. Identification and comparison of watershed issues, prioritization of watershed issues and data analysis are all done according to these predefined social categories.

When identifying watershed issues, representation problem could be addressed by breaking the larger group into sub-groups (gender or age). One of the reasons in which the Galessa watershed team attempted to capture diverse views during diagnostic, planning and monitoring activities were to solicit views from small groups of land users grouped according to social categories of presumed relevance. During watershed diagnosis, for example, resource users were grouped according to

gender, wealth, age and landscape location (where landholdings are distributed differently on the landscape and relevant spatial categories exist). This idea of triangulation also comes in when considering group vs. individual interviews. Based on these methods about 39 watershed issues were identified by different social groups.

Generating watershed issues

Once watershed issues have been identified by different social groups, responses from the different groups were lumped into a single list and repetitions eliminated to reduce the list to a manageable number of issues for subsequent ranking and planning. Thirty-nine watershed issues, which were identified by local residents at Galessa, were combined on the basis of their similarity into 18 issues (Table 1). This involved a great deal of discussion, to ensure that the issues had the same meaning when articulated in the farmers' own words before deciding to combine them.

Ranking watershed issues

Once a condensed list of watershed issues has been identified, a representative sample of watershed residents were again consulted on the basis of established social parameters such as gender, wealth, age and landscape locations. That time, however, they were asked to rank the relative importance of identified issues. Two ranking methods were tested in the Watershed: absolute and pair-wise ranking. Using the first method, participants were asked to give a rating of 1 to 10 for all identified watershed issues. When using the pair-wise ranking, each watershed issue was contrasted with all the other issues to systematically discern their *relative* importance. Each issue was compared with each other issue, and the number corresponding to the more important of the two was entered into the box. To finalize the exercise, the frequency of prioritization of each issue, for example, the number of times issue number "14" was put in a box was tabulated, and the corresponding number placed in the right-hand column. There was a tendency among agricultural researchers to prefer this approach for its greater rigor, given the subjective nature of absolute ranking. For example, what one person means by an "8" may be different from what another person means by an 8. This also complicates the process of averaging ranks, supporting the use of pair-wise ranking. Pair-wise ranking overcomes this limitation by systematically comparing each issue with each other issue to understand their relative importance. However, it takes more time.

Table 1. Consolidating watershed issues into a condensed list at Galessa watershed

Issues	Original farmers statements
Loss of water, soil, seeds and fertilizer due to excess run off	Crops washed away in heavy rains, flooding of cropland , loss of topsoil due to erosion, insufficient soil conservation and fertilizer washed away in heavy rains
Water shortage for livestock and human beings	Shortage of water for livestock and humans in dry season, conflict from competition over water (springs)
Poor water quality	Poor quality of drinking water, need for cooperation in fencing and cleaning watering points
Problems associated with the lack of common drainage	Conflict from drainage of water from fields , need for cooperation in the location of drainage ditches and need for cooperation in soil conservation activities
Crop failure from shortage of rains	Crop failure from shortage of rains
Soil fertility decline and limited access to fertilizer	Low soil fertility, high cost of fertilizer, insufficient farmyard manure, reduced productivity of crops and livestock from shortened fallow
Feed shortage	Shortage of grazing land, feed shortage in the dry season and Conflict from grazing of individual fallow land
Shortage of oxen	Lack of oxen for ploughing fields
Land shortage due to population pressure	Land shortage and cultivation of upper slopes due to high population, and effects of population pressure on large families
Lack of improved crop varieties	Lack of improved varieties for certain crops
Wood and fuel shortage	Shortage of fuel wood, shortage of wood for fencing, houses and livestock structures, absence of trees for livestock (shade and grazing), deforestation due to high population pressure and dependence on Eucalyptus due to deforestation
Loss of indigenous tree species	Loss of indigenous tree species
Effects of eucalyptus on soils, crops and water	Negative effects of Eucalyptus on crops and soil, conflict from Eucalyptus on farm boundaries and negative impact of Eucalyptus on water availability
Theft of agricultural produce	Theft of crops in the field during food shortages
Conflict from paths and farm boundaries	Conflicts from farmland paths and borders
Low productivity of animals	Need for cooperation to reduce the number of livestock
Limited sharing of seed	Need for cooperation in the exchange of seed and planting material
Conflict between villages over watering points	Invasion of livestock drinking area by neighboring villages, blockage of paths to watering points

Analysis

Following ranking, each interview was entered into a separate worksheet in Microsoft Excel. The worksheets were labeled according to the village, social group and the number of the interviewee Village and watershed level syntheses was compiled by averaging the ranks of individuals or groups, as follows:

Village-level analysis of ranks: Prepare village-level averages of ranks for each social group by averaging the ranks given to each watershed issue by individuals belonging to each category (Table 2). Prepare single village-level ranks for each watershed issue by either averaging the ranks given by all interviewees from the village or averaging the ranks of each social group from the village.

Watershed-level analysis of ranks: At the watershed level, group averages were again compiled. This time averaging was done across social groups at village level rather than across individuals representing these groups. This was done by averaging across social groups rather than individuals. It is also possible to compile watershed-level ranks by village rather than by social unit to see how village priorities differ. Finally, absolute or pair-wise ranks were converted to priorities by giving a "1" to the top priority (highest averages) for each social group, a "2" to the second highest priority, and so on. The highest priorities for this watershed were the loss of indigenous tree species, which is the highest priority for 4 out of 6 social groups, and poor water quality – which

Table 2. Sample database-socially disaggregated ranks at village level using pair-wise ranking

Watershed issues	(a) Village average (of all interviewees)	(b) Village average (of group ranks)	(c) Social groups						Overall priority Ameya Village
			Men	Women	High wealth	Low wealth	Old	Young	
Loss of water, soil, seeds and fertilizer due to excess run-off	5.00	4.97	4.67	2.33	5.00	4.00	5.00	8.67	2
Water shortage for livestock and human beings	5.87	5.44	9.67	3.00	2.00	4.00	8.00	6.00	5.5[b]
Poor water quality	4.88	4.75	5.33	2.33	1.67	2.50	9.67	7.00	1
Problems associated with lack of common drainage	8.82	8.75	8.00	8.33	8.00	7.50	11.33	9.33	16
Crop failure from shortage of rains	5.71	5.44	9.00	9.33	2.67	1.00	4.67	6.00	5.5
Soil fertility decline and limited access to fertilizer	5.82	5.67	6.00	2.67	3.67	3.00	10.00	8.67	8
Feed shortage	5.41	5.47	3.67	6.00	4.67	6.50	7.33	4.67	7
Shortage of oxen	5.18	5.28	3.67	5.00	6.00	7.00	2.67	7.33	4
Land shortage due to population pressure	5.47	5.69	3.00	2.67	7.33	9.50	6.00	5.67	9
Lack of improved crop varieties	6.65	6.72	6.33	6.00	7.67	8.00	7.33	5.00	12
Wood and fuel shortage	5.71	5.72	3.67	4.67	7.67	6.00	8.00	4.33	10
Loss of indigenous tree species	5.06	5.00	1.67	6.67	7.33	4.00	6.33	4.00	3
Effect of eucalyptus on soil, crop and water	7.59	7.58	8.00	7.67	6.67	7.50	9.33	6.33	14
Theft of agricultural produce	8.94	8.89	12.33	12.00	8.33	8.00	8.00	4.67	17
Conflict from paths and farm boundaries	9.47	9.53	10.33	10.67	11.00	10.50	8.67	6.00	18
Low productivity of animals	5.71	5.81	3.33	5.00	8.00	7.50	5.00	6.00	11
Limited sharing of seed points	6.75	6.97	7.67	7.67	8.50	9.00	5.00	4.00	13
Conflict between villages over watering points	9.13	8.33	10.67	11.00	9.00	2.00	9.00	8.33	15

[a] *These were determined from column 'b'*

[b] *when average ranks (column 'b') are the same, final priorities are averaged. If as in this case two watershed issues have the same average rank, then their positions (5th and 6th) are averaged.*

is within the top 3 priorities for 5 out of 6 social groups (Table 3).

Table 3. Sample database-socially disaggregated ranks at watershed level (ranks averaged by social groups across all watershed villages).

Watershed issues	(a) Group ranks averaged across WS villages						(b) Watershed priorities of each social group					
	men	women	elder	youth	High wealth	Low wealth	men	women	Elder	youth	High	Low wealth
Loss of water, soil, seeds and fertilizer due to excess run-off	5.5	5.5	5.3	7.1	6.6	6.3	6	6	3	9	6	7
Water shortage for livestock and human beings	9.3	6.9	8.1	6.6	7.0	5.3	11	9	11	8	7	4
Poor water quality	3.4	5.2	4.9	5.2	3.1	3.3	2	5	2	3	1	1
Problems associated with lack of common drainage	10.8	9	10.9	11.3	11.1	11.3	15	12	15	15	16	16
Crop failure from shortage of rains	9.6	8.0	6.9	10.4	4.4	7.2	12	10	9	14	3	8
Soil fertility decline and limited access to fertilizer	4.6	4.8	5.7	6.3	4.7	5.3	3	4	5	7	4	3
Feed shortage	6.4	9.1	5.6	7.7	8.4	9.9	7	13	4	10	11	15
Shortage of oxen	9.6	4.7	7.3	5.6	7.0	7.4	13	3	10	5	8	10
Land shortage due to population pressure	5.4	4.1	5.7	3.7	6.0	6.0	5	2	6	2	5	5
Lack of improved crop varieties	7.0	10.9	8.9	7.7	7.5	9.3	9	15	13	11	10	13
Wood and fuel shortage	5.0	6.8	6.8	5.4	7.5	6.3	4	8	8	4	9	6
Loss of indigenous tree species	2.7	3.9	4.3	3.3	4.3	3.3	1	1	1	1	2	2
Effect of eucalyptus on soil, crop and water	9.9	8.2	10.0	9.9	10.1	9.9	14	11	14	13	14	14
Theft of agricultural produce	14.6	14.6	12.9	12.1	12.4	13.5	18	18	18	18	17	18
Conflict from paths and farm boundaries	13.2	13.3	12.3	11.6	12.8	13.5	17	17	16	16	18	17
Low productivity of animals	7.4	10.9	8.6	7.9	8.5	7.8	10	16	12	12	12	11
Limited sharing of seed points	6.7	5.8	5.9	5.8	9.7	7.3	8	7	7	6	13	9
Conflict between villages over watering points	12.3	10.5	12.6	11.9	10.2	9.2	16	14	17	17	15	12

Planning

The planning methodology consisted of clustering of identified issues according to strong functional relationships; identification of objectives and research questions according to higher-level system goals; and development of integrated R&D interventions at site team and community levels.

Clustering issues based on functional relationships

This section describes the process for moving from discrete watershed issues identified by local residents to the planning of an integrated research and development agenda. The planning was done at the level of support institutions (R&D teams), but must be harmonized with local watershed planning process. The first step was the creation of functional "clusters" defined by strong causal relationships between discrete watershed issues, and which simplify the watershed agenda by providing focus and enabling several related issues to be addressed simultaneously. Two principles were employed to develop an integrated intervention strategy from the list of identified watershed problems (social and ecological principles). The first principle was to identify issues of high priority to most social groups. The idea behind this was that by focusing on the issues of high relevance to most watershed residents, future R&D efforts are likely to have greater pay-offs as a function of the broad social support they receive within watershed communities. The second principle was to identify watershed issues that are functionally linked. The rationale behind this is that such issues should be managed jointly to enable greater pay-offs from investments and explicit management of the causal interactions and spin-offs (both positive and negative) characterizing interactions between these issues at present and after any intervention. Of these original 18 watershed issues, eight were identified as having highest priority by most of the farmers (Table 4). The list includes poor water quality and quantity, loss of indigenous tree species, loss of soil, seed and fertilizer from excess runoff, low soil fertility, shortage of oxen, lack of improved seed, feed and fuel shortages.

Table 4: Result of ranking at the watershed level

Issue	Rank	Priority
Loss of indigenous tree species (LITS)	3.5	1
Poor water quality (PWQ)	4.2	2
Land shortage due to high population (LSHP)	5.1	-
Soil fertility decline (SFD)	5.1	3
Wood shortage (WS)	6.1	4
Loss of seed and fertility because of runoff (LSF)	6.2	5
Lack of access to improved seeds (LAIS)	6.8	6
Shortage of oxen (SO)	7.1	
Water shortage for livestock and human (WSLH)	7.4	7
Crop failure due to drought (CFD)	8.0	-
Feed shortage (FS)	8.1	8
Low productivity of animals (LPA)	8.6	-

Of these eight issues, it was decided that only seven would be addressed. Due to limited options, the shortage of oxen was temporarily excluded in the list. According to their strong functional relationships, the seven identified issues were categorized into two major clusters (themes):

Cluster 1: Soil and water conservation and utilization

This cluster includes poor water quality and quantity, loss of seed, fertilizer and soil from excess run-off, loss of indigenous tree species, and crop failure due to drought. The rationale for this clustering was on the recognition that:

- water quality is being affected by seed, fertilizer and soil loss from the fields;
- substitution of indigenous trees with Eucalyptus has caused the depletion of groundwater and the drying of springs;
- integration of appropriate trees and soil conservation structures on the landscape could enhance spring recharge (water quantity) and reduce the loss of seed, fertilizer and soil from the landscape; and
- crop failure due to drought could be ameliorated by reducing water loss from run-off.

Cluster 2. Integrated nutrient management and production

This cluster includes soil fertility decline, wood and fuel shortage, loss of indigenous tree species, limited access to improved seed, feed shortage, and land shortage. The rationale behind this clustering was on the recognition that:

- loss of indigenous tree species and fuel wood availability has exacerbated soil fertility decline through the increased use of cow dung and crop residues for fuel and the former must be dealt with the emphasis to ameliorate soil fertility decline;
- intensification of the system to reduce land pressure will require a balancing act so that increased agricultural production does not further compromise the already ailing nutrient status in the system;
- improved seed often requires high soil fertility, as well as placing a demand on already limited nutrient resources; and
- the traditional practice of rotating between cropland and fallow (for grazing) between seasons and years means that interventions in the livestock system will have a direct impact on the cropping system, and vice-versa.

The common logic behind these relationships caused the team to name this the “Integrated Production and Nutrient Management Cluster.” Clearly, the identification of such function clusters requires a relative

intimate knowledge of the system. It is important to note that this knowledge can be provided either by farmers or researchers who have been working in the system in a participatory manner for some time. We would encourage that both options be explored when applying this methodology in the new sites. Both clusters were then drawn graphically in terms of the relationship between the problem and the integrated solutions. These diagrams were found to be much more user friendly, given their simplicity as well as their role in moving from problems to solutions. While these clusters are themselves functionally linked, the classification of issues into the above clusters enables workable integration of system components and emphasizes the strongest functional relationships.

Identifying objectives and research questions

Integration in planning can be addressed from the standpoint of both component integration and disciplinary or sectoral integration. For the first of these, higher-level system goals should be specified for each cluster in order to avoid disintegration during planning.

The following are examples of objective and research question in Soil and Water Conservation and Utilization (SWCU) Cluster:

Overall SWCU Cluster Objective: To enhance the positive synergies between water, soil and tree management in micro-catchments.

Primary research question: How can NRM practices (SWC structures, tree planting, drainage systems, etc.) enhance agricultural production/ productivity through decreased erosion while also enhancing spring recharge long-term? Accordingly, every sub-step has their own research objectives and questions under the framework of the respective clusters.

Developing integrated research and development interventions

It is a general approach for planning that strengthens the articulation of research-development linkages. This forces R&D teams to ask the questions, “How can effective and equitable participatory action learning processes be facilitated?;” “What is the role of empirical research in bringing concrete change to local residents or off-site users?;” “What role can action research play in distilling general lessons from the change process?;” and, most importantly, “How can these different

contributions be effectively integrated and sequenced so as to maximize returns from R&D investments?" Three components in Planning for Integrated R&D Interventions were identified in Galessa watershed. Those were community action process; action research; and empirical research.

Community action process

Community action processes are short-term, evolving as new challenges and opportunities emerge. They are also important to mobilize the community through existing collective action institutions or establish new institutions for INRM. For example, negotiations on outfield intensification were a community action process at Galessa watershed during 2006. Negotiate whether spatial or temporal intensification processes are possible.

Participatory action research

Participatory action research (PAR) is emphatic on the need to include farmers and their aspirations, interests and priorities improving their engagement with development process (Opondo *et al.,* 2006). Returns to research aims become joined but secondary. AHI promotes the use of PAR as a way to develop and test development process modalities, and reflections on the process. Its apparent results are used to inform the process as well as other actors who might be implementing similar processes elsewhere. The PAR process fosters local capacity building and given that it is a relatively new process for AHI's partners and these partners also learn by doing. Coxhead and Buenavista (2001) observed that PAR enhances deeper involvement of farmers and relevant stakeholders in research process, transforming them from information providers to collegial partners. AHI uses an 'experiential learning approach' in that PAR has planning, action, reflection and re-planning stages. At each point of PAR documentation of the stages occurs.

The action research process may be broken down into an iterative series of steps aimed at enable change, including participatory problem identification, planning, and implementation, monitoring and re-planning. It is essentially a process of adaptive management that seeks to understand, through implementation, what works where and why.

Empirical research (ER)

While the merits of ER lie in its flexible, iterative nature, there is also a role for empirical research in which the objects of study and methods are

fixed. While empirical research has been greatly criticized for leading to overly academic research and contributing little to real development, there are several instances where it is required to enable development outcomes (German and Stroud, 2004). For example, empirical research can assist in filling critical information gaps hindering agricultural development by shedding light on more illusive dimensions of perceived problems and solutions. In such cases, research questions can often be targeted by local residents. Other cases may require research to be targeted by outsiders to bring on sustainability and equity in the development process. Achieving quality in empirical research entails well-known standards for scientific research. Methods will vary according to the objectives and standards for research quality within the field of interest like biophysical and social sciences. Depending on the minimum level of technical knowledge required to derive reliable information, local residents can often be involved as researchers.

Participatory action planning

This is annual breakdowns of major activities. It includes the costs involved, time line, detailed activities, expected outputs, means of communication of results, as well as the relative weight of each component out of the total project. The responsible persons for each activity were also be assigned. This plan was done with relevant stakeholders including farmers, researchers at different levels, governmental organizations, non-governmental organizations and policy makers at different levels. The action plan was revised every year based on the recommendations obtained from the participatory action learning and participatory monitoring and evaluations.

Implementation

All the activities planned have been implemented based on their action plan. However, due to ambitious planning, some activities weren't implemented according to the schedule.

Participatory monitoring and evaluation

This is a process where different stakeholders are participating at different levels and different times. Three levels of the tool's application are emphasized: participatory M&E at the watershed level, with local interest groups, and by the R&D team itself. The tool emphasizes how to move from proscriptive intervention process to an adaptive learning process that acknowledges the uncertainties and subjectivities in any

change process. This has been conducted during farmers' research groups meetings, community meetings, field days, annual and biannual review meetings, informal transect walks of the researchers and farmers.

Conclusion

Watersheds include resources that have different types of rights and associated rules. There are interactions among the resource users, the resources themselves, and the institutions that govern their access, use and management. The goal of watershed research is thus to understand these interactions at different scales and to use that knowledge as a basis for designing policies, institutions and technologies.

Stakeholders' involvement in problem identification, prioritization, planning and design, implementation, and monitoring and evaluation can improve the effectiveness of watershed management projects. The use of socially disaggregated problem identification and prioritization methods can help to show which social categories are affected by which problems. Conventional methods of identifying stakeholders and facilitating their interaction are challenged by the diversity of stakeholders, interests, and claims on watershed resources. Accurate information on the impacts of human activity on watershed processes is one of the elements of PIWM. The ability of the research systems to negotiate, facilitate, recognize, and resolve conflicts can be as important as the technical skills. The skills of conflict resolution need to be built into the watershed research teams. Although the cost of facilitation is costly, working with all stallholders is very crucial for the effectiveness of PIWM.

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Watershed-based Soil and Water Conservation Experiences in Ethiopian Highlands

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Introduction

Ethiopia has been described as one of the most serious soil erosion areas in the world (Blaikie, 1985). Soil erosion by water and its associated effects are recognized to be severe threats to the national economy of Ethiopia (Hurni, 1993; Sutcliffe, 1993). Since more than 85% of the country's population depends on agriculture for living, physical soil and nutrient losses lead to food insecurity. Hurni (1990, 1993) estimated that soil loss due to erosion in Ethiopia amounts to 1493 million tons per year, of which about 42 t/ha per year is estimated to have come from cultivated fields and it can be even higher on steep slopes with a soil loss rate greater than 300 t/ha/yr (USAID, 2000). This is far greater than the tolerable soil loss as well as the annual rate of soil formation in the country.

About 50% of the highlands of Ethiopia are already 'significantly eroded and erosion causes a decline in land productivity at the rate of 2.2% per year. The highlands of Ethiopia in general experience severe soil erosion mainly due to steep terrain, poor surface cover, intensive cultivation of sloppy areas and degradation of grazing lands due to population and livestock pressure.

Extensive outfield areas in Galessa watershed are underutilized and highly degraded. While household landholdings are some of the highest in Ethiopia yield and soil fertility levels are extremely low. Causes include the effect of repeated land reforms and public land tenure on

perceived tenure security; a free grazing system that threatens perennial vegetation and conservation structures; and increased use of dung for fuel, diverting valuable nutrient resources from agricultural fields. Adoption of soil and water conservation measures is negligible due to farmers' unwillingness to invest in activities with medium- and long-term benefits and the perception that outfield investments are made impossible by the free grazing system. Small landholdings and land fragmentation create additional challenges in constructing waterways to drain excess water from the landscape, because these structures must cross multiple plots of different landowners (Zenebe, 2005).

The main objective of this study was to test different approaches that are important to encourage farmers to invest on soil and water conservation activities.

Methodology

The study area

The watershed is situated in Dendi Wereda at 09°06'54"N to 09°07'52"N and 37° 07'16"E to 37°08'54"E, West Shewa Zone of the Oromiya Regional State in the central highlands of Ethiopia. The watershed was 340 ha and the dominant crops grown in the area were barley, potato, and enset. The area has highly undulating, rolling & hilly topography ranging from 2820 to 3100 meters above mean sea level.

Approaches

Farmers in the watershed have not been aware about the current situation of soil degradation and effective controlling methods. Different approaches were used to create public awareness on soil erosion and controlling mechanisms.

Cross-site visits and reflection meetings

Two cross-site visits were organized for farmers:

- The first visit was organized in 2004 to Debresina and Ankober weredas of the Amhara National Regional State; and
- The second visit was also organized in 2006 to Gunnuno watershed in Wolaita, Konso, and Derashe special weredas of Southern Nations Nationalities and People Regional State.

Farmers were selected by the general assembly of the watershed community based on village, gender, age, and wealth status. In both visits, a total of thirty farmers, three development agents, two subject matter specialists from the district and six researchers from Holetta Research Center participated in the visit. The two sites were selected because these areas are well known in rich experience in soil and water conservation in the country. Following the field visits, reflection meetings were organized at the watershed level. The first step used in reflection meeting was video show on what the farmers visited, how they were visiting and the discussions made during the visit. The second step was facilitating discussion after the video show to openly discuss on the issue. During the discussion farmers who visited the site explained and discussed what they have visited in each of the sites and the other farmers asked questions on some unclear issues. The role of researchers was to facilitate the forum.

Empirical research

Empirical research can also facilitate attitude change by making visible biophysical processes that are otherwise difficult to observe. An experiment conducted in Galessa on plots with and without soil bunds illustrated to farmers what is lost from their fields and what is retained as a result of conservation structures

Formation of Farmers' Research Groups (FRGs)

Today, farmers' involvement in agricultural research is not a new concept. FRGs can be formed through internal or external institutions. Internal initiation could happen when farmers themselves take self initiation to organize themselves in group to solve their common problems and request the research for technical help. On the other hand, research and extension organizations could take an initiation to form or organize groups based on specific objectives.

In Galessa watershed, AHI project played a major role in initiation, organizing and soliciting as well as supporting funds. Accordingly, FRGs in erosion and soil and water conservation were established in the watershed in each village (Toma, Tiro, Sembo, kemete-lencha and Ameya).

Since FRGs are expected to have a close link and intimate collaboration within the group and with members of the other groups, linking

mechanisms and strategies need to be designed by the group right from the formation of groups. For this purpose, each FRG member had their own operational committee composed of five individuals. These individuals were the chairman, commander, secretary, treasurer, and a member.

Negotiation support and bylaws reforms

Several negotiations were conducted on watershed issues requiring collective action. The major issues required negotiation support and bylaw reform in the watershed were on bund spacing, common waterways and restricting free grazing as conservation structures and multipurpose trees and grasses were affected by livestock.

Training

Training both practical in the filed and theoretical levels was very important tool for awareness creation and capacity building. Each FRGs was trained on the causes of soil erosion and the major controlling methods. They have also trained how to design soil bunds, cut-off drains and waterways.

Participatory monitoring and evaluation

This forum brought different stakeholders together at different levels. The major fora for PM&E were watershed meetings, field days, FRG meetings, annual review and planning meetings. Participatory monitoring and evaluation was used as an approach to create awareness, evaluate the different approaches, and filter the lessons from each activity and the major challenges. It was also used as a tool to generate information for re-planning and looking for alternative solutions.

Results and Lessons

Awareness creation

The farmers participated in the visit were very much impressed with the program (cross site visit) and the works of the farmers in the visited areas. The participating farmers from Galessa said that their attitude towards SWC is completely changed after they visited the selected areas. They also appreciated farmers in the visited areas and confirmed that they can change the Galessa watershed by applying integrated watershed management practices so that they can improve their livelihood. They

have also realized that this kind of arrangements can effectively change the farmers' attitude towards any planned interventions. The local indicators used by farmers to compare different treatments on soil and water loss experiments were the color and the amount of run-off leaving the plots as well as the mount of soil deposited on soil bunds. This indicators convinced farmers to construct soil bunds on their plots.

During PM&E it was noted that farmers' appreciation towards the advantage of soil bunds in terms of reducing soil loss and runoff, and their willingness to continue the construction of soil bunds in the future was highly improved. Training has facilitated SWC works and decreases the cost of design of these structures.

Change in attitude and perception

Change in confidence in solving NRM problems and change in attitude of farmers towards soil erosion and controlling mechanisms has been increased as a result of different approaches tested. According to household survey, 67% of the watershed inhabitants have implemented soil and water conservation measures whereas only 10% of inhabitants living outside the watershed have implemented soil and water conservation measures. The same survey also showed that farmers' perception on soil and water conservation and related activities has been improved after intervention (Table 1).

Table 1. Knowledge, attitude and practice of Soil and water conservation after intervention

Variables	Percentages of respondents		
	Agreed	Disagreed	Not sure
It is possible to conduct SWC measures collectively	97	3	0
I have seen considerable benefit due to collective action (CA) in SWC	97	3	0
Enough awareness has been created about CA in SWC	79.9	9	12.1
There is a change of attitude in the society about the need of CA in SWC	87.9	3	9.1
Farmers participation in SWC has increased after the intervention	87.9	12.1	0
Bylaws have use for SWC	100	0	0

Another indicator for the change in attitude was the effectiveness of the bylaw for soil and water conservation activities. The result showed that the compliance on the developed bylaw (Figure 1) was very high the watershed. This means majority of the farmers have obeyed by the bylaw formulated by them.

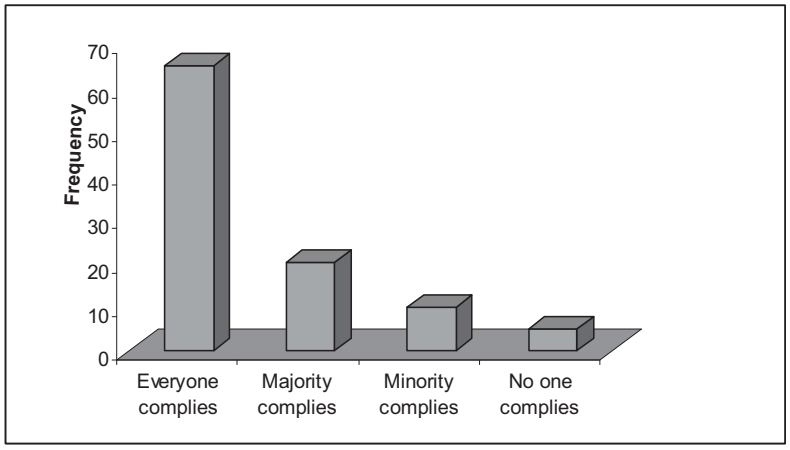

Figure 1. Community compliance of bylaws in SWC at Galessa watershed

Soil bunds and planting MPTs and grasses

Farmers voluntarily constructed soil bunds in all villages of the watershed and planted different multipurpose trees and grasses. Soil bunds have been constructed and different MPTs have been planted on soil bunds since 2004. . A total of 35 hectares have been protected with soil bund and almost all the bunds have been planted with MPTs and grasses to stabilize the structures and to intensify the outfield. The main MPTs and grasses planted were tree Lucerne, elephant grass, vetiver grass and phalaris. The performance of tree Lucerne and elephant grass was better than the others grasses.

Challenges

Property right and soil and water conservation

Despite their complexity and diversity, all watersheds share two keystone resources: water and land. Property rights to land resources generally vary across the different types of land that make up watersheds. Insecure property rights to cropland can reduce incentives to invest in land improvements and conservation structures such as terraces or trees that could reduce soil erosion and sediment flows. Often, however, water rights are more dynamic, flexible, and contested than land rights. Bundle of rights on cultivated land in the outfield, besides any other factors, influenced farmers' long term investment. For example, none of the shared in plots have received animal manure. This is because of the fact that on the one hand, farmers perceived the manure will stay in the soil for about three years; on the other hand, the length of sharing land is not greater than one year.

Collective actions for SWC

Collective action as an institution is commonly overlooked or, when recognized, frequently misunderstood. Most basically, this collective action can be defined as voluntary action taken by a group to achieve common interests (Marshall 1998). The action can take place through an organization such as a producer cooperative or members can participate in such action directly.

Effective soil and water conservation requires various stakeholders to coordinate their use of and investments in these resources. Robust collective management depends on the level of existing community organization and social capital. Strong norms and social relations enable people to work together to achieve their goals. The size and social structure of communities sharing the watershed influence their ability to stimulate and sustain collective action.

Watersheds know no boundaries. Collective action will be most easily achieved among people of the same ethnic, cultural, political and/or administrative group. Rarely, if ever, are ethnic, cultural or administrative boundaries consistent with hydrologic boundaries. Achieving coordination often requires reconciling socially defined boundaries like villages with physically defined boundaries like catchments. Although there are technical reasons to use catchments as natural units when applying a watershed approach to natural resource management, organizing collective action for SWC along strict hydrological boundaries was difficult. Hydrological boundaries and features of watersheds or sub-watersheds rarely correspond to the village, the district, or other social or administrative unit. For example Galessa watershed is found in two peasant associations and contains fully and partially five villages. Some of the households in a village were dissected by the hydrological boundary. Collective action through the existing administrative institutions, for instance, Gere-Missoma, Peasant Associations and local institutions such as Idir, equb, and senbete were difficult for watershed based SWC as their boundaries were not reconcile with the hydrological boundary.

Participation in SWC

The extensive nature of resources and the interdependency of users within a watershed underscore the need for broad stakeholder participation in developing and implementing watershed management technologies.

Finding mechanisms to identify relevant stakeholders-including users and non-users of resources, both inside and outside the watershed and to facilitate exchange of information, mediation of conflicts and negotiation of mutually acceptable land management options is not an easy task Achieving effective participation were challenging because stakeholders often differ greatly in their social, economic, and political power and access. Identifying stakeholders and facilitating their interaction are also challenged by the diversity of stakeholders, interests, mandates, and claims on watershed resources.

Although there are several interest groups of farmers in a given watershed, four major categories were found in Galessa watershed. These four categories of farmers have divergent interest in different issues of the watershed because they do have unequal benefits of collective action in the watershed. This case study showed how these different categories of farmers behaved in watershed management activities.

Type I: Farmers whose residential house and farmland are entirely inside the watershed and covered 11.7 % of the watershed residences. These were farmers who were willing and fully participating in watershed activities and meetings. This is because they could benefit from every activity implemented in the watershed.

Type II: Farmers whose residential house was inside the watershed and their farmland was partially inside and partially outside the watershed. This group covered 57.9% of the watershed residences. Since these farmers have farmlands partially inside the watershed, they were partial beneficiaries of the some watershed activities implemented in farmlands in the watershed. The level of participation of type I farmers were better than type II farmers. They were also more interested in technologies that can be adapted around homestead at individual household levels.

Type III: Farmers whose residential house is inside the watershed and without farmland. These types of farmers covered 1.2%, were mostly landless and these were of two types: The first category of farmers are those completely engaged in off-farm activities while the second category of farmers are those partially off-farm and those partially farming (rent-in/ shared-in). The categories of these farmers had no any interest in almost all of the watershed activities except spring management as their livelihood depends on completely on off-farm activities. The second category was also interested in short-term benefits

from improved variety and resistant in long-term investment like soil and water conservation activities.

Type IV: Farmers whose residential house is outside the watershed and their farmland was entirely inside the watershed. This group covered 29.2 % of the total household in the watershed. It was challenging for watershed facilitators to participate those farmers whose residential house was outside the watershed and their farmland was entirely inside the watershed in different watershed activities. This was because some of these farmers were at distant from the watershed and/or either they shared out or rented out their farmlands and living in adjacent towns

Spatial inter-linkages and externalities

Spatial inter-linkages related to the flow of water and nutrients are inherent in watersheds. Soil erosion in the upstream may harm downstream uses of land and water, while conservation measures in the upstream may benefit downstream use. Coordination or collective action is often required, which may be difficult because benefits and costs are distributed unevenly. This is not only complicate implementation, but also raises difficulties for evaluation. In particular, since the extent of such complexity will vary by case, an activity that works in one location may not work well in another. Subtleties in underlying differences can make it difficult for researchers to understand causal relationships governing success. The experience at Galessa watershed showed that farmers having flat to gentle lands were reluctant to construct or collaborate for soil bunds construction. These plots are either the sources (if in the upstream) or the sinks (if in the downstream) of run-off. A farmer in Ameya village refused to construct soil bund and the plot stayed a source of high run-off for the downstream plots.

Due to the lack of natural waterways to drain excess water collected from several soil bunds, there was a need to have artificial common waterways. However, getting common waterways was one of the main challenges in soil and water conservation in the watershed. This is because farmers should lose part of their arable land. Negotiation support and persuasions were used to convince farmers to secure common waterways in appropriate areas. This approach was successful in all of the villages in the watershed.

Long gestation and difficulty in perceiving benefits

Some watershed activities may have short-term effects, but majority of watershed activities have long-term impacts, some of which may be

difficult to evaluate or even perceive. Soil erosion, for example, is a slow process in many places and the benefits of arresting it may not be recognized easily. Recharging groundwater, stabilizing hillsides through vegetative cover, and increasing soil moisture and organic matter all take time. As a result, it was difficult to know the conditions that would have prevailed in the absence of interventions. Perceiving benefits is particularly difficult where interventions do not raise productivity but merely prevent gradual degradation.

Even if impacts are perceptible, it is difficult to assess the economic value of the numerous potential activity benefits that do not enter the market. These include such environmental and natural resource improvements as greater abundance and wider diversity of natural flora and fauna, higher groundwater levels, and lower risk of landslides and flooding.

Free grazing

Conflicts resulting from free grazing have spatial dimensions related to the distribution of grazing lands and the administrative units from which grazing households emanate. In Galessa watershed, livestock are restricted on the uncultivated mainly fallow and natural pasture areas during cropping season, whereas during dry season grazing is open access as there is no crop in the outfield.

Different approaches have been tried to intensify the Galessa watershed. The first approach was tried in 2005/2006. In this approach discussions and series of meetings were held to intensify the outfields through construction of soil bunds and planting MPTs. The whole community in the watershed was convinced and mobilized to construct conservation structures and planting MPTs and they were also agreed on the protection of MPTs from grazing during the dry season. During 2005/2006 cropping season, farmers of each village constructed soil bunds and planted MPTs on the structures. However, farmers were not able to stop free movement of cattle and almost all MPTs were devastated by free grazing. Farmers raised different reasons for the failure of the approach. Some of these reasons were: presence of different interest groups. For example, those with large number of livestock were not supporting outfield intensification; it was difficult to control livestock from adjacent areas entering to the watershed; and large livestock population coupled with lack of animal feed in the watershed made it difficult to control free grazing with in short period of time.

The second approach was tried in 2006/2007. In this case, only interested groups having adjacent plots were organized and planted multipurpose trees on soil bunds. Two groups with seven member each were organized and agreed to serve as guard turn by turn, assuming once per week to control free grazing during the dry period in the selected small catchments in two villages were organized and agreed to hire a guard through contribution of money to control free grazing during the dry period.

Still this approach has not been working due to the fact that the amount of money that will be paid for the guard was beyond the expectation of farmers and farmers cannot contribute such amount of money. This approach was failed due to loss of commitment and ambitious planning.

The third approach planned for 2007/2008 was introducing high value crop like apple in the watershed as an incentive to control free grazing. The logic here was when high value tree crops like apple is planted in the outfield, farmers restrict their livestock from the outfield. However, farmers were not able to plant apple seedlings in the outfield because of fear of theft problem.

Outfield intensification in Ethiopia with the existing free grazing system is extremely complex issue. So, it requires gradual change through diversifying income generating enterprises, improved livestock and forage technologies which can substitute the economic return of farmers from the current livestock management system. Moreover, this should be supported by strong policy.

High cost of facilitation

Cost of facilitation was high as compared to the conventional approach. This is because it requires frequent follow-up and supervision of activities such as empirical researches, action research, and community action processes; and engagement of multidisciplinary team. Although watershed is expensive, it is a fraction of future benefits achieved by preventing environmental degradation and greatly reducing the need for costly remediation.

Challenge in managing multidisciplinary team

The different team members in Galessa watershed management were much more diverse and included soil scientist, soil and water

conservationist, hydrologist, economist, sociologist, agro-forester, crop breeders, forage agronomist, dairy specialist and fruit expert. Commitment to participatory watershed management research approaches may demand significant changes in the way we think about both the theory and practice of conventional research at plot level. This has been challenged by the different team members in different times. Some of the major factors that hindered the functionality of interdisciplinary team were: lack of common understanding on the approaches and how to work together, workload, turnover of coordinators and team members.

Conclusions and Recommendations

- The problem of soil erosion is complex phenomena and the solution is beyond research and technical innovations. Thus there is a need to integrate different innovations especially, policy, socio-economic and technological interventions;
- Generating basic information at watershed level is very important. This is because there is lack of enough basic information in the highlands which are very important to design different hydrological and SWC structures;
- There has been poor perception among different researchers and experts that SWC technologies developed some where else regardless of farming system, hydrology, physiography, pedography, socio economic variations, can be effective everywhere. But the experience in Galessa watershed showed that generating, testing, and evaluating different technologies which will be effective as per the agro-ecologies, farming system and other variations in the country is crucial;
- Effective SWC at watershed level requires high level of collective action, high security of property rights, and long time to get benefits. Long gestation of benefits of SWC activities have influenced the adoption of the structures and farmers' willingness to invest in the outfield. There is an urgent need to create awareness at different levels so as to invest for the future generation; and
- Hydrological boundary delineation was not effective for watershed based soil and water conservation as it dissects the administrative/institutional boundaries. Hybrid (flexible) watershed delineation is, therefore, crucial to mobilize the community with the existing institutions. However, the implementation of conservation activities should follow the watershed logic, i.e., from ridge to valley.

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Participatory Tree Nursery Management and Tree Planting

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Introduction

Human and livestock population, coupled with many other physical, socioeconomic and political factors causes severe degradation of natural resources. Forests are among the natural resources which decline at alarming rate in the highlands of Ethiopia. Forest clearing is continuing both in the high forests and on-farm remnant trees. Hence, this resulted in the loss of crop productivity, shortage of forest products and environmental degradation. The annual loss of high forest areas of the country is estimated to be 150,000 to 200,000 ha. If the forest clearing continues at present trend, the remaining forests would be devoid of vegetation within a short period of time (MNRDEP, 1994).

It was believed that about 35 % of the land area of the country was covered with high forests in the 1900s. The coverage was reduced to 16 %, 3.6 %, 2.7 %, and less than 2.3 % by the early 1950s, 1980s, 1989 and 1994, respectively (GPDRE, 1990; MNRDEP, 1994). The causes of the declining of forests are diverse. However, the low standards of living of the people coupled with the lack of alternative options to alleviate poverty are some of the factors responsible for aggravating the problem. Planting trees in and around farmlands, villages, homesteads, along roads and waterways can be potential niches to integrate different species and address the increasing demand for forest resources. Along with planting of trees, proper protection, management and utilization are very crucial. Integration of trees in the farming system can be achieved if land, labor and capital are available; and the priorities of the farmers respected. Thus, farmers' participation in the problem identification,

planning and implementation stages of the research can have significant impact on the promotion of tree planting activities.

As previous experiences from other African countries indicate, most farmers had little input to decide on their tree species preference. It was rather the scientists or extension workers used to decide for them. In actual circumstances, successful diffusion and adoption of improved tree based technologies depend not only on the technical performance of the technologies but also on farmers' participation during the different stages of technology generation.

Participatory on-farm testing of tree and shrub species is useful for evaluating the performance of the species under a wider range of biophysical (soil, flora, and fauna) and socioeconomic conditions (Kindu *et al*., 2008). It also provides important diagnostic information about farmers' problem, and helping to get farmers' assessment of a practice, their ideas on how it may be modified and for observing their innovations. Moreover, it encourages farmers and researchers to work together and share experiences. Participatory nursery management and planting of trees was carried out at Galessa watershed from 2004 to 2007 to increase farmers' participation in seedling rising and promoting planting of trees at the watershed and thereby document, processes, lessons and constraints.

Methodologies

The study site

The study was conducted at Galessa watershed, Dendi district, West Shewa Zone of the Oromiya Region from 2004 to 2007. The watershed is located in the central highlands of Ethiopia with an altitude range of 2820-3100 meter above sea level. The rainfall pattern is bimodal. The main rainy season is from June to September with a mean annual rainfall of >1000 mm. Barley is the most dominant crop followed by potato and enset (*Ensete ventricosum*). Cattle, sheep and horses are dominant livestock in the study area. The dominant soil of the watershed is Haplic Luvisols.

Nursery management

The initial watershed survey in 2004 showed that the loss of indigenous tree species and the shortage of wood resources as two of the 18 prioritized problems of the watershed. Discussion forum was organized with watershed farmers to find out solutions for the aforementioned tree related problems. During the discussion forum farmers suggested the establishment of their own community nurseries at the two villages. Those farmers who were interested in seedling rising were organized by village. Farmers and researchers made a transect walk in the watershed and assessed sites that are suitable to tree nursery establishment and selected appropriate nursery sites. Two community-based tree nurseries were established at two villages. The first nursery site was at Tiro (Legatebo nursery site) and the second site was at Ameya village. Indigenous and exotic tree species were selected based on farmers' interest and raised in the two nurseries.

Trainings were given to the farmers on the methods of raising seedlings (nursery layout, site preparation, potting, seeding, transplanting and pricking out) and tree nursery management practices. Moreover, nursery tools and tree seeds were provided to farmers by African Highlands Initiative (AHI) project. Each year (from 2004 to 2007), a discussion forum was organized with farmers to evaluate and document major challenges and constraints in participatory nursery management. During the process of participatory nursery management farmers set local nursery bylaws that encourage equal contribution of costs and benefits among the participating farmers.

Tree planting

Different meetings were held before the distribution of seedlings to avoid improper site selection, land preparation and planting. Farmers were informed to prepare and make ready planting sites prior to planting. Practical training days were organized and conducted at the time of planting. Regular meetings and group discussion forums were handled every time with farmers. Field visits were conducted in order to enable farmers share experiences from each other. In addition to the nursery management activities, tree planting around homesteads, abandoned land and valley bottoms were conducted to evaluate the performance of different tree species. Tree species such as *Dombeya torrida, Rhamnus prinoides, Acacia decurrens, Hagenia abyssinica, Eucalyptus globulus*

and *Chamaecytisus palmensis* were planted with a 1.5 m intra and 2 m inter row spacing in a randomized complete block design (RCBD) with three replications. Survival counts of the species were done every three and six months to calculate their survival percentage. Graduated stick and caliper were used to measure height and root collar diameter of the tree and shrub species, respectively.

Results and Discussion

Farmers' experiences and reflections

Three nursery groups worked at Tiro village and one nursery group worked at Ameya village. Each nursery group was composed of five committee members, which includes a chairman, secretary, cashier, supervisor and a member. The committee had an overall responsibility of organizing meetings, follow-up the day-to-day activities of the nursery and identifying the level of participation of the farmers.

Bylaws on nursery management has been developed, commented and approved by the community group in the watershed. The farmers put restrictions on members who would not perform the expected responsibilities. A community member who doesn't properly manage seedlings during his or her turn and doesn't participate meetings organized by researchers or representative group leaders shall be punished. Similarly group leaders who don't perform his responsibility such as leading and supervising the members shall be punished. It is included in the bylaw that the final sharing of the seedlings will be only for group members in the watershed.

Most of the seedlings raised in the year 2004/2005 died at both nurseries. A discussion forum was held by researchers and farmers before the onset of 2005/2006 seedling raising activities in order to investigate the possible causes of the poor survival of the seedlings at the two nurseries. The objectives of the participatory discussion were: to identify the previous year (2004/2005) tree nursery problems, propose possible solutions for the specified problems and prepare a nursery activity plan.

During the group discussion, farmers identified the following major problems that are associated with the management of community nursery:

Improper fencing of the nursery site: The nursery site was not properly fenced. This was because of wider spacing of the fencing poles while fencing the nursery site, use of poor quality nails and poor construction of the nursery gate. As a result, browsing animals damaged the seedlings.

Poor implementation of nursery activities and differences in level of participation: Farmers didn't weed and water the seedlings regularly. Moreover, all farmers didn't show equal participation in the process and this influenced those actively participating farmers. The reluctance of some farmers and lack of continuous follow up of the nursery activities by the management committees were the major reasons for the implementation of the plans.

Difficulties to implement local nursery bylaws: At the beginning of participatory nursery management there was no law set by the farmers. In the mean time, farmers found that most farmers didn't actively participate in the nursery activity. Then, farmers decided and set local bylaws so as to enable all farmers to participate equally. However, the local law was not implemented as expected. This was because of the social relationships among the different social groups that hindered the implementation of punishments agreed in the bylaw.

The watershed farmers arrived at the following possible interventions so as to minimize the aforementioned problems:

- Each members of the nursery group agreed to bring poles and involve during the maintenance of the fence.
- Farmers requested assistance from community facilitator to purchase nursery construction materials such as U-shape nail and barbed wire.
- Pot filling with sand, manure and local soil should be made prior to sowing date. The committee of each village should arrange timetable and share responsibilities to each member, and carry out continuous supervision.
- The watershed committee should implement bylaws.

Researchers and farmers held a group discussion forum in October 2006. The objectives of the participatory discussion were to assess the year 2005/2006 tree nursery management problems and propose possible solutions accordingly. Major issues raised by the watershed farmers

include: inefficiency to raise seedlings according to the proposed calendar, lack of implementing the bylaws and refusal of the nursery site landowner to provide land for nursery establishment.

Performances of trees and shrubs

Survival of the species

The survival percentages of trees planted around the homestead were better than that of the trees planted on abandoned land and in valley bottoms (Table 1). A 100% survival rate was recorded for *A. decurrens and* 97.8 % for *E. globulus* around the homesteads. *Chamaecytisus palmensis* showed the lowest survival rate as compared to the other species. On the other hand, tree planted at the valley bottoms showed poor survival percentage as compared to the trees planted around the homesteads and on abandoned land. *Acacia decurrens* followed by *R. prinoides* resulted in the highest survival rate on valley bottoms. *Do*mbeya *torrida* followed by *C. palmensis* showed the lowest survival rate. The low survival rate of the trees on valley bottoms as compared to the other niches might be due to the frequent occurrence of frost hazard of the former than the later.

Table 1. The survival rate (%) of different trees and shrubs at different niches of the Galessa watershed

Tree species planted	Homestead	Abandoned land	Valley bottom
Acacia decurrens	100	86.1	66
Chamaecytisus palmensis	75.6	58.3	81
Dombeya torrida	91.1	28.6	39.1
Eucalyptus globulus	97.8	-	85.2
Hagenia abyssinica	93.3	73	-
Rhamnus prinoides	86.7	83.3	54
Juniperus procera	-	-	60
Olea africana	-	-	61
Mean	90.75	65.86	65.05

Growth of trees

Height and root collar diameter of trees planted on abandoned land was better than trees planted in valley bottoms. *Chamaecytisus palmensis* provided the highest mean height growth (2.28 m) around the homestead as compared to the abandoned land and valley bottoms. On the abandoned land, the highest height growth was recorded for *A. decurrens* followed by *E. globulus.* On the other hand, the lowest height growth was recorded for *R. prinoides* followed by *H. abyssinica* (Table 2). Like that of the height growth, the root collar diameter varied among the tree

species. The highest root collar diameter was recorded for *C. palmensis* followed by *D. torrida* (Table 3). *Rhamnus prinoides* provided the lowest root collar diameter in all of the three tree growing niches. Better soil fertility and less frequent frosts can be some of the factors that contributed to better growth of the tree species around the homestead.

Table 2. Height growth (m) of trees planted at the three niches of the Galessa watershed *(After two years of establishment)*

Tree species planted	Homestead	Abandoned land	Valley bottom
Acacia decurrens	1.95±(1.11)*	0.82±(0.33)	0.48 ±(0.25)
Chamaecytisus palmensis	2.28±(1.10)	0.48±(0.19)	0.49±(0.25)
Dombeya torrida	1.42±(0.42)	0.30±(0.17)	-
Eucalyptus globulus	2.0±(0.54)	0.54±(0.28)	-
Hagenia abyssinica	0.89±(0.41)	0.23±(0.14)	0.17±(0.08)
Rhamnus prinoides	0.82±(0.43)	0.21±(0.11)	0.21±(0.07)

**Figures in the parenthesis are standard deviations*

Table 3. Root collar diameter (cm) of trees planted at the three niches of the Galessa watershed after two years of establishment.

Tree species planted	Homestead	Abandoned land	Valley bottom
Acacia decurrens	1.34±(0.65)	1.37±(0.39)	0.88±(0.23)
Chamaecytisus palmensis	2.32±(1.80)	0.70±(0.23)	0.89±(0.26)
Dombeya torrida	2.28±(0.78)	0.81±(0.27)	-
Eucalyptus globulus	1.74±(0.45)	0.70±(0.40)	-
Hagenia abyssinica	2.05±(0.83)	0.86±(0.35)	0.81±(0.24)
Rhamnus prinoides	1.20±(0.68)	0.56±(0.23)	0.58±(0.11)

**Figures in the parenthesis are standard deviations*

Major Constraints

Lack of fencing

Some of the trees planted near the homesteads as live fence and others were planted on open fields. Some farmers protected the seedlings around the homesteads through fencing. But, most farmers did not fence the seedlings. Due to this problem, most of the seedlings were trampled, grazed and browsed by animals.

Narrow spacing

Most of the framers' planted seedlings too closely. Some farmers planted with a spacing of less than 10 cm. As a result, the survival and growth performance of seedlings affected due to competition for water and nutrient resources.

Unwise planting

It was found that some farmers planted tree seedlings without removing the polyethylene bags. Moreover, most farmers didn't conduct proper planting of the seedlings. They planted the seedlings in a slant position rather than vertical (straight upward) position.

Poor site selection

Some farmers planted seedlings underneath of the live fence.

Dispersed planting

Some farmers planted the seedlings in scattered areas where they have land. This has created inconveniencies for timely weeding, fencing and mulching of the seedlings.

Poor management

Most farmers did not weed, hoe and manure the seedlings. The seedlings in some farmers' fields totally invaded by weed.

Animal browsing and trampling

Animals graze and browse during the dry season freely. This has resulted in poor survival of the trees.

Conclusion and Recommendations

Participatory nursery management can be more effective so long as incentive mechanisms designed to facilitators within the community.

Participatory community nursery management enabled farmers to raise tree and shrub seedlings in their vicinity. It also benefited those farmers who didn't have land near the watering points.

Participatory nursery management enabled farmers to learn from each other on how to raise and manage tree seedling in the nursery.
Negotiations among farmers were required to reduce the impact of free grazing on trees planted in the outfields.

Chamaecytisus palmensis showed good performance and survival percentage both on abandoned land and valley bottom sites. Therefore, further work should be done to promote the species to reclaim degraded sites at the watershed.

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Availability and Consumption of Woody and Non-woody Fuel Biomass at Galessa

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Introduction

At Galessa watershed, population pressure has resulted in increasing shortage of farmlands, and this has resulted indiscriminate cutting of trees. Due to this, farmers mentioned loss of trees and shrubs and shortage of fuel wood in the landscape as one of their priority problems. Over population growth and the declined economic situation in the area have also led to rapid forest destruction of the nearby Chilmo forest. The shortage of fuel wood has already forced farmers at Gallessa to use cow dung as a source of fuel. African Highlands Initiative (AHI) in collaboration with Holetta Agricultural Research Center is working in an integrated watershed management approach to overcome the wood, food and feed related problems. The paper summarizes the research findings of major fuel source, amount used at household level, wood resource availability, the wood balance and possible interventions.

Methodology

Informal group and individual discussions were held with farmers in the watershed on issues related to fuel wood shortage and associated problems. In addition, issues about land holding and land allocations by individual farmers for different production purposes were thoroughly discussed. Farmers were briefed about the objectives of the assessment survey. The list of the watershed farmers on village bases was obtained

from the watershed committee. Watershed farmers were classified based on their wealth category as rich, medium, poor, and very poor.
The fuel wood consumption assessment formal survey was conducted for one year from April 2006 to April 2007 on 43 households. The assessment format contained the name of the farmer, name of the village where farmers reside, sex, age, family size and wealth category of the household. Survey on land holding and land-use type was carried out in the same period on 36 households.

The amount of fuel wood and cow dung used in each household was documented. Measurements of dried fuel wood and cow dung consumption of each household were done by mass balance every two to three days of the year. The land of 36 farmers were measured and recorded for each land use types. The forest and woodlot area and the number of trees planted in each household were enumerated and recorded. Moreover, the total wood production in each household was estimated through direct measurements of tree height and diameter at breast height (DBH).

Results and Discussion

Landholding and land use

The land holding and land-use types at Galessa watershed varied from farmer to farmer. The major land-use types recorded in the watershed are cropland (outfield and home garden), forest land (homestead and woodlot) and grazing land. Among the 36 surveyed farmers, the highest land holding was 6.15 ha. The lowest landholding ranged from landless farmers to farmers who have 0.12 ha. More than 50% of the surveyed farmers have ≥ 2 ha. Similarly, more than 25% of the surveyed farmers have ≥ 3 ha. Therefore, the land holding of the farmers at Galessa watershed is above the land holding of many highland areas of the country.

Cropland: Farmers of the study area have cropland holding both in the outfield and home garden. The highest and lowest land holding of the farmers in the outfield was 5.58 and 0.21 ha hh^{-1}, respectively. Likewise, the highest landholding at the home garden was 1.38 and 0.02 ha hh^{-1}, respectively.

Forestland: Farmers in the watershed plant tree to satisfy their fuel wood, construction wood, farm implements, and generate income. They plant trees as woodlots and live fences. Among the 36 surveyed households only 13 planted trees in the form of woodlots. Woodlots comprised of 2.05% of the total watershed area. *Eucalyptus globulus* were a dominant woodlot species followed by *Cupressus lusitanica*. The biggest area that was occupied by a woodlot was 0.44 ha hh^{-1}. The lowest woodlot area coverage was 0.01 ha hh^{-1}.

Grazing land: Grazing land is another form of land-use type that exists at Galessa watershed. Farmers allocated a certain area of land for grazing. The share of grazing land in the watershed was 6.18% without the inclusion of the fallow period. Among 36 interviewed households only 20 of them had grazing land. The biggest grazing land recorded was 0.88 ha hh^{-1} whereas the lowest grazing land was 0.02 ha hh^{-1}.

Table 1. Landholding of the sampled farmers

Land-use type	Area (ha)	Area (%)
Crop land		
Outfields	58.99	74.82
Home garden	13.36	16.95
Forest (woodlot)	1.613	2.05
Grazing land	4.874	6.18
Total	78.837	100

Table 2. Land holding of the surveyed farmers

Percent of farmers who owned land	Total landholding (ha)
13.8	0.1-0.50
27.7	0.5-1.50
16.7	1.50-2.50
19.46	2.50-3.50
8.37	3.50-4.50
11.2	4.50-5.50
2.77	5.50-6.00

Tree planting and wood production

Farmers plant trees as woodlot and live fence around homesteads. The dominant exotic trees planted by the farmers were *E. globulus* and *C. lusitanica.* Farmers also planted indigenous tree species such as *Hagenia*

abyssinica, Buddleja polystachya, Dombeya torrida, Acacia decurrens and *Chamaecytisus palmensis* (Table 3). *Chamaecytisus palmensis* and *B. polystachys* provided the lowest wood production. This may be due to the damage caused by the livestock population at the early stage of the planted trees in the outfield. The number of trees planted varied from household to household. Most households planted *E. globulus* more than the other species and obtained as high as 33.37 m^3. The lowest wood production from the households was 0.07 m^3.

Table 3. Tree species planted by sampled farmers and their respective wood production

Planted species	No. of trees	Wood production (m^3)
Eucalyptus globulus	12233	171.482
Cupressus lusitanica	976	63.15
Hagenia abyssinica	18	3.304
Buddleja polystachya	21	0.949
Dombeya torrida	6	1.60
Acacia decurrens	92	7.201
Chamaecytisus palmensis	60	0.43
Total	13406	248.11

Fuel wood and dung utilization

Fuel wood is the major source of energy at Galessa watershed. Farmers in the watershed obtain their fuel wood mainly from the trees planted around the homesteads as live fence and/or woodlots. Some households collect fuel wood from Chilmo forest. The annual total fuel wood and cow dung consumption of the households at the watershed was found to be 189.07 m^3 and 13178.30 kg, respectively. The fuel wood and dung demand of the households at the watershed varied depending on seasons of the year, family size, and wealth category.

Table 4. Fuel wood (m^3) and cow dung (kg) consumption pattern at the watershed

Categories	Seasons			
	June-Aug	Sep-Nov	Dec-Feb	Mar-May
Total fuel wood ($m^3\ yr^{-1}$)	42.99	58.98	54.38	32.72
Mean fuel wood used ($m^3\ hh^{-1}$)	1.00	1.38	1.26	0.76
Total dung ($kg\ yr^{-1}$)	4188.80	1876.6	2145.9	4967.00
Mean dung used ($kg\ hh^{-1}$)	97.41	43.63	49.91	115.52

The mean annual fuel wood consumption of the households was higher from August to November. The household mean annual fuel wood consumption was 0.463, 0.461, 0.456 and 0.454 m^3 hh^{-1} in the months of August, September, October, and November, respectively (Table 5). On the other hand, the lowest mean fuel wood consumption observed in the months of May, April, July and June. The very cold weather condition at the watershed is the reason for the high fuel wood consumption from August to November.

Table 5. Fuel wood and dung consumption of the households on monthly basis

Months	Fuel wood		Dung	
	Total annual consumption (m^3)	Mean annual consumption of the hh (m^3)	Total annual consumption (kg)	Mean annual consumption (kg hh^{-1})
June	12.06	0.281	1367.7	31.81
July	11.02	0.256	1237.2	28.77
August	19.91	0.463	1583.9	36.83
September	19.83	0.461	1234.3	28.70
October	19.62	0.456	600.9	13.97
November	19.53	0.454	41.4	0.96
December	17.71	0.412	126	2.93
January	17.84	0.414	752	17.49
February	18.83	0.438	1267.9	29.49
March	17.77	0.413	2619.3	60.91
April	8.69	0.202	1395.30	32.45
May	6.26	0.146	952.9	22.16
Total	171.07	4.396	13178.8	306.48

The cow dung demand of the households also varied from month to month. The highest cow dung demand was noticed from March to June. The increased cow dung consumption from March to June was may be due to the availability of the cow dung in the field and favorable condition for the collection and preparation of the cow dung. On the other hand, the lowest cow dung consumption was observed from November to January.

The average annual fuel wood demand of each household was directly proportional to its wealth status. Wealth categories of 1, 2, 3 and 4 demanded 4.74, 4.69, 4.51 and 3.72 m^3 of fuel wood, respectively (Table 6). Similarly, the average annual cow dung demand of the wealth ranks

of 2, 1, 3 and 4 was 402.16, 329.33, 256.43 and 256.43 kg, respectively (Table 6).

Table 6. Fuel wood and dung consumption based on wealth rank

Wealth rank	Number of hh	Fuel wood (m^3)		Cow dung (kg)	
		Average annual fuel wood used hh^{-1}	Total annual	Average annual dung used hh^{-1}	Total annual dung used
Very rich	9	4.74	42.66	329.33	3183.50
Rich	11	4.69	51.59	402.16	4642.40
Medium	11	4.51	49.2	256.43	3039.70
Poor	12	3.72	44.77	247.52	3189.30

Besides wealth categories, fuel wood demand of the watershed was directly proportional to family size. The family size with >10, 6-10, 3-5 and 2 required 6.67, 4.53, 4.19 and 2.14 m^3 hh^{-1}, respectively (Table 7)..

Table 7. Fuel wood (m^3) and dung (kg) consumption based on family size

Family size	Number of hh	Fuel wood used hh^{-1} yr^{-1}	Total fuel wood used yr^{-1}	Cow dung used hh^{-1} yr^{-1}	Total dung used
2	1	2.14	2.14	144.80	144.80
3-5	16	4.19	68.3	278.72	4961.50
6-10	25	4.53	114.6	336.65	8918.30
>10	1	6.67	6.67	158.30	158.30

The impact of dung on soil fertility

The farmers at Galessa watershed use cow dung to supplement their fuel wood requirement rather than applying and improving the fertility of the depleted soils. The amount of N, P, and K lost every year at Galessa watershed due to the utilization of cow dung as fuel source was calculated using the present conditions (nutrient concentration, price and rate of application). The farmers forced to buy 16.15 quintals (1615 kg) of DAP yr^{-1}. At the time when the price of DAP was 300 birr $Quintal^{-1}$, the farmers expend 5000 birr yr^{-1} (Table 8). This has a significant impact both on the farmers' economy and the fertility status of the soil.

Table 8. Nutrient content and cost estimate from cow dung samples at Galessa watershed

Essential nutrients	Nutrient content	Total used dung kg^{-1}	Nutrients lost kg yr^{-1}
Total N (%)	1.17	13178.8	154.19
Available P (ppm)	1.31	13178.8	172.64
K (meq /100% of soil)	1.03	13178.8	135.74
Organic C (%)	51.87	13178.8	6835.84

Demand and supply of fuel wood

The current fuel wood demand (579460.75 kg) at the watershed is greater than the supply (552191.50 kg) (Table 9). If intervention options aren't designed, the natural resources degradation of the watershed will be aggravated. Since the existing fuel sources couldn't satisfy the demand, the community at the watershed partly fulfilled their requirement by fetching wood from the nearby natural forests. The following wood demand and supply scenarios are expected at the watershed:

- Based on the current situation, each hh should plant 0.25 ha yr^{-1} for four continuous years (625 m^2 yr^{-1} of land or 2500 trees during four years). In other words, a total of 36 ha of land in which 9 ha yr^{-1} need to be planted for four continues years. The spacing can be 1 m x 1 m. The rotation period will be four years. It is expected that the trees attain a height of 5 m and a DBH of 5 cm after four years of establishment. After four years of tree planting interventions the watershed forest coverage can reach to 12%. Through the implementation of the tree planting scheme, the cow dung can be used as sources of organic fertilizer at the watershed;
- At the moment, there is an attempt to introduce energy saving stove at the watershed. If the trend of introduction of the stoves continues at the current level of initiation, the fuel wood demand will be reduced by 50%. This approach will also help to maintain the forest cover that will be 6% after four years of tree planting interventions; and
- If the national population growth rate continues with that of 3% and applies to the Galessa watershed, the wood demand after four years will increase by 18.75%. It is essential to raise the forest cover of the watershed to 16% where there are no energy saving stoves and other energy conserving technologies.

Table 9. Fuel wood demand and supply of the watershed

Demand and supply	Amount
Fuel wood supply of the sampled farmers	116256.88 Kg
Fuel wood supply of the watershed	552191.68 Kg
Fuel demand (annual utilization) of the sampled farmer	120097.55 Kg
Fuel demand of the watershed	579460.75 Kg
Fuel deficit of the sampled farmers	3840.67 Kg
Fuel wood deficit of the watershed per annum	27269.07 Kg
Fuel wood percentage supply from planted trees	89 %
Dung percentage of the total fuel supply of the watershed	11 %

Conclusion and Recommendations

The survey result clearly showed that land allocated for planting trees is very low (2.05%). This doesn't fulfill the wood requirement of the watershed farmers. Therefore, it is urgently required to increase land allocation for tree planting. An average of 12% land allocation increase by individual household is required so as to attain wood resource requirement. This should be facilitated through well designed implementation strategy and supported by policy and/or local bylaws.

It is important to introduce alternative energy sources to reduce further wood resource degradation.

The use of cow dung as fuel is not recommended because soil fertility decline is the major problem at the watershed. Therefore, farmers should be advised to use cow dung for soil fertility maintenance.

Indigenous Farm Forestry Trees and Shrubs in Galessa Watershed

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Introduction

Indigenous tree and shrub species that are used for soil fertility improvement at Galessa watershed have been given little research attention. Similarly, the local knowledge hasn't been supported by scientific investigations. Hence, evaluation studies were conducted at Galessa watershed and the surrounding areas to identify and prioritize indigenous tree and shrub species for soil fertility improvement; assess soil properties under the indigenous trees and shrubs; and determine the nutrient concentration and other quality characteristics of the green biomass of indigenous tree and shrub species.

Materials and Methods

The study was carried out from 2004 to 2006 in Dendi (Galessa) and Jeldu *weredas* of the highlands of central Ethiopia. Niches, structure and composition of the tree and shrub species were investigated through direct observation, as well as group and individual discussion approaches. The tree and shrub species useful for soil fertility improvement were prioritized according to their leaf shedding pattern and decomposition rate by preference ranking method. A total of 150 farmers participated for questionnaire survey.

Senecio gigas, *Hagenia abyssinica*, *Dombeya torrida*, *Buddleja polystachya,* and *Chamaecytisus palmensis* were included in the plant and soil sampling scheme. A transect approach was considered for soil sampling. A sampling depths of 0-15, 15-30, and 30-50 cm and locations of 75 cm (hereafter referred to as closest), 150 cm (hereafter referred to as midst), and 225 cm (hereafter referred to as distant) at both sides from

the base of each marked tree were considered (Power *et al*., 2003; Wezel, 2000; Hailu *et al*., 2000; Kindu and Taye, 1997). Soil samples collected from similar locations were thoroughly mixed to obtain composite samples. Three replicated soil samples were collected under the five species. The soil pH was determined in 1:2.5 soil suspensions in deionised water for active acidity using potentiometric pH-Meter (ÖNORM L1083, 2005). Organic carbon was determined by C/S-Element Analyzer LECO S/C 444 using oven-dry samples. Dry combustion at 1400 ^{o}C in pure O_2 atmosphere and infrared detection of evolved CO_2 was applied (ÖNORM L1080, 2005). Total nitrogen was determined by Semi-micro-Kjeldahl procedure using the air-dry samples (ÖNORM L1082, 2005). Available P was determined by Olsen method (Olsen and Sommers, 1982).

The total N content of the foliage samples collected from the five species of the tree and shrub species was determined by Kjeldahl digestion using Na_2SO_4 and $CuSO_4$ as catalysts. Oven dried foliage samples were extracted with a mixture of HNO_3 and $HClO_4$. The total N, K, Ca, Mg, Na, S, Mn and Fe content of the extracts was determined by the use of a simultaneous ICP-OES. Lignin was determined by the methods of Van Soest and Robertson (1985). Soluble phenolic compounds were measured by organic solvent extraction and precipitation by trivalent ytterbium (Reed *et al*., 1985). Yb^{+++} forms a complex with free phenolic OH-groups and this complex precipitates. This precipitate is determined gravimetrically and the results are reported as mg phenolics g^{-1} plant material. This method yields quantitative data for total phenolics.

A one-way analysis of variance was conducted on soil pH, organic C, total N, exchangeable K, lignin and soluble phenolics using SAS (SAS Institute, 1999). The significance between means was tested using the least significance difference. The following model was considered while running the ANOVA:

$$Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij},$$

where μ is the overall mean, α_i the i^{th} treatment (species) effect, β_j the j^{th} block (site) effect and e_{ij} is the random error associated with Y_{ij}.

Results

Useful species for soil fertility and farmers preferences

Researchers together with farmers identified more than 16 tree and shrub species around homesteads, farmlands and other niches (Table 1). Soil improving tree species were mainly concentrated around homesteads and in forests. More than 86% of the farmers in the study areas need to plant trees around homesteads for better management and protection purposes. The percentage of farmers who mentioned lack of seedlings, a free grazing livestock system and a lack of awareness as major problems for the planting of indigenous soil fertility improving species is 60 %, 40 % and 25%, respectively. Farmers highly prefer *Senecio gigas, H. abyssinica* and *D. torrida* as the most useful tree and shrub species for soil fertility improvement (Table 2).

Table 1. Soil improving tree and shrub species identified in Galessa watershed

Species	Local names	Family names
Buddleja polystachya	Anfari	Loganiaceae
Dombeya torrida	Danisa	Sterculiaceae
Dracaena steudneri	Lankuso	Agavaceae
Hagenia abyssinica	Heto	Rosaceae
Juniperus procera.	Gatira	Cupressaceae
Kalanchoe deficiens	Bosokie	Crassulaceae
Leonotis ocymifolia	Bokolu	Lamiaceae
Myrica salicifolia	Reji	Myricaceae
Phytolacca dodecandra	Indode	Phytolaccaceae
Rubus apetalus	Gora	Rosaceae
Rubus pinnatus	Gura	Rosaceae
Schefflera abyssinica	Luke	Araliaceae
Senecio gigas	Osolie	Asteraceae
Trichilia roka	Anona	Meliaceae
Urtica simensis	Dobi	Urticaceae
Vernonia auriculifera.	Chochinga	Asteraceae

Foliage nutrient content and other qualities

The macronutrients content in the foliage differed depending on the species. *Chamaecytisus palmensis, D. torrid* and *B. polystachya* had a high N content in their foliage as compared to the other tree and shrub species. On the other hand, the content of N in the foliage of *H. abyssinica* was comparatively lower than the N content in other tree and shrub species (Table 3). *Senecio gigas* showed a higher P, K and S content in its foliage. The high content of P, K and S in *S. gigas* may be

traced back to the scavenging of these nutrients in a large soil volume and their accumulation in the aboveground organs. According to Garrity and Mercado (1994), members of the Asteraceae family, to which *S. gigas* belongs, are effective nutrient scavengers.

Table 2. Tree and shrub species ranked for soil fertility improvement at Galessa watershed

Soil improving species	No. of respondents [a]	Score
Senecio gigas	142	743
Hagenia abyssinica	147	734
Dombeya torrida	133	512
Vernonia auriculifera	122	357
Buddleja polystachya	99	272
Myrica salicifolia	100	205
Leonotis africana	60	106
Kalanchoe deficiens	9	39
Dracaena steudneri	5	16
Juniperus procera	3	10
Maytenus senegalensis	3	8

Note: Sample size was 150 households. Each household scored six preferred tree species for soil fertility improvement.
[a] Number of respondents who selected the species in the top 6. If a farmer selected a species first, it received a value of 6; if second, a value of 5; if third, a value of 4; if fourth, a value of 3; if fifth, Score is sums of individual farmer value given to the respective species.

The content of lignin and soluble phenolics in the foliage differed from species to species. The foliage lignin content was high in *B. polystachya* (173 mg g^{-1}) and relatively low in *H. abyssinica* (53 mg g^{-1}) (Table 4). Generally, the foliage lignin contents of most of our tree and shrub species were below the critical level of 150 mg g^{-1} dry matter. Lignin content above 150 mg g^{-1} impairs the decomposition of tree foliages, since lignin protects the cellulose in the cell wall from microbial attack (Chesson, 1997, Palm and Rowland, 1997).

Table 3. Lignin and soluble phenolics composition of the foliage and flower bud of the tree and shrub species

Foliage	*B. polystachya*	*C. palmensis*	*D. torrida*	*H. abyssinica*	*S. gigas*	SEM
Lignin	173[a]	124[ba]	100[bc]	53[c]	80[bc]	12.37
Soluble phenolics	82[b]	10[c]	54[b]	169[a]	79[b]	14.41
Flower bud						
Lignin	161[b]	98[dc]	199[a]	73[d]	106[c]	12.84
Soluble phenolics	14[c]	9[c]	15[c]	234[a]	38[b]	23.16

Lignin and soluble phenolics are in mg g^{-1} dry matter.
SEM - Standard error of the means (n = 15).
Means with different letters within a row are significantly different ($p < 0.05$).

Unlike the content of lignin, soluble phenolics were high in the foliage of *H. abyssinica*. *Chamaecytisus palmensis* had the lowest foliage soluble phenolics content. The variation among species for soluble phenolics in the foliage was from 10 to 169 mg g^{-1} (Table 4). According to Constantinides and Fownes (1994), the soluble phenolics content of green foliage of tree and shrub species can reach as high as 100 mg g^{-1}. Soluble phenolics content > 30 to 40 mg g^{-1} results in the immobilization of N (Palm, 1995).

Table 4. Macronutrient composition of foliage, flower bud and stem in five tree and shrub species.

Foliage	*B. polystachya*	*C. palmensis*	*D. torrida*	*H. abyssinica*	*S. gigas*	SEM
C	473^{b}	484^{a}	456^{c}	459^{c}	439^{d}	4.24
N	36.66^{a}	36.50^{a}	37.47^{a}	30.07^{b}	34.20^{ba}	0.94
P	4.71^{a}	2.50^{b}	3.76^{a}	3.71^{ba}	4.75^{a}	0.27
K	21.55^{c}	14.93^{d}	27.00^{b}	21.22^{c}	55.50^{a}	3.83
Ca	10.93^{b}	9.30^{b}	22.97^{a}	9.69^{b}	11.94^{b}	1.42
Mg	2.07^{b}	1.97^{b}	2.81^{a}	2.38^{ba}	2.57^{ba}	0.11
S	3.46^{b}	2.55^{c}	3.62^{ba}	2.03^{d}	4.01^{a}	0.20

Organic C, N, P, K, Ca, Mg and S are in mg g^{-1} dry matter.
SEM - Standard error of the means (n = 15).
Means with different letters within a row are significantly different (p <0.05).

Soil properties under tree and shrub species

Soil pH under *H. abyssinica* and *S. gigas* were above 6.34 (Table 5). The soil organic C contents under *H. abyssinica* were higher by 23.25, 24.53 and 21.03 mg g^{-1} than under *B. polystachya* in the closest, midst and distant positions, respectively. The difference in N was 1.85, 2.27 and 1.83 mg g^{-1}. Available P had the following order in the top 0-15 cm soil depth of the closest and midst horizontal positions: *H. abyssinica* > *S. gigas* > *C. palmensis* > *D. torrida* > *B. polystachya* (Figure 1). The contents of exchangeable K varied significantly at the three horizontal positions. The soil under *H. abyssinica* and *S. gigas* had a high content of soil K in all three horizontal positions (Table 6).

Table 5. Soil pH and organic C at the 0-15 cm depth and different positions from the base of the five tree and shrub species

Species	pH (H_2O)			Organic C (mg g^{-1})		
	75 cm	150 cm	225 cm	75 cm	150 cm	225 cm
Buddleja polystachya	6.07^{b}	5.90^{c}	5.86^{b}	51.31^{b}	40.33^{b}	39.73^{b}
Chamaecytisus palmensis	6.01^{b}	5.97^{bc}	6.09^{b}	61.37^{ba}	58.63^{ba}	56.36^{ba}
Dombeya torrida	6.14^{ba}	5.92^{bc}	5.85^{b}	63.50^{ba}	59.86^{ba}	57.59^{a}
Hagenia abyssinica	6.80^{a}	6.70^{a}	6.95^{a}	74.56^{a}	64.86^{a}	60.76^{a}
Senecio gigas	6.59^{ba}	6.47^{ba}	6.47^{ba}	58.93^{ba}	55.11^{ba}	53.00^{ba}
SEM	0.121	0.111	0.139	3.302	3.372	2.899

Means with different letters within a column at similar position are significantly different (p <0.05).

Table 6. Total N and exchangeable K at the 0-15 cm depth and different positions from the base of the five tree and shrub species

Species	Total N (mg g^{-1})			K (µg g^{-1})		
	75 cm	150 cm	225 cm	75 cm	150 cm	225 cm
Buddleja polystachya	4.75^{a}	3.99^{b}	3.83^{b}	826^{b}	568^{a}	455^{c}
Chamaecytisus palmensis	5.92^{a}	5.74^{ba}	5.19^{ba}	1428^{ba}	1409^{a}	1291^{bac}
Dombeya torrida	4.92^{a}	5.36^{ba}	5.36^{ba}	927^{b}	771^{a}	639^{bc}
Hagenia abyssinica	6.60^{a}	6.26^{a}	5.66^{a}	1929^{ba}	1592^{a}	1642^{a}
Senecio gigas	5.36^{a}	5.15^{ba}	5.04^{ba}	2306^{a}	1518^{a}	1507^{ba}
SEM	0.335	0.333	0.274	215.11	175.62	167.27

Means with different letters within a column at similar position are significantly different ($p < 0.05$).

The high content of organic C, N, P and exchangeable K under the vicinity of *H. abyssinica* as compared to *B. polystachya* can be associated with the fact that the former has a more efficient nutrient cycling power than the latter. *Hagenia abyssinica* constantly sheds a high amount of leaves and provides the soil in its vicinity with mulch and green manure. Kindu et al (2006) reported the presence of a high amount of litter deposition under 64 months old *H. abyssinica* and *Grevillea robusta* on Nitisols of central Ethiopia. *Dombeya torrida* and *S. gigas* shed a substantial amount of leaves, even though their leaf shedding pattern is not as regular as that of *H. abyssinica*. Soil organic C, N, P and K depicted a decreasing pattern from the closest to the midst and distant positions under most of the tree and shrub species. An improvement of soil nutrients by various tree and shrub species in topsoil and close to the tree stems has been reported earlier (Abebe *et al*., 2001; Ashagrie *et al*., 1999; Gindaba *et al*., 2005; Hailu *et al*., 2000).

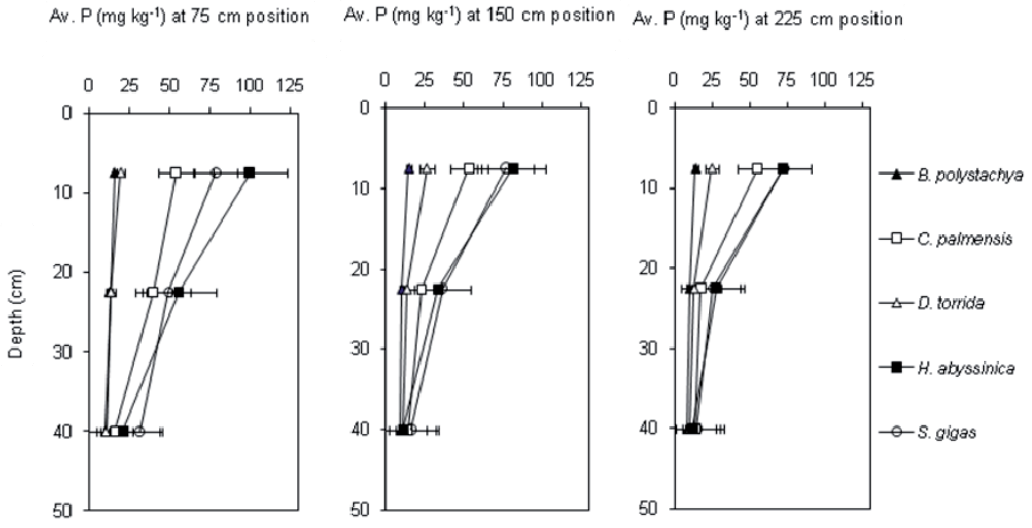

Figure 1. Trends of available P under five tree and shrub species at different soil depths and horizontal positions

Horizontal bars show standard errors of the mean.

Conclusions and Recommendations

The following are concluded and recommended based on the social and biophysical results of the study:

- The soil within the vicinity of *H. abyssinia, S. gigas* and *C. palmensis* contains a substantial amount of nutrients. This is an indication of the species' potential to improve the fertility of soils. Hence, research is urgently needed to evaluate the performance of the three species at Galessa watershed and other similar areas where soil erosion and soil fertility depletion are critical problems;
- Indigenous species are superior in terms of their macronutrient and lignin composition whereas the exotic species had a reasonable amount of soluble phenolics. Hence, the indigenous and exotic species can be potential sources of plant nutrients at Galessa watershed and other high altitude areas where there are limited soil fertility management options;
- Limited tree and shrub species have been studied for soil fertility improvement values as the lab cost is high to study all. Hence, most of the identified species at Galessa watershed need to be characterized for their nutrient content and other quality characteristics; and
- More leguminous woody species are needed for Galessa watershed in line with the indigenous species to sustain the addition of N inputs to the soil system.

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Spring Management for Integrated Watershed Management in Galessa

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Introduction

Galessa watershed is characterized by unpredictable rainfall patterns with periodic and perennial water shortages and poor water quality. Small springs, seasonal torrents and rivers had been the main sources of water in this area. All these water sources have been unprotected and shared by both humans and livestock. As a result, water-borne human diseases were a major threat to watershed residents. Due to the destruction of trees and lack of any soil and water conservation (SWC) measures in the upstream part of the watershed, these water sources have been declining over time. As a result, water for human and livestock was found to be the top problem in the area and it was selected as a main entry point for other watershed management activities during participatory watershed problem identification and prioritization period. Accordingly, five structures (three springs, one collection chamber and one cattle trough) were proposed so as to solve the aforementioned problems.

The main objectives of spring management was to improve the quality and quantity of water supply for human and livestock so that it would be used as an entry point, and increase the participation of farmers on all watershed management related activities.

Procedures

The major procedures conducted for spring management were:

- Participatory problem identification and prioritization: during participatory problem identification and prioritization, water in terms of quality and quantity was the top priority for almost all social groups in the watershed;
- Formation of spring committees at village level based on spring location: Spring committees for each three villages were formed from different social groups. The responsibilities and of the committee before and after construction of structures was clearly mentioned by the community;
- Agreement on objectives for spring management: Since different stakeholder assumed that spring management was not a mandate of research, it was crucial to reach on agreement on the objective of spring development. Accordingly, the objective, beyond improving the quality and quantity of water, was to spring management was increase the participation of farmers on all watershed management related activities;
- Identification and consultation with stakeholders: Stakeholders were identified from the local communities' wereda offices, zonal departments and research;
- Development of designs: Water Resources Development Department of the Zone assigned an engineer to design the structures and to estimate the cost. During designing the structures, the participation of local farmers was very high;
- Cost estimation and cost sharing: the estimated cost was shared among different stakeholders. AHI project covered more than 50% of the cost while the rest was covered by farmers through the contribution of labor, local material and money. Spring committee was responsible to mobilize resources and ensure the materials and labor from farmers;
- Participatory bylaw development and implementation: this bylaw included both pre-and post-construction of springs. The bylaw mainly focused on monthly contribution of money, local material, labor, and water use ethics. Its implementation governed construction of structures per the specification of the design and cost estimation, contribution of money and materials among the different stakeholders as per the agreement;
- Periodic follow-up and participatory monitoring and evaluation; and
- Negotiation support: This activity was targeted to remove eucalyptus species around the Ameya spring. Several persuasions and

negotiations among the different interest groups were held at different time.

Result and Discussions

Identification of three springs

Three potential springs were identified by the community and the experts from different stakeholders. The springs were identified based on their potential (annual flow) and the number of beneficiaries. All springs have multiple uses-human and livestock consumptions, cleaning and irrigating tree nurseries. According to these criteria Sombo spring at Sombo village, Lege Aba Tebo spring at Tiro village and Ameya spring at Ameya village were selected (Figure 1). Based on their annual flow and number of beneficiaries, springs were prioritized and Lege Aba Tebo has got high attention by the community due to high number of beneficiaries and high annual flow.

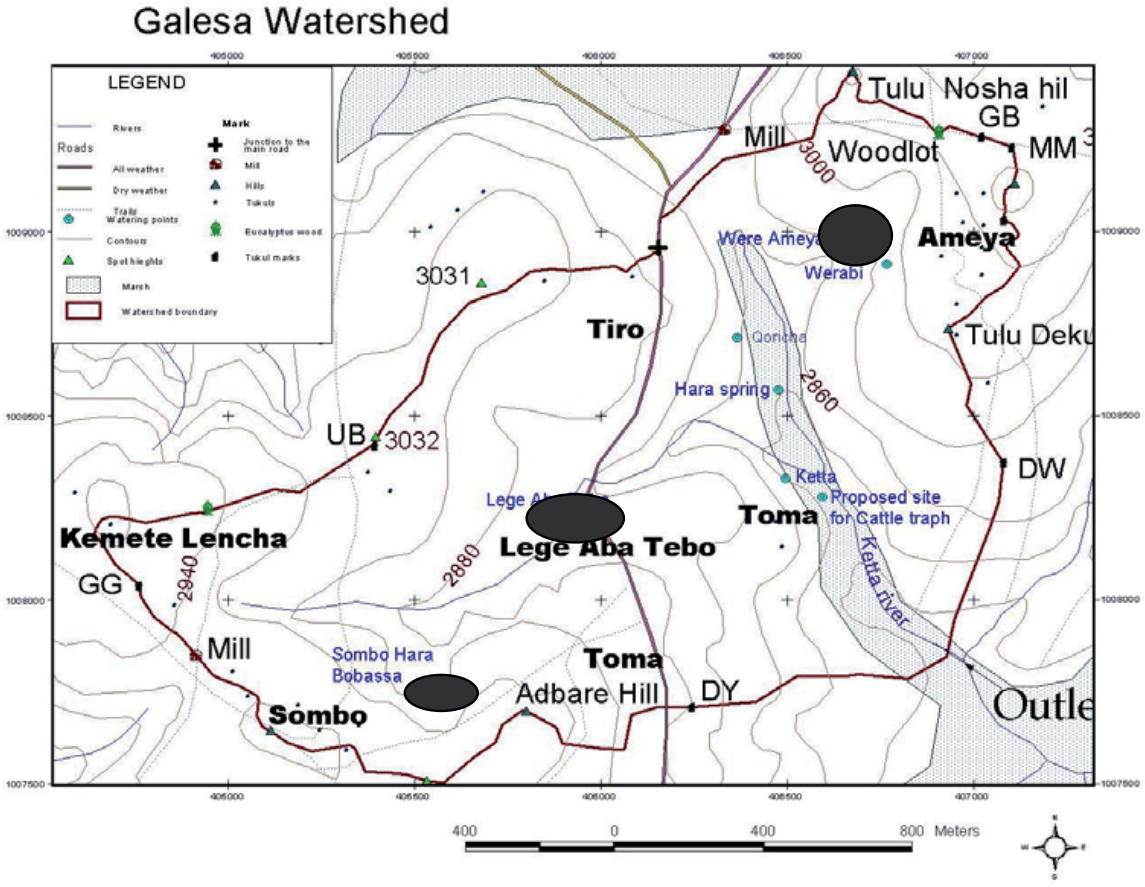

Figure 1. The location of three constructed springs in the watershed

Stakeholders involved on spring management

The participation of stakeholders in problem identification, prioritization, planning, implementation and monitoring and evaluation has been crucial in spring management. The major stakeholders identified and involved in the management of springs in Galessa watershed were:

- Farmers inside the watershed;
- Farmers outside the watershed;
- Local institutions (Idir, Ikub, Senbete and Mahber);
- Peasant Associations and Gere-missoma;
- Wereda offices (Office of Agriculture and rural development (OARD) Office of Rural Water Resources Development (ORW);
- Zonal offices (Office of Agriculture and rural development (OARD) Office of Rural Water Resources Development (ORW);
- African Highlands Initiative Project; and
- Research Center (HRC),

Constructing springs

The development of three on spot springs, the construction of one collection chamber with a capacity of 9.62m^2 and 6.6m length cattle trough with fittings supply and pipes lying of 132m of different diameters were completed and handed over to the water committee of the watershed and the Water Office of the Wereda during inauguration. The construction of all the project structures has been accomplished with good marksmanship and as per the design. Community participation was also ensured to the extent possible, which in turn builds confidence, and trust among the community so that they were motivated to involve in other watershed management related activities such as the construction of soil conservation structures and niche compatible a forestation. In addition to this, assessment of water-borne disease for humans and livestock has been done. Physical, biological and chemical physical analysis has been done by Ethiopian Health and Nutrition Research Institute (EHNRI). According to the result from EHNRI, water samples from Tiro and Sombo Villages indicated that the water is bacteriologically non-potable. According to the recommendation from EHNRI, the two springs were chlorinated.

Handing over to the community

After the springs were constructed, the springs were handed over to the beneficiaries with the presence of all stakeholders which were involved at different stakes of spring management. The responsibility of the spring

management was shared among the key stakeholders during the handing over ceremony. Accordingly, the spring committees of respective springs were responsible to control the overall sustainability of the springs by implementing the bylaws, fund raising, organizing the community for different activities and establishing network with the district water resources development office and with research institutes. The offices of water resources development at district level was responsible to supervise the structures and the bylaws, to train the local community for maintaining the structures and to maintain the structures if the problems are beyond the capacity of the rural communities. The office of health at district level was responsible to periodically supervise the springs for its potablity and chlorinate if necessary.

Effectiveness of bylaw on spring management

The bylaw which was developed for spring management except the removal of eucalyptus species was effectively implemented. There are several indicators for the effectiveness of this bylaw. Some of the indicators are:

- There has not been any complaining on the bylaw;
- There is no problem on the monthly contribution;
- Fencing and maintenance of springs without the support of researchers; and
- High voluntary participation of different stakeholders

Outcome

Different social groups in different locations interviewed on the impact of spring management on key problems that were mentioned during problem identification in the watershed. As shown in table 2, majority of the respondents respond that reducing water quality and time to fetch water were the most important outcomes of spring management. Out of the total interviewed individuals, 77.4% (n=36) of them confirmed that time for fetching water decreases after construction of the structures. Similarly, 82.9 % responded that the prevalence of waterborne disease decrease after spring management. Most of the respondents also mentioned that the quantity of water has been increasing from time to time after the construction of springs.

Table 1. Farmers perception (%) on the impact of spring management

Response		village					
		Tiro	Toma	Sombo	Ameya	Kemete	Non-watershed
Time spent for fetching	Increased	6.5			6.5	3.2	
	Decreased	16.1	16.1	19.4	16.1	6.5	3.2
	The same as before				3.2		
Waterborne disease prevalence	Decreased	19.4	12.9	12.9	22.6	9.7	3.2
	The same as before	3.2	3.2	6.5	3.2		

Conclusion

Linking diverse stakeholders and continuous negotiation are an unsurpassed alternative to handle natural resource conflicts and ensure sustainable management of water resources. For interventions like most NRM practices that take long to yield desired results the use of entry points is the appropriate path that will ensure long term interest by the target communities.

Building sustainability into the spring development and management activities conducted thus far at Galessa through local negotiations, bylaw reforms, institutional strengthening and monitoring has shown that these processes are essential in ensuring the sustainability of integrated watershed interventions. Continuous communication and feedback between district and site levels are required in implementing solutions and resolving problems, as successes and challenges are two sides of the same coin.

Aspects Influencing Dissemination of Barley Varieties in Galessa Watershed

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Introduction

Since the late 1980s, different research methods were proposed and currently a holistic approach that aims at multi-objectives, diverse stakeholder issues within the context of multiple scale settings with a participatory component and solid integration (Rhoades 1998; Amede *et al.* 2004; Sayer and Campbell 2001) is being persuaded. However, such methodologies and concepts need further refinement and applicability tests in model sites. Accordingly, the African Highlands Initiative (AHI) in collaboration with the Ethiopian Institute of Agricultural Research (EIAR) is working on method development in a 'pilot' watershed site, Galessa, Ethiopia. The work in the watershed was started with extensive exploration in a participatory and holistic approach where problems, opportunities and intervention points for the availing past component research results were discerned though criticized for being less adaptive. Barley was among the commodities considered for intervention in the watershed, since it is the major cereal in the locality. Therefore, assessing and ascertaining past barley research results in a participatory way was found imperative as the relevance of such evaluations were also reported in past studies (Baidu-Forson 1997; Witcombe et al. 1999; Mulatu and Belete, 2001). Processes from evaluating the available barley technologies to dissemination were studied during 2003 to 2007 to identify appropriate technologies, aspects influencing dissemination, and the needs directing future research as presented hereafter.

Methodology

Extensive exploration was made in a participatory way during 2003 following the delineation of the 'pilot' site, Galessa watershed, to

identify and prioritize problems and discern opportunities and entry points for interventions.

Assessment on the available technological options was made and fitness tests were conducted as per the decision of farmers. A researcher-designed and farmer-managed adaptation trial comprising varieties studied in the past (Berhanu and Berhane 2006) with the inclusion of new from the breeding pipeline and the local check was conducted during 2004 and 2005 with volunteer farmers. One farmer field was used each year and multi-disciplinary and participatory field evaluations were made. Split-plot design in three replications was employed where two fertilizer rates, half and full recommended rates (21/23 and 41/46 kg/ha of N/P_2O_5 respectively), were assigned to main plots and varieties to sub plots. Five varieties were tested in 2004 and 6 in 2005, with the exclusion of two from 2004 and inclusion of three varieties in 2005 making the total varieties tested eight in the two seasons. The sub-plot size was 2 m x 2.5 m = 5 m^2 (10 rows of 2.5 m length at 20 cm row spacing) where 4 m^2 (the central 8 rows) was harvested to measure grain and above ground biomass yields. One herbicide spray and one hand weeding were practiced to control weeds. Quantitative data on the major barley leaf diseases, grain and biomass yields, and other agronomic traits were taken. Qualitative data on farmers' selection criteria, varietal preference, and their perception to fertilizer use were recorded during field performance evaluation at heading crop stage. Farmers compared the fertilizer effect based on the field performance of the crop while the varieties based on varietal traits. Farmers' comments, selection criteria, and ranking were summarized. Combined and separate analyses on grain and biomass yields were performed using the SAS program (SAS, 1987). The results were reflected to the community to get more feedbacks.

To assess the constraints that made the dissemination of the recommended technologies arduous, discussions were made with the community in the planning meeting and informal seed multiplication scheme was decided to be carried out as a subsequent activity in the process. Owing to the ease of management in barley seed production, the activity was decided to be handled by individual and volunteer farmers. The scheme was conducted in two phases, in 2004 and 2006. Starter seeds of two varieties ('HB 42' and 'ARDU 12-60B') were given to five farmers (25 kg of 'HB 42' for 4 farmers each and 10 kg of 'ARDU12-60B' for one farmer) in phase I during 2004 where 'HB 42' was planted on 0.80 ha and 'ARDU 12-60B' on 0.1 ha. In phase II, starter seeds of

'Shege' and 'HB 1307' were issued to ten farmers (25 kg of 'Shege' each for 8 farmers and 50 kg of 'HB 1307' each for two farmers) and 'Shege' was planted on 4 ha while 'HB 1307' on 1 ha in 2006. The common practice in the locality for barley production was followed with some additional operations and guidance from technical staffs to produce 'acceptable quality' seeds.

Group training and discussions with seed-producing farmers were made on precautions in seed production. Major points in the discussions with the seed-producing farmers were made to include:

- allocating fertile fields for seed increase activity;
- isolating the seed increase fields from other varieties to avoid admixtures;
- proper management and satisfactory weed control;
- rouging out off-types and wild oats;
- cautions to be taken during harvesting, threshing and storing; and
- cleaning the seed prior planting the next cycle were worth mentioning.

Data on the amount of seed produced and utilized were taken and summarized from 2004 till the planting of 2007 cropping season. Tracking the dissemination of the varieties was done till the planting of 2006 cropping season (cycle II) for the first phase and till 2007 (cycle I) for the second phase. Farmers also evaluated some seed increase fields during field days and other occasions.

Results and Discussions

Barley-fallow cropping system was identified as the dominant system in the crop culture where one low productive major local cultivar, 'Baleme', predominates. Poor soil fertility and lack of improved varieties were identified as the major constraints threatening barley's productivity. Intervening with barley was considered promising since the crop is considerably relevant to the community and improvement in its productivity is believed to enhance livelihoods of farmers and help to rescue natural resources.

Farmers' perceptions

Fertilizer

Farmers' perception on use of fertilizer levels was indifferent since the crop performances in the fields were similar with both rates though farmers acknowledged the use of the recommended rate in past study (Berhanu and Berhane 2006). Failure to differentiate fertilizer effect in the field was reasoned out to be the good fertility status of the trial field in 2004 (since it was near homestead) and the waterlogged condition in 2005.

Varieties

The preferred varietal traits in field evaluations were tall plant height, long-six-rowed spike, high tillering capacity and density, white grain color, better tolerance to lodging and water logging, and disease resistance/tolerance. Farmers' selection criteria were more or less similar with those reported in past study (Berhanu and Berhane 2006) except for the uniqueness of some criteria such as early maturity in the past and better disease and water logging resistance/tolerance in the current, the cause for the difference being variations in the occurrence of the incidences. Farmers' varietal preference varied with fertilizer levels as it has exhibited a site-driven tendency in past studies (Berhanu and Berhane 2006; Mulatu et al. 2001). In the current study, farmers' preference tended to the local cultivar, 'Baleme', under the lower fertilizer rate and to the improved food barley variety, 'HB 1307', under the higher fertilizer rate in both seasons, the two being the most preferred on the average (Table 1). However, the combined grain yield data proved the superiority of 'HB 1307' under both rates. Among the traits that attracted farmers towards the local and 'HB 1307' were their better water logging tolerance and biomass yields. Besides, good disease resistance was a trait that motivated farmers' preference for 'HB 1307'.

Researchers' assessment

Spatial and fertilizer effects on varieties

The significant difference in varietal response to spatial differences as previously studied on systematically sampled fields in the vicinity of the watershed were mainly due to differences in soil fertility and frost incidences (Berhanu and Berhane 2006). Frost was considered to have spatial influence since its effect was more pronounced in the low-lying than in the up-fields of the locality, though it can also be regarded

temporal depending on the prevalence of the incidence across seasons. The magnitude of the positive response in grain and biomass yields to the higher fertilizer rate varied across site groups though all were significantly responsive (Berhanu and Berhane 2006). In the current study, the recommended fertilizer rate has also considerably increased grain and above ground biomass yields though fertilizer response was highly depended on weather condition where year x fertilizer interaction effect was highly significant ($P< 0.01$). Separate yearly data analyses made on grain and biomass yields indicated that fertilizer main effects were highly significant ($P < 0.01$) in 2004 but not in 2005 (Table 1). The cause for the poor fertilizer response and weak crop performance of 2005 was due to severe water logged condition resulted from the excess rains, indicating the stress was also detrimental for fertilizer use. Generally, the current study has also confirmed the importance of fertility management; hence, efficient methods for soil improvement should deserve high priority.

Table 1. Mean grain yield (t ha^{-1}) and farmers' ranking of food barley varieties tested at Galessa in 2004 and 2005 cropping seasons with two fertilizer levels (L_1 = 21/23 and L_2 = 41/46, N/P_2O_5, kg ha^{-1})

Variety	Grain yield					
	2004 [a]			2005 [a]		
	L_1	L_2	Ave.	L_1	L_2	Ave.
HB 42	*	*	*	F	F	F
ARDU 12-60B	[4] 2.3	[4] 3.2	[3] 2.8	[3] 1.3	[3] 1.5	[2] 1.4
Shege	*	*	*	F	F	F
Dimtu	*	*	*	F	F	F
HB 1307 [b]	[2] 4.2 a	[1] 5.6 a	[1] 4.9 a	[2] 2.1	[1] 2.5 a	[1] 2.3 a
EH 1627/F7.B1.5.21.18	[3] 4.4 a	[3] 4.6 a	[2] 4.5 a	*	*	*
IBON 149/95	[5] 1.9	[5] 2.2	[4] 2.1	*	*	*
Local check	[1] 3.8	[2] 4.0	[1] 3.9	[1] 1.8	[2] 2.0	[1] 1.9
Mean	3.3	3.9	3.6	1.7	2.0	1.9

*NB. * = not tested, F = total crop failure, and Ave.= average.*

Figures in superscript indicate farmers' ranking (1= highly preferred, 2 = highly preferred but one, 3= intermediate, 4= less preferred but one and 5 = less preferred).

[a] Means followed by letter 'a' are significantly higher than the local at $LSD_{0.05}$.

[b] Cross number EH 1700/F7.B1.63.70, which latter designated as 'HB 1307' on release in 2006

CV%, SE ±, and $LSD_{0.05}$ for grain yield are 6.2, 0.07, and 0.20 in 2004 and 13.3, 0.09, and 0.30 in 2005, respectively.

Temporal effects on varietal response

Stability of varieties under climatic fluctuations and other stresses is of great concern to farmers and the use of landraces is their strategy since they perform better in most environments owing to their population buffering capacity emanating from the genetic heterogeneity of the component lines constituting them (Ceccarelli et al. 1987). Stability analysis made on biomass yield in the previous study has confirmed the

better performance of the local cultivar, 'Baleme', in most environments (Berhanu and Berhane 2006).

This study has also proved the better water logging tolerance of the local cultivar along with one improved variety, 'HB 1307', despite the complete failure of the rest improved varieties in 2005 (Table 1). Although seasonal variations in the previous study had significant influence, it was mild relative to the current situation since complete failure of three varieties has occurred in 2005 though they performed better and recommended for use in good crop fields in the past study (Berhanu and Berhane 2006). However, the new food barley variety, 'HB 1307', proved it's superiority in both seasons. The grain yield advantage of 'HB 1307' over the mean performance of the rest varieties was 47.4% and 39.4% in 2004 and 2005, respectively, the average being 44.7% while it was 25.6% and 21.1% in 2004 and 2005, respectively, the average being 24.1% over the local cultivar, 'Baleme'. Development of a perfect variety that perform best in all environments is less probable, however, the performance of 'HB 1307' is a formidable achievement since it has shown a greater grain and biomass yield advantages both under favorable and waterlogged condition than the so far tested improved varieties and the local cultivar. Therefore, 'HB 1307' is a dependable food type variety and its use in the watershed is highly recommended.

In selected fields where soil degradation and other abiotic stresses are minimal, most improved varieties can give better yield advantages and use of the local cultivar in stressful fields should be indispensable so that exploiting opportunities and minimizing risks through diversity will not to be derelict. Moreover, benefits from improved technologies could be maximized through selective use if farmers' indigenous technical knowledge is integrated with the knowledge and production requirements of the technologies.

Accessing appropriate technologies

Farmers' perceptions

The need for planting the improved varieties on fertile soils and use of fertilizer was appreciated by farmers during seed increase field visits since complete crop failure and poor crop performances were observed on highly degraded fields allotted by some pioneer seed-producing farmers, (one field of 'HB 42' and three fields of 'Shege)'. However, the improved varieties in most seed increase fields have attracted farmers

since they performed better than the local cultivar in the near by fields. Besides, the quality of the improved varieties in making local recipes such as 'enjera' and 'kinche' attracted some farmers to adopt the varieties, a criterion not stated in field evaluations of the varieties during agronomic fitness tests.

Researchers' assessment

Although some seed increase fields in the two phases suffered from severe water logged conditions (due to excess rain) of 2005 and 2006 cropping seasons unlike 2004, relevant information were obtained from the activities. Most pioneer seed-producers of phase I continued growing the varieties till 2006 along with other three 1st cycle and seven 2nd cycle growers in the watershed with seeds purchased and/or exchanged from early adopters. The prices and exchange rates of the locally produced seeds were not higher than the prevailing grain prices except for quality check-ups on exchange. Except one failure among the fields planted with the starter seed of 'HB 42' in phase I, the rest four (80%) pioneer seed-producers continued growing the varieties along with 10 first and second cycle producers making the total growers of the two varieties 14 in 2006 in the watershed (Table 2). The activity of phase II was tracked till the 1st cycle (the planting of 2007 cropping season) and except three pioneer seed-producers of 'Shege' who quitted the activity, most pioneer seed-producers continued growing the varieties along with other four 1st cycle producers in the watershed with seeds purchased and/or exchanged making the total participants to 11 in 2007 cropping season. All pioneer farmers involved in multiplying the variety 'HB 1307' along with 4 new adopters continued growing the variety while no new adopters of 'Shege' were involved in the 1st cycle of phase II. Generally, farmers' preference tended towards the two varieties, 'HB 42' and 'HB 1307', since the dissemination of these varieties was better than the rest.

Table 2. The dissemination pattern of the improved food barley varieties by number of adopting farmers and area (ha) covered in the two phases of the seed multiplication scheme at Galessa watershed site during 2004 to 2007.

Phase	Variety	Year			
		2004	2005	2006	2007
	HB 42	4 (0.8) *	6 (4)	11 (7)	-
I	ARDU 12-60B	1 (0.1) *	1 (0.25)	3 (1.5)	-
	HB 1307	-	-	2 (1) *	6 (3.75)
II	Shege	-	-	8 (1.6) *	5 (6.25)

NB. Figures out of parentheses are number of participant farmers while in are estimates of planted area in ha.

** = Issued as a starter seed*

In both cycles, the proportions of the seed spared for own and relatives were higher than for neighbors and others. However, the seed proportion spared for own and relatives decreased while that went for neighbors and out of the watershed increased with an increase in cycle (Table 3). Similarly, the proportion utilized as grain increased with increase in cycle.

Though adequate seeds were produced to accommodate more farmers, few farmers adopted the varieties, only 38.7 %, 22.2 % of the total produce in the 1st and the 2nd cycles, respectively) and went for planting. This indicates that farmers' need adequate information about the whole aspects of the varieties from the activities of the neighboring adopters' prior to their involvement. As a farmer-to-farmer technology dissemination model, the activity proved relevant since it can give better chance for new adopters to evaluate the whole aspects of the varieties, from production to consumption.

Table 3. The utilization pattern of the improved food barley varieties production in the two phases of the informal seed multiplication scheme in Galessa during 2004 to 2007

Cycle	Total Produced (kg)	Utilization [a]				
		As Grain	As seed			
			Own & relatives *	Neighbors	Out of Watershed	Total
I	3965	2430	1285	150	100	1535
		(61.3%)	(32.4%)	(3.8%)	(2.5%)	(38.7%)
II	4500	3500	550	300	150	1000
		(77.8%)	(12.2%)	(6.7%)	(3.3%)	(22.2%)

NB. Cycle I considered four varieties while Cycle II the earlier issued two varieties.
** = Relatives indicate relations such as father, mother, son, daughter, sister and brother.*
[a] *Figures out of parentheses indicate amount in kg.*

Prospects of the varieties

Generally, the so far studies made in the locality indicated that no single variety was superior under every situation signifying the need for selective use and diversification. However, four points can indicate as the varieties are gradually gaining acceptance and farmers are interested.

- First, most of the pioneer and all of the follower farmers kept on growing the varieties;
- Secondly, unlike the pioneer farmers who received the starter seed for free, follower farmers acquired the seeds either through purchase or exchange;
- Thirdly, farmers showed interest for some quality traits of the varieties in making local recipes such as 'enjera' and 'kinche', a criterion that was not mentioned during field evaluations, this imply

that merits of varieties are not limited to field performance but extends till consumption; and

- Finally, the varieties were disseminated beyond the watershed of which 2.5 % and 3.3% of the produce went as seed to farmers out of the watershed from the 1st and 2nd cycles, respectively.

Drawbacks in seed production

Indications on the possibility of producing own barley seeds are strong. However, there were situations that aggravated the speed of seed quality deterioration that resulted from competing interests and need further work for attitudinal change to reduce the speed of deterioration with an increase in production cycle. Such insights include:

- Farmers' reluctance to rogue out (wild oats and other mixed varieties or off-types) from fields and in cleaning seeds since they regarded as grain;
- Fear of trampling damages during rouging since it is usually practiced after flowering stage when the crop is highly vulnerable; and
- The deterioration of seed quality with an increase in the size of the seed multiplication field. This was mainly due to the difficulties in practicing intensive management on larger plots and may demand limiting the size of the seed increase fields.

Since merits of improved varieties and success of farmers' crop can only be realized by using quality seed (Carver 1980; Srivastara 1996), acquainting farmers with the basic precautions in seed production and overcoming the attitudinal drawbacks are crucial.

Prospect of the scheme

Generally, the scheme seems dependable and producing seeds of 'acceptable quality' with a tolerable quality loss not detrimental for productivity seems feasible since:

- Most field and post harvest precautions in seed production such as field isolation, rouging, cleaning, avoiding contamination in threshing grounds and storage can easily be taken care of by farmers;
- Drawbacks in quality maintenance could be improved through discussions and training;
- Farmers' gradual adopting tendency for risk aversion and the need for adequate information from production to consumption could be fulfilled since it can give better chance to evaluate the whole aspects of the varieties from earlier adopters;

- The self-pollinating nature of the crop is an advantage where past studies made on seed production of crops such as wheat have found the non-lucrative nature of the business due to the self-pollinating nature of the crop and farmers tendency to replant own seed rather than purchasing quality seed every year (Van Gastel et al. 2002); and
- Such activities could create adequate awareness and demand to dare seed purchase for eventual replenishment since the current farmers' practices in purchasing or exchanging locally produced seed are indicatives.

Generally, farmers should be encouraged to produce their own barley seed to overcome the shortage, the entailed high prices, and doubt provided adequate efforts to alter farmers' attitudinal drawbacks in quality maintenance are made.

Conclusion and Recommendations

The knowledge shared from the interactive activities was imperative where valuable results of practical importance for the locality and future research were gained. Important issues for the locality and future research use were articulated and some aspects influencing the dissemination of the varieties were understood.

Generally, the so far studies in the locality indicated that no single variety was superior under every situation demonstrating the need for selective use by integrating farmers' knowledge to exploit opportunities and minimize risks through diversity. The major spatial and temporal factors contributing to the differential varietal responses and that should deserve future research attention include: soil fertility, frost and disease incidences, and water logging during excess rainfall. Moreover, other farmers' needs and constraints like lodging tolerance, grain quality, and other varietal traits for future technology generation were also understood.

Relevance of the commodity is a prime factor in influencing the dissemination of agricultural technology and has to be cleared through surveys and extensive explorations prior intervention.

In the presence of agricultural technological options for a particular commodity that are presumed to be relevant for certain locality,

considering participatory technological fitness tests as a subsequent step in the process to assess the merits and demerits of the technologies to exploit opportunities and averse risks, to acquaint farmers with the technology and facilitate the integration of farmers' knowledge in technology use, are important to avoid inappropriate use and enhance adoption.

Supply shortage and/or the entailed high prices unaffordable to small-scale farmers were not the only factors hindering dissemination, but not daring risk also has a considerable influence. Therefore, simple and inexpensive ways to access appropriate technologies like informal seed multiplication and practices that build farmers' confidence should also be sought with the stakeholders to enhance adoption.

Generally, effective adoption demand the relevance of the commodity, ascertaining appropriateness of the technologies through participatory fitness tests, integrating farmers' indigenous knowledge for use, simple and inexpensive ways to access the suitable technologies, and raising farmers' confidence through concerted stakeholders efforts.

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Scaling up and Participatory Evaluation of Potato Technologies in Galessa Watershed

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Introduction

Potato has been an important staple food in Galessa for the past many years. However, it has been difficult to produce the local variety during the rainy season due to late blight disease and shortage of the improved varieties. as reported by GebreMedhin, *et.al* (2001) lack of high yielding and sufficient quantity of good quality seed potatoes are the most important constraints that limit both potato production and productivity in Galessa Watershed. Consequently, farmers have been forced to use inferior and under-sized tubers from local varieties. Such tubers have a high potential of harboring tuber–borne diseases such as bacterial wilt and other diseases caused by viruses. Bacterial wilt (*Ralstonia Solanacearum*) leads to great yield losses (Barton *et al.,* 1997; Michieka, 1993) and reduced storage life due to post-harvest rotting (Nyangeri *et al*., 1984).

Due to the lack of storage facilities farmers in Galessa area usually use sacks or pile potatoes in dark rooms or under shade. They also use a piece meal harvest in extended harvesting system where the tubers are left in the soil for months until the next harvesting. In such process, the tubers become infested with potato tuber moth, red ants and other soil-borne potato diseases (Sengoba *et al.,* 2001). As a result, the tubers will not be in their optimum health and physiological stage for planting. This in turn results into poor establishment and eventually very poor growth and yield (Berga *et al.,* 1997).

Improving income of resource poor farmers in Galessa watershed through the integrated use of various potato technologies was taken as one the first priorities in the watershed. Thus multiplication and scaling

up of the improved variety was found to be useful, so that every farmer in the watershed can get access to improved potato seed. Therefore, the main objectives of this study were to introduce different improved potato varieties and other important potato technologies in Galessa watershed, and to demonstrate potato production using organic and in-organic fertilizers for resource poor farmers in the watershed.

Methodology

Seed Multiplication

Initially, it was difficult to provide improved potato seed to all farmers in the watershed; the best alternative was to organize the farmers through Farmers Research Group (FRGs). During the participatory watershed planning meeting, strong discussions were made with the farmers in the watershed how to organize them to multiply and scale out the limited amount of seeds of improved potatoes varieties provided by Holetta Agricultural Research Center, so that all farmers in the watershed could get a good access to improved potato varieties and production techniques. Based on this agreement, one FRG with 26 members was established in 2004 by selecting representative farmers from each village based on their willingness and interest to share land and involve in all activities related to improved potato seed production. Participating farmers preferred variety Menagesha for starting improved seed multiplication and scaling out in the watershed. This activity was started by planting Menagesha in 800 m^2 of land shared by each FRG members. Planting was done in the first week of June using the recommended spacing for seed tuber production. In organic fertilizer added during planting at a rate of 165 and 195 kg/ha Urea and DAP, respectively.

Supplementary spray of Ridomil against late blight applied twice at a rate of 2.0 kg/ha. All the recommended management practices for improved seed potato production were strictly applied at each FRG field with full involvement of every member. Moreover, each FRG member and other participating farmers were well trained practically in the field on the whole aspects of farmers based improved potato seed production techniques from planting up to post-harvest handling in DLS. Diffused light store was also constructed for this FRG.

In 2005, five new FRGs were established in Ameya, Toma, Tiro, Sombo and Kemete-lencha villages. Together with the previous FRG, a total of

six FRGs were actively involved for improved potato seed production. Potato varieties Menagesha, Wechecha and Tolcha were used for seed multiplication and scaling out activities. The plot size for each variety varied from 223 m^2 to 1500 m^2 .

Regular follow up and field sessions were given to all participated farmers in FRGs for seed Potato production in the watershed. In general, all the FRGs were given several trainings including the positive selection which is very efficient techniques for quality potato seed production during potato growth period in the field. All the FRG members in the watershed were trained how to select plants showing good characters with vigorous growth and retained as seed for the next cropping season.

Potato production using fertilizers

Each of the five FRGs in Galessa watershed prepared compost for seed and ware potato production. Potato variety wechecha was used for this study using the recommended rate of organic and inorganic fertilizers. The three fertilizer levels used for fertilizer trial were:

- Full compost (4.43 q/plot);
- Half compost (2.22 q /plot) + ½ inorganic fertilizers (0.63 q/plot urea+ 0.73 q/plot DAP); and
- Full fertilizer (1.23 q/plot urea and 1.45 q /plot DAP).

The total plot size for fertilizer study was 223.8 m^2, each treatment with 74.6 m^2. These were replicated in five villages for each FRGs. The net harvested area was 58.94 m^2. Before planting, the sample of the compost was analyzed for N and P content (Table 1).

Table 1. Contents of N and P for compost sampled from different FRGs in the watershed

FRGs /Village/	N (%)	P (%)
Sombo	0.50	0.24
Kemete Lencha	0.66	0.17
Tiro	0.44	0.11
Toma	0.67	0.33
Ameya	0.65	0.28

Results and Discussion

Seed multiplication

During potato production, the FRGs fields were frequently evaluated and monitored together with all the participating farmers. All the FRG members and other participated farmers were very happy with the over all field performance of each potato variety. They have also appreciated the knowledge they gained in quality seed and ware potato productions.

In 2004, twenty quintals of clean potato seed of Menagesha variety was produced from 800 m^2 of land and one DLS was constructed with the support of AHI project. The produced clean seed was stored in the DLS and each participated farmers were trained how to manage seed potato in the DLS. These seed potato was shared among the FRG members for each village. The newly established FRG of each village used this seed for further potato seed production in the watershed.

In 2005, 8170.2 m^2 land was covered with improved potato seed multiplication using FRGs established in each village. In that year, more intensive and regular follow up and field sessions were given to all farmers participated in this activity. Moreover, several trainings were given mainly positive selection, post harvest handling of seed potato in diffused light stores and different potato food preparation.

All the FRGs members are now volunteers to share their clean seed among themselves for further production in large scale so that every farmer in the watershed get an access to improved potato varieties. Currently all the FRGs members are capable in all the field management of seed potato production without the support of the researchers. Furthermore, in all villages most farmers are technically capable in managing improved potato seed production especially land preparation, planting and compost preparation and application. For example in 2005 alone, the six FRGs produced 150 quintals of clean and healthy potato seed from Menagesha, Wechecha and Tolcha and seven diffused light stores were constructed in the watershed.

Training in positive selection

Positive selection is one of the most important techniques that help potato seed producers to produce quality seed. This technique is so simple and can easily transfer to subsistence potato farmers through FRGs. All FRG

members were trained about the importance and necessity of positive selection and acquired practical knowledge when and how to apply this practice in their fields so as to produce a quality planting material for their future use. Currently, all the FRG members are aware to select plants showing good characters with vigorous growth and retain as seed for the next cropping season. However, successive multiplication of potato seed by FRGs exposes them to various diseases, insect pests and stresses. Therefore, farmers need to select and well manage potato to get clean and health seed every year.

Disease follow-up

Training on late blight, viral and bacterial diseases managements were given to all members of the FRGs. Annually, 50 farmers in Galessa watershed participated in potato disease management training.

In all FRG fields, late blight severity ranged from 20-55% and potato leaf curl virus was severe on Menagesha (Table 2). For the control of this disease a contact fungicide Mancozeb was sprayed as third spray either to arrest or minimize the late blight disease build-up in each FRG field.

Table 2. Late blight and leaf curl virus severity in Galessa FRG fields, 2005

FRGs village	Variety	Late blight (%)	Leaf curl (%)
Tiro	Wechecha	30	-
	Menagesha	20	50
Sombo	Wechecha	20	-
	Menagesha	35	25
Kemete-Lencha	Wechecha	35	-
	Menagesha	25	30
Toma	Wechecha	30	-
	Menagesha	25	10
Ameya	Wechecha	55	-
	Menagesha	30	20

Use of fertilizer

Analyses of variance across villages indicated that total tuber yield of potato was significantly ($p<0.05$) increased by using inorganic fertilizer than organic fertilizer. Tuber yield advantage of 48 % was obtained from an application of half compost and half inorganic fertilizer over that of compost application whilst treatments that received full inorganic fertilizer resulted in about 70 % yield advantage over that of compost.

This result clearly manifested the advantages of inorganic fertilizer applications in potato production. On one hand, those farmers who can afford the purchase of inorganic fertilizer can use this fertilizer to get high yield from potato. On the other hand, middle class farmers can go for half compost and half inorganic fertilizer application in order to get reasonable potato yield. Conversely, resource poor farmers can use compost to produce potato without using any inorganic fertilizers which is very advantageous for retaining soil nutrient.

Conclusion and Recommendations

Almost all farmers in the watershed get a good access to improved potato technologies. Some of these are improved potato varieties, relatively clean and healthy seed potato production techniques, compost preparation and its application in potato production, DLS construction and potato post harvest handling and different potato food preparation. All FRGs members are now volunteers to share their clean seed among themselves for further production in large scale so that every farmer in the watershed get an access to improved potato varieties.

Now FRGs in Galessa watershed can continue the field management of seed potato production without the support of researchers. Furthermore, in all the villages most farmers now technically capable in improved potato seed production especially in land preparation, planting and compost preparation and application, however they needs supervision and follow up in positive selection in the field and post harvest handling of seed potato particularly exclusion of infected tubers in the DLS. From this study it is possible to conclude that potato technologies could easily be disseminated through FRG approach.

Farmers in Galessa watershed who can afford to buy chemical fertilizers can use full recommended inorganic fertilizer to get the maximum potato yield. Alternatively it is possible to get a reasonable yield from potato using half of the recommended inorganic fertilizers together with half of the recommended compost for potato production in Galessa watershed without depleting soil nutrient.

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Integrating Linseed Varieties into Barley-based Cropping System of Galessa Watershed

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Introduction

According to previous survey (Kindu *et al*., 2002) barely is the most prominent crop followed by potato and enset (*Ensete ventricosum*) in Galessa area. Barely covers almost all the outfields, while potato followed by enset dominates around the homesteads. It was reported that barley yields have been declining over the years due to lack of high yielding varieties, moisture shortage, low soil fertility, increased soil erosion, uneven distribution of rainfall, severe frost and desiccating winds during the grain filling periods. Mono-cropping due to lack of alternative crops and their varieties were also reported as some of the causes for yield reductions (Kindu *et al*., 2002).

In order to overcome such limitations of crops, some efforts like introducing improved varieties of linseed (*Linum usitatissimum* L.) into the system have been underway since 2005 based on the demands of farmers. Farmers were interested to diversify their crops and cropping system (Adugna and Amare, 2008), as small scale farmers usually prefer multiple cropping systems for minimizing economical and environmental risks, while fulfilling the goals of subsistence (Geleta *et al*., 2002; Gemechu and Adugna, 2004). This participatory activity was also done to multiply two improved linseed varieties—Berene and Tolle—under farmers' conditions and to evaluate additional varieties for release thereby to facilitate the dissemination and utilization of quality seeds in Galessa and similar areas.

The study which has been done jointly with the farmers, motivating them to play active roles in seed production, distribution and marketing schemes so that farmers can secure various technical and economical benefits (Almekinders and Louwaars, 1999)

This report covers the major activities undertaken since 2004/05 cropping season focusing on seed production and variety tests. The major objectives of the study were to respond to farmers demand and explore the integration of improved linseed varieties in Galessa cropping system; to assess how the integration of linseed varieties could improve yield productivity, seed system, food and nutrition; and, to analyze the overall performance in terms of productivity and sustainability of the cropping system.

Methodology

Seeds of two linseed varieties, 'Berene' and 'Tolle' were distributed to 30 farmers in 2005, 100 farmers in 2006 and 20 farmers in 2007. The overall cultivation package was comprised of 2-3 times tillage frequencies, 1st week of June sowing, manual broadcasting of seeds at 40 kg/ha, fertilizers of 30 kg/ha urea and 50 kg/ha DAP and twice hand weeding, approximately one and two months after sowing.

Farmers' participatory evaluation were undertaken to assess the performance of the trials. Random samples were taken from most farmers' plots, using a quadrant-sampling technique to assess the seed yield, oil content and other seed quality parameters. Oil content was analyzed using Nuclear Magnetic Resonance Spectrometer. Percentages of seed germination, purity, inert matters and other quality aspects were also analyzed at the Seed Health Unit of HRC. The collected data were analyzed for their variance and significance using AGROBASE 98 software (Agronomix Software, 1998). Twelve more varieties have been tested in the West Shewa weredas, including at Jeldu/Galessa since 2004.

The result of the studies were accomplished through joint review and planning including experience-sharing, participatory implementation, and evaluation and synthesizing and scaling out/ up of the promising results. The experience sharing or training was conducted during practical phases of field preparation on tillage frequencies, sowing and seed covering operations; and at critical weeding time on managements of weeding, quality seeds and other post-harvest handling practices.

Results and Discussion

One hundred farmers were involved in the study in 2006 and results from random samples of 10 farmers were analyzed and presented . Seed yield was in the ranges of 410-1010 kg/ha, while that of oil content was 38-41%. Performance of seed yield was generally good for majority farmers except two farmers who had below the national average (600 kg/ha) due mainly to poor soil fertility conditions. Seed yield of 2005 was within the range of 200-1300 kg/ha. Twenty-two farmers out of 29 were obtained seed yields above the national average (Fig. 1). On the other hand, seed oil content of 38-41% was one of the best records for Galessa during this year unlike the previous season when majority of the farmers scored 35-37% (Fig. 2). Generally, the oil content obtained from Galessa was adequate enough to meet a good quality production both in 2005 and 2006 cropping seasons. The seed yields and oil content of linseed at Galessa were dependable and have positive contributions with a considerable integration to barley-based cropping system.

Regarding seed quality determinants such as germination percentage has ranged from 83-100% in 2006 and 82-99% in 2005 (Fig. 3). During 2006, almost all sampled farmers got above 90%, which was the minimum standard for breeder or pre-basic seed (NAIA, 2000; Adugna, 2006). This result showed that Galessa farmers have the capacity of producing high quality linseed in terms of germination percentage, which is very decisive for ensuring high quality seeds. With regard to the physical purity, the farmers' seeds were in the ranges of 89-97% in 2006 and 82-97% in 2005 (Fig. 3). Over 50% of the sampled farmers had above 95% of pure seeds, which is the minimum purity standard for basic seed (NAIA, 2000). This data also confirms that majority (about 60%) of Galessa farmers can produce a good quality seed for other farmers in the highlands of Ethiopia if they are supported with necessary skills and premium prices for their clean seeds. The relative importance of different seed quality parameters indicate that germination percentage, followed by seed health, genetic purity, moisture percentage, uniformity and size, physical purity and treatment, package and label are the most decisive factors in the given order (Adugna *et al*., 2006). Moreover, indigenous knowledge about crop diversity that refers to attributes such as yield, seed quality and growing environments are required to enhance integration of crops and their continued evolution, adding values both to the existing and incoming new crops.

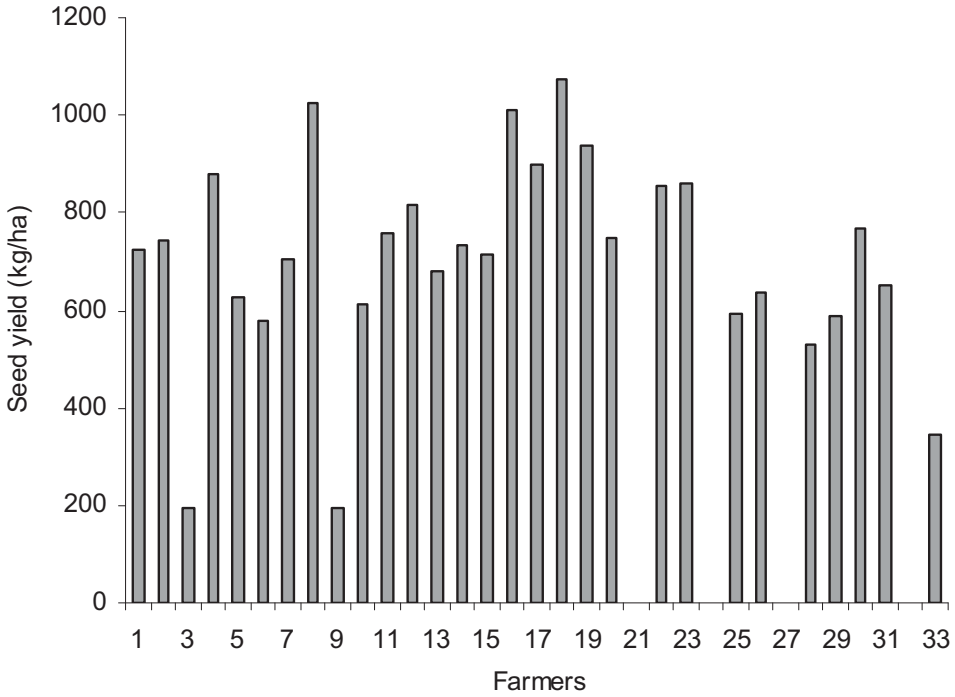

Fig 1. A graph showing seed yield of Berene linseed variety sown at Galessa, 2005/06

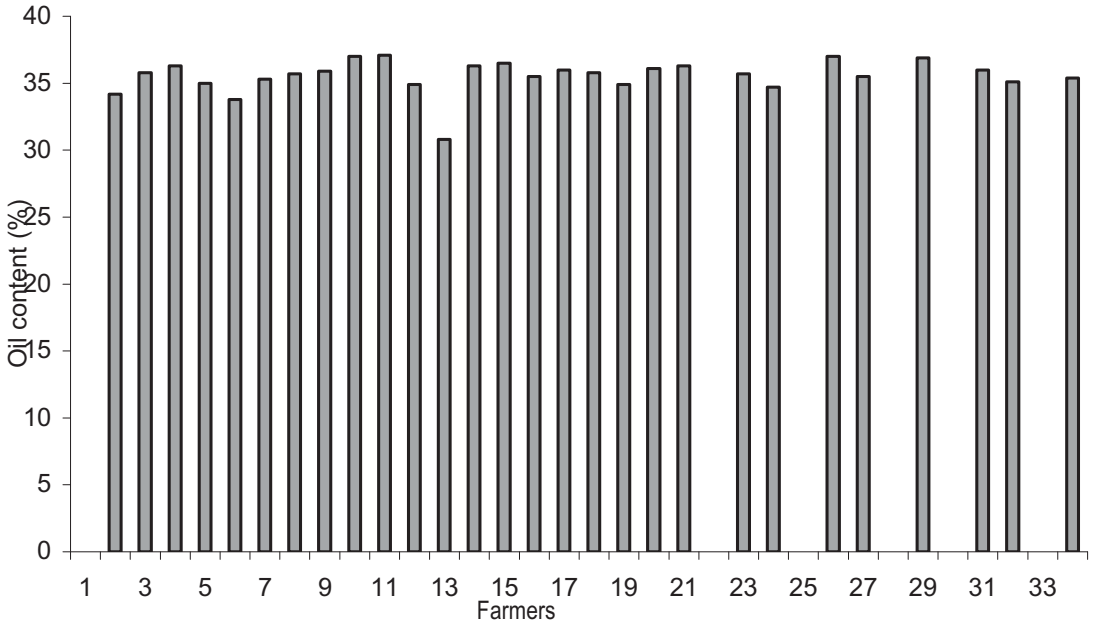

Fig 2. Oil content of Berene linseed variety tested at Galessa on farmers fields, 2005/06

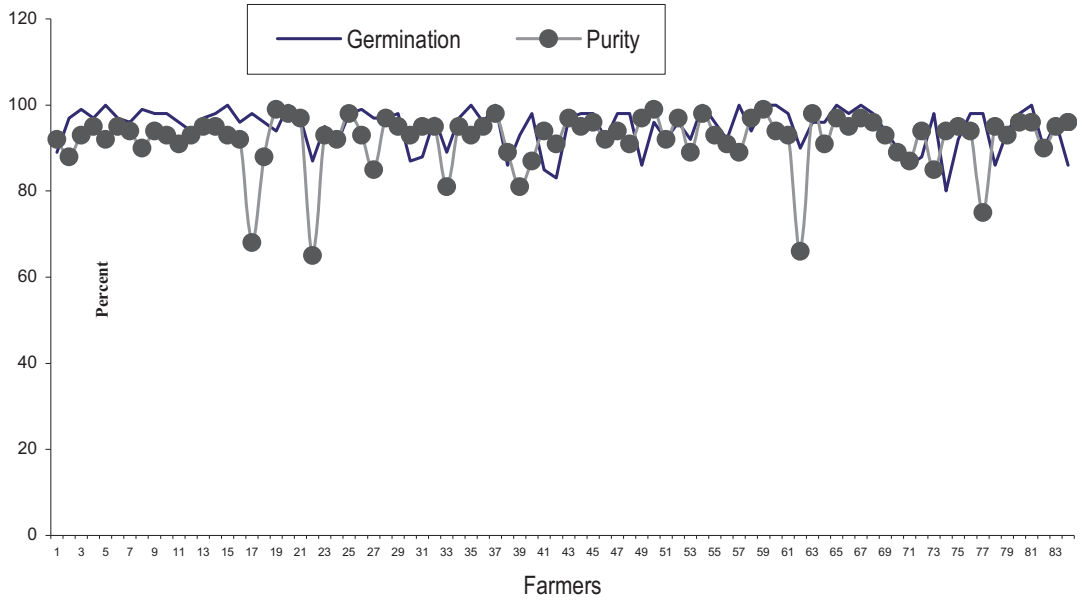

Fig 3. Percent of germination and pure seeds of linseed at Galesa in 2006/07

The percent of inert matter such as dusts, soils, debris, and chaff was relatively higher than the expected level of 2% and this result was very similar to that of the previous season. The high level of inert matter was due mainly to the dusty threshing grounds used by the farmers and poor seed cleaning practices. Farmers in Galessa area use cattle dung-cemented threshing grounds and winnow to separate inert materials from the seeds. Some farmers also use traditional tools like sieves and trays for additional seed cleaning and it is possible to improve such seed cleaning system. It is also possible to introduce the modern seed cleaning machines after organizing the farmers into seed producing associations or cooperatives.

In order to avail alternative varieties of linseed on top of existing ones, different variety trials have been underway in the high altitude, frosty and degraded environments of Galessa, Jeldu, Tikur Enchini and Chelia Weredas of West Shewa Zone and their seed yields were summarized in Tables 1 and 2. There was a significant difference ($P < 0.05$) among the varieties for seed yield across the four sites. Seed yield was highest at Holetta followed by that of Jeldu. A variety known as CI-1652 x Omega/23/A gave the highest seed yield (over 1900 kg/ha) at both locations and its oil content was also high. This variety was also superior on three on-farm tests under Galessa biophysical conditions and it came out as one of the promising varieties. Thus, it was identified as a candidate variety for specific release in its well adapted localities like Galessa. Such participatory variety selection and releasing specifically adapted varieties

for the small-scale farmers dwelling under marginal areas like Galessa are very important (Adugna *et al*., 2006) to support the adoption and dissemination processes of new varieties (Adugna *et al*., 2008).

Table 1. Mean seed yield (kg/ha) of linseed genotypes tested under regional variety trial during 2004 and 2005 seasons

Genotypes	Holeta		Jeldu/Galesa		Chelia	T/Inchini	Mean
	2004	2005	2004	2005	2004	2004	
Chilalo x Omega/10	1875	1411	1710	1559	1254	849	1443.0
PGRC 1006 x Chilalo/1/A	1503	1609	1380	1546	1224	546	1301.3
CI-1652 x Omega/10	1737	1347	1521	1666	1320	419	1335.0
Chilalo x Omega/13	1849	1597	1013	1965	1378	741	1423.8
CI-1652 x Omega/17	1733	1182	1258	1449	987	405	1169.0
Chilalo x Omega/12	1862	1656	1417	1889	1388	692	1484.0
Chilalo x Omega/3	1750	1865	1665	1828	1506	757	1561.8
CI-1652 x Omega/23/A	**1960**	**1542**	**1918**	**1973**	**1137**	**556**	**1514.3**
PGRC 1006 x CI-1525/7/A	1566	1291	1598	1101	916	210	1113.7
Omega x CI-1525/20/A	1597	1330	1395	1560	1051	385	1219.7
Tolle	1687	1181	1419	1557	1255	561	1276.7
Local check	1393	975	1272	1242	1018	333	1038.8
Mean	1709	1415	1464	1611	1203	538	1323.4
LSD 5%	239.4	436.5	343.8	335.9	343.8	222.8	-
CV %	11.7	25.8	23.89	17.4	23.89	34.62	-

Table 2. Mean seed yield (kg/ha) and major agronomic traits of four linseed genotypes tested under three on-farm tests at Galessa in 2006/07

Variety	Seed yield (kg/ha)				Mean agronomic performance				
	On-farm-1	On-farm-2	On-farm-3	Mean	Plant ht (cm)	Maturity (days)	Powdery mildew	Pasmo	Plant Stand
CI-1652 X Omega/23/A	**1390**	**785**	**1195**	**1123**	**68**	**197**	**1.33**	**1.00**	**83**
Belay-96	1264	692	979	1145	58	194	1.27	1.00	80
Tolle	1171	493	788	807	62	197	1.00	1.17	77
L. Check	810	461	654	642	49	178	1.83	1.67	77
Mean	1158.75	607.75	904	929.3	59	192	1.3	1.2	79
LSD	-	-	-	182.2	8.7	4.1	0.3	0.4	7.33
CV (%)	-	-	-	10.4	9.4	1.4	15.8	23.5	6.01

In short, farmers have shown interest in linseed for the following principal reasons: high value (cash and industrial) crop, high food and nutritional values (health benefits), good market price (250 birr/q in 2004 and 700 Birr/q in 2007), require low inputs such as tillage, fertilizers, pesticides, and weeding; well adapted to frosty and marginal highlands like Galessa; and, it generally meets many needs of the smallholder farmers.

Owing to these benefits, a good number of farmers were involved in growing improved varieties of linseed. In fact, oilseeds including linseed are used in Ethiopia for basic dietary requirements, providing large quantities of oils and proteins under traditional systems (Geleta *et al*., 2002). They were noted to improve taste, palatability and nutritional quality of the staple foods. As a result, majority of Galessa farmers were happy about the seed yield and thereby incomes obtained from growing linseed. For such pertinent technology, joint planning and analysis were the driving forces for positive changes. The farmers had high potentials for production of good quality seeds in Galessa areas. This could give a possibility of value adding via seed cleaning, packing and oil processing, i.e., producing edible oils for people and meals for livestock feed, which are useful for food security, income and employment generations. This makes improved varieties of linseed appropriate technology for integrated development strategies that provide sources of crop diversity, rotation, food, feed and income, capacitating the small scale farmers to invest in natural resource conservations.

On the other hand, some challenges like market links for the produced quality seeds, dependency syndrome (some farmers require seed supports every year), weeds problem, frost damage, inadequate seed cleaning and grading for better prices were encountered. Moreover, the recommended rates of seeds and fertilizes were questionable in practical applications under the farmers' socio-economics and biophysical environments of the extreme highlands where very low soil temperature and high weed populations are prevalent. To cope with these problems, farmers use seed rates up to 70 kg/ha. They also grow linseed without applying fertilizes to minimize cost of production. They believe fertilizers have little impacts on yield of linseed.

Conclusion

Improved varieties of linseed are being well adopted and thus further consolidations of such activities are needed in days ahead. Additional variety trials are also required on farmers' fields to release more relevant and productive varieties. Improving insights and skills of farmers are vital for fast spreading of new technologies and future emphases will concentrate on these aspects from production to consumption continuum. In short, the following main points can be concluded from the current study:

- Improved linseed varieties were appropriate for Galessa areas and has met farmers needs, i.e., it has been well integrating;
- Majority of farmers were observed to produce quality seeds of linseed;
- Participatory planning and evaluation were helpful for both farmers, researchers and other actors;
- Information/knowledge sharing improved attitudes, practices and skills at all levels; and,
- Further works are needed on weeding practices and post-harvest handling to attain reasonable profits via series of value additions.

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Livestock Management in the Galessa Watershed

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Introduction

The highland of Ethiopia is characterized by high human and livestock population, degraded natural resource base and less productive and eroded soil. The African Highlands Initiative (AHI) was appeared as one of the regional programs in Africa to undertake participatory on-farm research in some African countries and to contribute towards food security through improving natural resources management (NRM) and agricultural productivity in the highlands of East African countries since 1995. Ethiopia is among the countries identified to participate in the project. The project operates at benchmark sites in the countries. The benchmark sites are characterized by having high population densities, small farm size, a declining resource (soil) base, adequate rainfall (> 1000 mm annually) and situated in the highlands (>1400 m). Accordingly, Ginchi benchmark site was selected as one of the benchmark and watershed site in the country. The site was selected based on presence of high human and livestock populations, increased land shortage, declining or poor soil productivity, representative of larger areas of the highland, and the presence of different stakeholders.

The project is aimed to develop effective and efficient approaches for sustainable integrated natural resources management (INRM) and enhanced productivity in the area, so that the practice and experiences gained could be scaled up/ out to other part of the intensively cultivated highlands of the country. The purpose being accomplished would ensure that communities residing in representative highland watersheds would be able to sustain their land and water resources and more innovative and able to integrate technical and management options into their farming system and watershed areas. It is also assumed that research institutions would be able to implement INRM as part of their research undertakings.

The benchmark site is located in Dendi district which is in western Shewa Zone, Oromiya Region. The site includes the whole of Galessa Qoftu and part of Galessa Kota Gishier peasant associations and has five villages. The altitude ranges from 2820 to 3100 m and the area is estimated to be 340 ha .The farming system is dominated by mixed crop-livestock production system. Cattle, sheep, goats and equines are widely available livestock species in the watershed.

The objective of the study was to assess major species of livestock, distribution, utilization, and feed management in Galessa watershed.

Methodology

The watershed core team members comprised of researchers from livestock, crop, natural resource, extension, and agricultural economics have created awareness about the objectives of the study to representatives of the watershed community. Following the awareness creation, general assembly of the community which included elders, traditional and religious leaders; farmers of different wealth category, women farmers; youth and executive leaders of the farmers association were contacted to collect socio-economic and biophysical information of the watershed.

Secondary data collection, interview, transect walk, seasonal calendar, historical trend analysis, and institutional and gender analysis. Participatory Rural Appraisal (PRA) tools were employed in the data collection for better understanding of the watershed.

The data collected were enriched by door to door Visit and discussion with different category of the community. Data were summarized using simple descriptive statistics in SPSS. The baseline information needed within the watershed include various aspects of the agricultural production and socio economic status.

Results and Discussions

Livestock population distribution and utilization

Cattle (43.3%) and sheep and goats (42.4%) are the dominant species of livestock kept in the watershed followed by horse, mule and donkey 14%

together (Tables 1and 2). Most of the farmers in the watershed keep more than one species of domestic animals. Farmers gave different reasons for this. Most of the frames agree that, having more number of animals is an indicator of wealth. Others responded that owning more livestock species, especially sheep and goats is a means of risk aversion in case of natural disaster or any incidence of disease out brake. Some farmers suggested that it is easy to manage and accommodate sheep and goats in smaller areas than large ruminants and that is why they prefer to keep them. Almost all farmers in the community appreciate the importance of sheep and goats as saved cash in the bank. They can sale the animals to pay the credits for agricultural inputs like fertilizer, herbicide, and insecticides. The cash earned from sale of sheep and goats is also used to meet emergency family cases and also payment of taxes.

Table 1. Number of livestock by species in the watershed

Village	No of livestock		
	Cattle	Sheep and goats	Equine
Ameya	159	104	42
Toma	116	108	41
Sombo	185	238	52
Tiro	131	137	60
Legeabatebo	51	48	13
Kemetelencha	54	46	21
Total	696	681	229

Table 2. Livestock Distribution in the village (%)

Village	No of livestock		
	Cattle	Sheep and goats	Equine
Ameya	22.8	15.3	18.3
Toma	16.7	15.9	17.9
Sombo	26.8	34.9	22.7
Tiro	18.7	20.1	26.2
Legeabatebo	7.3	7	5.7
Kemetelencha	7.7	6.8	9.2

Importance of livestock

Farmers in the study area give two reasons for keeping cattle. Production of oxen for land cultivation is the priority reason while, small quantity of butter they get from local dairy cows is the second reason for keeping cattle. Milk is not a priority issue for the community in the watershed.

This is simply because the daily milk yield is approximately one litter and the cows reported to stay in milk for about 6 months. Daily milk yield of low producing cows does not exceed one litter. Because of the low milk yield they get from cattle, farmers do not give much attention to milk as a product. According to the farming community in the watershed the small quantity of butter they get from the small amount of milk is more important for them, since according to them it brings about quiet better income on sale in the local markets. Butter is preferred for its better nutritional value in different forms together with cereals and food made out of *enset*. Butter is also considered to have medicinal and cosmetic values. Women put butter on their head, as a means of traditional hair dressing and to cure headaches. Moreover, it is used as massage in case of bone dislocations, breakage or back pains in elders.

Sheep and goats are mostly important for income generation and for meat which the farmers use during the public holidays. Draft animals especially horses are mostly used to transport farm products and people from place to place, like local markets and clinics in villages since car transportation is difficult because of poor infrastructure development in the study area.

Manure from cattle, sheep, goats and equines is used as farmyard fertilizer, while cattle dung is also used as fuel source for cooking food, and as material for decorating house. Cattle owners also make cakes dung for sale.

Livestock ownership

Eighty seven percent of the household in the watershed owns livestock (Table 3). The ownership varies among villages. Almost all of the farmers in Tomma village own one or more species of livestock, while comparatively farmers in Lagaabatabo own less livestock numbers. This could be explained by proximity and access to the "common grazing" land and opportunity to have access to some grazing areas outside the watershed, which favors the prior than the later. In real term there is no demarcated grazing land. Areas where most of the livestock species are commonly kept during the day is taken as communal grazing land.

Farmers respond that there is an increasing trend of livestock number in the watershed, since 1999 / 2000 when there was the occurrence of acute drought. The livestock number was increased during that as a means of risk aversion. Most of the farmers in the community agreed to reduce the

number of cattle in the watershed if they can have access to improved dairy types for better milk production.

Table 3. Human Population and livestock owners

Village	Households	Total	Male	Female	Livestock Owners	% Livestock Owners
Ameya	43	219	111	108	37	86.0
Toma	22	115	58	57	22	100.0
Sombo	45	226	111	115	38	84.4
Tiro	33	191	97	94	29	87.9
Lagbatabo	17	83	44	39	13	76.5
Kemete Lencha	11	60	29	31	10	90.9
Total	171	894	450	444	149	87.1

Livestock management

Grazing is the only source of livestock feed in the study area. However, there is no clearly demarcated area for grazing. Animals have to wonder in the fallow lands and in the fields of crop residues mainly barley. By-products of local beverages, mainly '*atella'* is given to milking cows. Oxen are given due attention during the times of heavy operational workload. They are allowed to get out of barn early in the morning before the rest of the herd and are left to graze on the areas left between plots of crop lands or the place protected for them called '*kallo'* (closed grazing land for their own animals).

The period after crop harvest is the convenient time for the animals to utilize crop after math and the body conditions improve. Farmers also keep small protected land between croplands to be used by milking better cows in addition to working oxen.

Milk production increases between September and December due to feed availability as it is right after the main rainy season in normal circumstances; feed shortages are very acute from January to May and July to August during the main rainy season because of restricted movement of animals as most of the land is covered with food crops.

Between February and April when the problem of feed shortage is more acute animals lose weight and milk production drops. Drinking water, both for livestock and human were critical and the outstanding problem in the study area. However, this was solved by the AHI project, by taking the issue as an entry point for INRM in the watershed. Fenced area in the home stead is generally used as barn for large cattle. Calves,

sheep, goats and equines are mostly kept in separate housed type barns. All species of animals are left for free grazing during the day and stay in the barn at night. Farmers in the study area do not have access to improved livestock management systems.

Production and productivity

Production and productivity in cattle is generally low. Daily milk yield is nearly one litter and the cows reported to stay in milk only for about 6 months. Age at first calving in cattle is almost 6 years, the period which is too long compared to other smallholder farms in the highlands. This might also be attributed to poor feed availability and poor livestock management systems practiced in the area. Age at first lambing or kidding in sheep and goats is approximately one and half to two years and they give birth every other year thereafter. Horses are more important than any other equine species in the watershed. Farmers do not pay more attention in following the productivity of equines except their utilization. Horses are the most dominant and the most preferred species of equines in the study area. Male horses serve from 10 to 15 years and are sold to other areas, while female horses stay in production not more than 10 years.

Market situations

Over 40 % of the communities in the Galessa watershed get their household income from sale of livestock and livestock products. In spite of such a great market opportunity and the adequate sheep population in the watershed, the community did not improve the quality of the supply. Very small sized and unfinished with comparatively low weight lambs are tracked to local markets. This is due to the lack of technology intervention in the area. Introductions of improved management and feeding practices, especially fattening packages, training the community towards market oriented agricultural products could be the immediate intervention area. Such interventions could improve the household income situations of the community and assist the farmers to pay more attentions to natural resource management in their surrounding.

Production constraints

Feed shortage is a major problem. This is associated with small land holdings created due to high human population pressure, degraded land and fallow system. In most cases animals are forced to stay by road sides just to pass the day. Under the present scenario of land holding and feed shortage, keeping a few productive animals rather than keeping a number

of animals of poor productivity may be advisable. The community members showed interest to have crossbred dairy cows and using part of their cropland for cultivating improved forages.

Conclusions

Issues of watershed, constraints and opportunities are complex and disserve multi dimensional interventions. Accordingly, in order to boost the productivity of the livestock sector and ultimately improve the living standard of the farming community in the watershed, systematic intervention in a well coordinated manner is very important.

Reduction of less productive cows and replacing with more productive improved crossbred dairy cows could be considered as an option to increases food production, income generation and maintenance of natural resources. This kind of intervention in the long run will lead to intensification of livestock production in the watershed. The project is now dealing with such intervention in demonstrating improved crossbred dairy cows with selected farmers in the watershed.

Technological interventions in the area of feeds and feeding are needed. Demonstrations of various multipurpose trees could solve the feed shortages, while also contribute to the betterment of natural resource management in the study area.

Enhancing household income generation for the community in the watershed is important. Unless the community secures their household income they will go out in search of off-farm income to cover their immediate expenses. But if means of optimizing income generation is created for them the possibility of paying more attention to natural resource management will be very high. This could be implemented through demonstrations of fattening packages on especially sheep, followed by gradual training of the community to produce better quality products for local markets. Production of finished lambs with improved weight, clean milk and milk products, semi processed honey, and honey products could be thought of as a means to improve the income generations.

Livestock Feed Situation and Prospects for Improvement in Galessa Watershed

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Introduction

In the farming system analysis made prior to the inception of the AHI program, feed shortage coupled with disease prevalence and low genetic performance of indigenous breeds were identified to be the major constraints of livestock production in the Galessa watershed. Among these constraints, feed shortage is the most remarkable one owing to biological, economic and environmental reasons. In economic terms, the major cost (60-70%) of livestock production is accounted for feed cost implying that feasibility of the livestock enterprise is mainly dictated by the feed supply. Biologically, poor nutrition is the major constraint as reduction of this constraint brings a dramatic improvement in livestock productivity. When appropriate feed production and utilization systems are in place, livestock production will become harmonious with the environment or even beneficial to the environment.

Knowledge on feed production and utilization in majority of the smallholder production systems such as the Galessa watershed has been very insignificant. Since the inception of the AHI Project, efforts have been made to get insights on the overall situation of conventionally available feed resources and evaluation of different forage crops to identify promising species/varieties to be integrated into the prevailing farming systems of the area.

This paper is aimed at assessing the prevailing scenario of livestock feed and highlighting the efforts made to improve feed supply in Galessa watershed.

Methodology

The Galessa watershed is located in the Ginchi Benchmark site, in the central highlands of Ethiopia. Administratively, it is part of Dendi wereda, West Shewa Zone, Oromiya Regional State. The watershed is located about 110 km northwest of Addis Ababa, and forms part of the northwestern highlands of Ethiopia. The Elevation ranges from 2820 to nearly 3,100 m. It is characterized by a mountainous and highly dissected terrain with steep slops in the upstream part and an undulating topography with very narrow valley bottoms in the downstream part. The climate is mainly humid and the annual rainfall of the area is projected to be over 1100 mm. Cattle, sheep and horses are the major livestock species reared in the area. The farming system is a typical mixed crop-livestock system carried out on a subsistence scale. Land and livestock are the most important assets of the people, with which they lead a sedentary life. Although they used to do marketing about 15 km away in the Ginchi town, there is a new established market place in the area.

The process begun by identifying farming systems constraints related to livestock production as prioritized by the community. Different livestock production constraints were identified in the area among which feed shortage was prioritized to be the major one.

The productivity of grazing lands was assessed at monthly interval by using quadrate sampling (0.5x0.5 m) for two consecutive years (1998-2000). Sampling of short arable fallows was conducted from March to October as the land was either covered with barley or ploughed for the next field preparation during October to February.

Selected forage species recommended for the highlands were evaluated in Galessa with farmer's participation. Fifty accessions of oats, vetch, clovers and medics were included in the initial screening.

A study on possible integration of selected forage species into the barley-fallow cropping system was done. In this study, three species of vetch hairy vetch, wooly pod vetch and common vetch, two clover species (*Trifolium quartinianum* and *Trifolium tembense*) and oats-vetch (Wooly pod vetch) mixture were grown as break forage crops, while the farmers practice (fallow) was also included as a control. The forage crops were grown and managed following the recommended agronomic practices for each and the fallow plot was protected from grazing. Herbage yields of the forage crops and the fallow plot was determined at their respective

maturity stages for harvest. In the subsequent years, barley was sown to all the plots. In order to assess the effects of the precursor treatments, the plots were splitted into two parts and the recommended fertilizer rate for barley (120/60 kg DAP/urea/ha) was applied to one half of the plot, while the other half received no fertilizer. Barley grain yield was then determined against the treatments.

There has been a tradition of producing oats for grain purpose (as human food) by some farmers in the area. Accordingly, four varieties with better herbage and grain production (CI-8237, Grayalgeris, Coker SR res 80 SA 130 and SRCP X 80 Ab 2291) were selected from the research station and the unknown variety owned by farmers was also collected and designated as `**farmer's variety**`. Ten interested farmers were selected and made to prepare the land based on their cultural practice. Each of the participating farmers allocated 156m^2 plots and each of the varieties were established on 2 x 4m^2 plots in June 2005. Besides measurements on biological parameters such as maturity, plant height, herbage and grain yield, information on some qualitative assessments were also collected.

Series of trainings and site visits were organized to representative watershed farmers. In the process, views and feedbacks on the overall aspirations of farmers were captured for subsequent planning and interventions.

Both from farmer's feedbacks and experiences in other parts of the highlands, adoption of improved forages has been very minimal under smallholder situations owing to both subsistence way of life of clients and an 'intermediate product' nature of forage crops. It has been understood that smallholder farmers at Galessa were less motivated to spare both land and labor to grow improved forage crops to feed the low productive livestock species they own. This in turn has been believed to have a challenging implication on the natural resource conservation efforts being undertaken in the area. This calls for the need to inject some thoughts of intensified livestock production by linking forage development with crossbred dairy cattle and natural resources conservation. This approach has been initiated in 2006 and six representative farmers have been selected for implementation. The planning was jointly made with the farmers and the selected farmers are expected to produce adequate feed (oats/vetch hay), develop more than 50 seedlings of tree lucerne and establish the required housing setup to acquire cross bred dairy cattle. Accordingly, cattle towards the last stage of gestation have been introduced to three farmers with confirmed

fulfillment of the requirements, while monitoring of the remaining three farmers has been underway. Qualitative and quantitative analysis methods were employed.

Results and Discussions

Productivity of communal grazing lands

The annual potential herbage productivity of the available grazing lands at Galessa is shown in Table 1. The average herbage yield did not show considerable variation between the two sampling years for all the three grazing areas. Herbage yields of the grazing lands were generally low over the assessment periods. The trend indicated that herbage yields of the three grazing areas were very low from May to August suggesting critical feed shortage during this period. This period is when most arable land is covered with crops and the available communal grazing areas are waterlogged and become less accessible to livestock. Consequently, animals are restricted from moving around and pieces of grazing land fragments are continuously overstocked with limited chance to re-grow. On the other hand, seasonally waterlogged and forest margin grazing areas comparatively gave better herbage yield in November and December while the herbage yield of short arable fallow lands was higher in March following barley harvest. This could be attributed to better stand of the aftermath following harvest.

The overall herbage yield of the three grazing areas at Galessa was much lower than what has been recorded for natural pasture in the highlands of Ethiopia. The recorded estimate of natural pasture yield in the highlands ranges from 1.5 to 2.5 t DM/ha on drained, relatively infertile soils and 4 to 6 t DM/ha on seasonally waterlogged fertile areas (Alemayehu, 1998). The overall average annual herbage yield of grazing lands in Galessa is 0.7 t DM/ha, which is by far below what has been recorded in other highlands of the country.

The consequence of feed shortage not only hampers livestock production and productivity, but also has both direct and indirect effect on natural resource management and crop production. Continuous overgrazing on the limited grazing areas could directly expose the soil to erosive forces leading into land degradation. Lack of adequate feed also has a direct effect on crop production as it determines the power output of draft oxen. On the other hand, feed shortage has an effect on the amount and quality of manure output and indirectly influences nutrient cycling and hence

soil fertility. This shows the close linkage of livestock production with crop production and natural resource management in integrated smallholder highland farming systems such as Galessa. Improving feed supply is therefore essential not only to improve livestock productivity, but also make livestock production friendly to the environment and enhances crop production. However, assessment of the available feed resources in Galessa did not warrant positive synergy within the integrated systems. This calls the need to look for other interventions that help to improve livestock feed supply while directly or indirectly supporting natural resource management in the area.

Table 1. Herbage yields (DM t/ha) of available grazing lands at Galessa

Month	Grazing area								
	Short arable fallow			Forest margin			Seasonally waterlogged area		
	98/99	99/ 2000	Mean	98/99	99/ 2000	Mean	98/99	99/ 2000	Mean
November	-	-	-	2.40	0.98	*1.69*	1.44	0.85	*1.14*
December	-	-	-	0.79	0.83	*0.81*	0.89	1.07	*0.98*
January	-	-	-	0.64	0.53	*0.60*	0.71	1.18	*0.94*
February	-	-	-	0.34	0.38	*0.36*	0.71	0.71	*0.71*
March	1.21	2.21	*1.71*	0.54	0.46	*0.50*	0.33	0.48	*0.40*
April	1.28	1.12	*1.20*	0.43	0.38	*0.40*	0.21	0.33	*0.27*
May	0.59	0.64	*0.62*	0.26	0.20	*0.23*	0.09	0.13	*0.11*
June	0.52	0.46	*0.49*	0.20	0.28	*0.24*	0.11	0.11	*0.11*
July	0.20	0.41	*0.30*	0.23	0.25	*0.24*	0.18	0.32	*0.25*
August	0.47	0.45	*0.46*	0.26	0.34	*0.30*	0.26	0.49	*0.40*
September	1.43	1.02	*1.23*	0.79	0.42	*0.60*	0.70	0.81	*0.75*
October	1.81	0.97	*1.39*	0.87	0.45	*0.66*	0.67	0.46	*0.56*
Mean	0.94	0.91	0.93	0.65	0.46	0.55	0.53	0.58	0.55

Evaluation of different forage species/accessions

The range and average herbage yields of the different forage species/accessions evaluated at Galessa is shown in the Table 2. Among the forage species evaluated, oats appear to produce considerably higher herbage yields which were also consistent over the testing seasons. Average herbage yield of the tested oats accessions ranged from 12.3 to 23.7 t DM/ha. Among the 18 accessions of oats evaluated, the first three accessions with higher average herbage yields were accession No. A-20 (23.7 t DM/ha), accession No. 1693 (23.2 t DM/ha) and accession No. 1765 (18.2 t DM/ha). Herbage productivity of most oats accessions was comparable to or slightly higher than the yield records available for different accessions under on-station conditions (Fekede, 2004). However, it was much higher than the figures recorded for oats under on-farm conditions in other parts of the highlands (Getnet et al., 2002). This may indicate Galessa to be one of the potential niches for oats promotion as livestock feed.

Among the forage legumes evaluated, Hairy vetch gave higher herbage yield followed by Common vetch and Narbon vetch respectively, while clovers were poorly performing species. Unlike that of oats, herbage yield performance of the forage legumes was inconsistent over the testing seasons. This may indicate that forage legumes are more affected by seasonal variations than grasses. According to Peters and Lascano (2003), legumes are usually less resilient than grasses to pests and diseases, and to climatic, edaphic and management changes. The legume accessions which gave higher average herbage yields were accession No. 2465 from Hairy vetch, accession No. 2742 from common vetch and accession No. 2388 from Narbon vetch. Among the clovers, *Trifolium tembense* gave relatively better herbage yield.

Herbage yield of the tested forage species was highly remarkable in view of the poor productivity of the available grazing areas in Galessa. For instance, on average about 9 and 25 fold more herbage yield was obtained per hectare from *Vicia species* and oats, respectively when compared to the productivity of the grazing lands. This shows the likelihood of improving livestock feed supply in the area using cultivated forage crops provided that proper entry points and uptake mechanisms are in place. In addition to its high productivity, oats is able to grow under situations detrimental to crop growth such as low soil fertility, water logging and frost with minimal managerial inputs. Moreover, forage legumes contribute significantly to soil nitrogen and provide a break in cereal-dominated rotations besides supplying quality livestock feed (McIntire and Derban 1987 as cited by Berhanu et al., 2003).

Table 2. Two years range and average herbage yields (DM t/ha) of forage species/accessions evaluated at Galessa

Forage	No. of accessions	Herbage yield range	Average herbage yield
Oats	18	12.3 – 23.7	17.0
Hairy vetch	10	6.1 – 9.4	8.1
Common vetch	8	5.2 – 9.3	7.2
Narbon vetch	5	2.0 – 3.7	3.1
Clovers	5 species*	0.1 – 1.6	0.8

** - T. tembense, T. quartinianum, T. decorum, T. steudineri, T. reupellianum*

Integrating forage crops into barley-fallow system

One of the options available to introduce improved forage crops to smallholder production systems is through integration into the existing cropping system. To this effect, efforts were made to assess the

possibility of incorporating some forage species into the barley-fallow cropping system in Galessa. Table 3 indicates average herbage yields of different forage crops grown during the fallow phase and grain yield of the subsequent barley crop. Highest herbage yield (12.0 t DM/ha) was obtained from oats/vetch mixture followed by the fallow plot (5.1 t DM/ha). Such yield from fallow plot was obtained by resting for at least four months during the cropping season (July-October). Otherwise, the potential herbage productivity of the arable fallow lands assessed under the usual practice of continuous grazing system in the area was about 0.9 t DM/ha as reported in this paper. According to the present result, an estimated six fold increment in herbage yield could be achieved by resting the arable fallow lands for about four months period. This shows strategic management systems such as resting followed by feed conservation in the form of hay could help to enhance livestock feed supply from arable fallow lands at Galessa and similar highland areas. Among the legumes, wooly pod vetch gave better herbage yield.

The yield of the subsequent barley grain did not show significant variation following the fallow plot, oats/vetch mixture and the *Vicia species*. The basic principle behind food-feed crop integration either via crop rotation or intercropping is to identify components compatible with the existing farming system while compromising both food and feed production on the same plot of land. In view of this, incorporating oats/vetch mixture in the barley-fallow cropping system could be an ideal approach to improve livestock feed supply without significant sacrifice in barley grain yield in the Galessa area. On average, about 7 t DM/ha more feed was obtained from oats/vetch mixture as compared to the fallow while sacrificing only 0.2 t/ha in grain yield of the subsequent barley crop. In other parts of the highlands where hay production (natural pasture, oats/vetch) and marketing is common like the Selale area, a bale of hay (an equivalent of 15 kg) costs about 30 birr or more according to seasons (authors, unpublished data). Based on this, more than two fold gains could be obtained by integrating oats/vetch mixture into the barley-fallow cropping system at Galessa and other similar highland areas. The fact that oats could be grown with minimum external inputs further enhances its contribution in such systems.

Table 3. Two years average herbage yields (DM t/ha) of selected forage species established during the fallow phase and grain yield (t/ha) of the succeeding barley crop at Galessa

Forage species (precursor treatment)	Herbage yield	Barley grain yield		Barley grain Mean
		With fertilizer	Without fertilizer	
Hairy vetch	0.9	2.5	2.0	2.3
Wooly pod vetch	2.1	2.4	2.2	2.3
Common vetch	0.4	2.4	2.1	2.3
Clover (quartinianum)	0.1	2.3	1.9	2.1
Clover (tembense)	0.5	2.0	1.5	1.8
Oats-vetch Mixture	12.0	2.1	2.3	2.2
Fallow	5.1	2.4	2.4	2.4
Mean		2.3	2.1	2.2

Evaluation of dual purpose oats varieties

Oats is grown as a dual purpose crop (feed and/or food grain) in some pocket areas of Galessa watershed. It is highly preferred by farmers because of its hardy nature which performs better under low fertility, water logging, frost and diseases with very minimal managerial inputs including land preparation, weed control and fertilization. Generally, it is possible to grow oats under circumstances detrimental for growing other crops. Galessa watershed area is characterized by most of the stressful conditions mentioned above and this could be one of the reasons why oats has acquired relative importance in the area. Although the initial aim of oats introduction to the smallholders in the highlands was for feed production, it has been realized that it is also being extensively grown as a food grain. However, it has been perceived that farmers have no awareness on the existence of different oats varieties with different merits and consequently they use to grow a single variety they own for feed and/or food (Getnet, 1999).

Oats varieties suitable for herbage and grain production, and also with varying maturity have been identified on research station at Holetta. Representative watershed farmers were made aware of availability of such varieties during their visit to Holetta. This was the basis for testing some of the varieties for multipurpose use targets in the area. Table 4 shows durations at forage harvest, plant height at harvest, average herbage dry matter yield, grain yield and thousand grains weight of five oats varieties evaluated on ten farmer's fields at Galessa watershed. There was considerable variability in maturity, plant height, herbage yield, grain yield and thousand-grain weight among the oats varieties.

Durations for forage harvest ranged from 142 to 182 days, herbage yield ranged from 4.7 t to 8.8 t/ha and grain yield ranged from 1.3 t to 1.6 t/ha. The oats variety CI-8237 was found to give higher herbage yield and was taller in height followed by the variety owned by farmers. These two varieties also had similar maturity and seem to share common features with respect to most of the measured biological parameters. On the other hand, the first two varieties (Coker SR res 80 SA 130 and SRCP X 80 Ab 2291) had comparatively low herbage productivity, shorter in height and mature earlier than the other varieties. These varieties gave better grain yield with higher thousand-grain weight than the other varieties, and thus could be potential candidates for multipurpose production in the area. The oats variety, Grayalgeris was late maturing and was intermediate in herbage productivity and plant height, but was poor in grain yield.

Results of the measured biological parameters coincided with the intelligent guesses by farmers during participatory vegetative evaluation of the varieties. With the intention to capture farmers` views and traits they prefer for selecting the varieties, participatory evaluation of the varieties was held by a team comprising researchers, technical assistants and farmers. All the farmers were highly interested in grain setting performance of the varieties as they are growing oats mainly for grain purpose. Accordingly, they expressed their preference on the oats variety Coker SR res 80 SA 130 followed by SRCP X 80 Ab 2291 for grain production. They are quite impressed by the bold grain type of these varieties as compared to the one they have ever known and use to grow. The early maturity of the two varieties was also well acknowledged by the farmers due to the fact they could mature earlier than barley and provide them with a food grain early when they are needy. According to farmers, this feature is also essential with respect to labor distribution for harvesting and threshing. For herbage production, the farmers showed interest on CI-8237 followed by their own variety due to better vegetative growth (taller in height) and the farmers perceived that high biomass production could be possible from these varieties thereby enable them to obtain substantial quantity of livestock feed. Moreover, farmers expressed that such vegetative growth is essential in adding substantial OM to soil and improves soil fertility upon decomposition of the aftermath. Generally, all the farmers showed marked affinity towards Coker SR res 80 SA 130 followed by SRCP X 80 Ab 2291 for grain production and CI-8237 followed by their own variety for herbage production.

Table 4. Average agronomic and yield performances of selected oats varieties evaluated on ten farmers fields at Galessa watershed, 2005/06

Parameter	Oats varieties					
	Coker SR res 80 SA 130	SRCP X 80 Ab 2291	CI-8237	Gray-algeris	Farmers` variety	Mean
Durations at forage harvest (days)	142	142	178	182	178	164
Plant height at harvest (cm)	94.3	96.8	151.9	125.5	147.5	123.2
Herbage DM yield (t/ha)	4.7	4.7	8.8	7.6	8.2	6.8
Grain yield (t/ha)	1.6	1.5	1.4	1.3	1.5	1.5
1000-grains weight (g)	39.2	36.9	32.9	28.6	32.5	34.02

Site visits, trainings and farmers feedbacks

During the different phases of AHI programs at Galessa, various community meetings were held aiming at common understanding of livestock production and natural resource related problems and suggestions on potential solutions.

Useful information was conveyed to representative farmers through training and cross site visits. Thirty representative farmers participated in forage and livestock related trainings/cross site visits organized with the support of the AHI during different times. In the process, some of the feedbacks captured from farmers included the following major aspects:

- The farmers inspired that it was their first time to visit how cross-bred dairy cows look like and be managed. In their first exposure, they felt difficulty to believe to observe a pregnant one year and eight months old crossbred heifer which they expected to age six years. Similarly, the higher milk production of cross-bred cows (about 10 liters a day) highly drew their attention. Relating this with the local cattle they own (with age at first calving of 6 years and milk yield of less than a liter per day), they understood that their livestock rearing system is quite inefficient and both economically and environmentally infeasible;
- It was their first exposure to most of the forage species except oats and to some extent Tree lucerne. They were impressed by the attractive stand and huge biomass of the available forage species. They were especially interested with the different oats varieties they observed because they had a culture of oats production for long period of time without knowing the presence of alternative varieties with varying merits (early maturity, high grain yield and high fodder

production). This was the basis for on-farm evaluation of five selected oats varieties in the watershed; and

- Generally understood the availability of useful livestock and forage related technologies with immense potential to improve feed supply and livestock productivity while contributing to natural resource conservation upon successful incorporation into farming system of the area.

Observations and Lessons Learnt

One of the major problems associated with livestock production in the Galessa watershed is the prevalence of feed shortage both in quantitative and qualitative aspects. This feed shortage coupled with the inherently poor genetic makeup of the indigenous livestock species has led to a further drop in livestock productivity and wellbeing of the society. The other threatening consequence of feed shortage is natural resource degradation being induced by a heavy grazing pressure on meagerly available grazing lands. This in turn will lead to reduction in the overall agricultural productivity in the watershed and other similar areas.

In the process of working with farmers since the inception of the AHI program in the Galessa watershed, it has been understood that there exists huge potential to reverse the problems associated with feed shortage. Forage species with more than 10 fold yield potential as compared to natural grazing lands available in the area have been identified. Possible ways of integrating into the farming system of the area have been explored. Farmers have also been sensitized about available forage technologies, and principles of improved forage production, management and utilization through series of trainings and cross site visits. The potential benefits of linking forage development with natural resource management has been the core focus of debates with farmers to reach a consensus that land degradation will be minimized while at the same time improving livestock feed supply. Representative farmers had also a chance to visit areas such as Konso where this principle has got marked practical applications.

Despite all these efforts and potentials, the farmers have been less motivated to adopt forage technologies to the anticipated level. It has been understood that the reluctance of farmers to grow forages is mainly attributed to the fact that given their subsistence way of life, they are unfamiliar with the concept of investing labor, land and capital in forages

rather than staple crops. Naturally, subsistence farmers are struggling to support their families` needs for staple food crops and perceive investment in forage as a high-risk strategy. Moreover, this is exacerbated if livestock production is for subsistence and if livestock productivity and response to improved technology are low as in the case of local cattle breeds whose milk yield does not exceed 1 liter/day in the highlands. On the other hand, experiences in other parts of the Ethiopian highlands confirmed better adoption of improved forage crops when linked with high grade livestock species, where livestock respond to improved feed technology and where profitability is high due to market-oriented livestock enterprises such as dairying. The situation in the Galessa watershed seems more complicated as forage development is expected to be linked not only with market-oriented livestock enterprise, but also with natural resource conservation to reverse the prevailing land degradation in the area. Therefore, it has been learnt that it is crucial to look for different approaches of livestock production which needs one or all of the following expectations:

- A few productive animals with intensive management while minimizing excessive free grazing and hence natural resource degradation. The approach is also expected to enable effective implementation of natural resource conservation measures for rehabilitating degraded areas;
- Feed production to ensure adequate feed supply while protecting soil runoff, improving soil fertility and provision of other side benefits for farmers such as fuel wood, live fences, nectar sources for honeybees;
- Increased milk production thereby improving the nutritional status of the community or increased income. Increased manure output is also anticipated thereby ensuring sustainable nutrient cycling and enhanced soil fertility. Manure also serves as an alternative fuel source in most highlands; and
- Increased overall agricultural productivity and improved income and wellbeing of the watershed community. This will help as a deriving force to enhance the courage, capacities and motives of the target groups to participate and invest in natural resource management operations.

Therefore, the overall hypothesis has been improved dairying with better market opportunities will improve farmer investments in natural resource conservation through sustainable production and use of forage crops. It was with the above hypothesis that the concept of integrating forage development with cross bred dairy cows in the Galessa watershed has

been initiated. The concept was jointly planned through participating representative farmers from the watershed. Six (2 women, 4 male) farmers representing each of the six villages in the watershed have been identified for demonstrating the concept. The farmers were identified by the community based on their own criteria. Some of the criteria considered for farmer identification were:

- level of awareness, uptake and implementation of newly emerging approaches and associated opportunities thereby serve as a potential model for the rest of the watershed community;
- willingness to spare at least a quarter of a hectare of land for forage production using oats/vetch mixture and also to establish from 50 to 100 seedlings of tree lucerne; and
- capability and attitudinal readiness to accommodate the requirements for improved dairy cattle management including housing, feeding, health care and product handling.

Subsequently, training was provided for three-days to the farmers at Holetta Research Center. Representative farmers from other highland areas where cross bred dairy cattle have been introduced such as Jeldu and Tichur-enchini were also participated in the training to enable experience sharing among the farmers. The basic concepts and principles of cross bred dairy cattle management including breeding, housing, feed production and conservation, feeding, health care, product processing, handling and marketing were covered in the training. The training was also supported by basic practical demonstrations on some management operations of crossbred dairy cattle. Moreover, the farmers had a chance to visit the dairy farm and forage field in the center.

Following the training, seeds of oats and vetch sufficient for planting a quarter of a hectare of land was provided to the six farmers. Moreover, seedlings of tree lucerne were raised at Holetta Research Center and about 100 seedlings have been provided to each of the six farmers. All required technical backstopping have been provided to the farmers for growing the forage crops beginning from June 2006. The six farmers have successfully grown oats/vetch mixture on a quarter of a hectare of land for hay. Herbage dry matter yield ranging from 2.6 to 10.0 t/ha was estimated from oats/vetch grown by the farmers. The farmers have also established tree lucerne on the outskirts of their homestead.

The other prerequisite for introducing cross bred dairy cows is to have appropriate housing of the cattle. All required technical assistance and

guidance have also been provided to farmers. Based on the assessment and monitoring made to evaluate their progress, three farmers have managed to establish the required housing setup and received pregnant cows.

Conclusions and Recommendations

The potential herbage productivity of natural grazing lands at Galessa is very low to support the animals. The problem of feed shortage has been reflected not only by poor body condition of animals, but contributed to land degradation due to continuous overgrazing on limited areas.

Possible ways of integrating improved forages into the barley-fallow system of the area have been explored. Farmers have also been sensitized on available forage technologies, and principles of improved forage production, management, and utilization through series of trainings and cross site visits. Particularly, the potential benefits of linking forage development with natural resource management has been the core focus of all discussions with farmers to reach a consensus that land degradation will be minimized while improving livestock feed supply.

The farmers have clearly appreciated the prevailing feed shortage and also understood the potential technological options to rectify feed shortage in the area. However, low productivity of the local cattle breeds coupled with their subsistence way of live did not motivate them to adopt improved forage production. On the other hand, experience in other parts of the Ethiopian highlands confirmed better adoption of improved forage crops when linked with market oriented enterprises such as dairying using cross bred cattle. Therefore, introducing crossbred dairy cattle with intention to derive the promotion of productive and better quality forages into the system in Galessa should continue. This is also expected to lay down the basis for intensification of livestock production and thereby promote effective conservation measures to reclaim degraded lands in the area.

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Collective Action Institutions and their Implications in Policy Options for Natural Resources Management

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Introduction

In Galessa, as in many other parts of the country, the people have evolved traditional methods of collective action, which play an important role in the struggle of their daily life and are a source of strength to the family at times of need like labor, birth, diseases, marriage and death. Though little attention has been given by many researchers and development practitioners, these institutions deserve close attention on account of their economic and social significance to contemporary Galessa watershed management activities as well as on account of the possibilities they may afford to those who are planning the present renaissance of natural resources management practice and poverty reduction strategies.

The objective of this study was to understand the trends, incentives, barriers, challenges and opportunities to collective action institutions in Galessa watershed.

Methodology

Focused group discussion and household survey were used for data collection. In the focused group discussion five groups were conducted in five villages of the watershed area. The discussants were identified based on gender as a criterion to incorporate the views of both men and women. Accordingly, two men groups, one married women group, one

widowed women group and one men and women group were arranged and results from the discussions has been analyzed.

The second method was household survey. The survey covered six villages. Respondents were selected by stratified random sampling methods. First the list of the households residing in the watershed area was prepared which was used as a sampling frame from which the selection producer was carried out. Secondly, the households were clustered in three wealthy categories set by the communities; high wealth group, medium wealth group and low wealth group based on their possession of oxen and cows. The major criteria used to group the households in to different wealth category were number of oxen, number of cows and number of calves one possessed by a respondent. In addition, the number of horses and donkeys were also used as criteria.

Accordingly, those households who have 3-4 oxen, 3-4 cows and may have one or more horses were considered as high wealth group locally called soressa (rich). Those households who have a pair of ox, two cows and with one or more horses were grouped as medium wealth families and those households who possessed one or no ox and one or no cow were categorized as low wealth families locally called hiyessa (poor).

Respondents were selected proportionate to the size of the population from Ameya, Sombo,Tiro, Lega Aba and Kemete Lencha villages. Data were collected from 60 households of different gender and wealth categories and the data has been analyzed using SPSS.

Results and Discussion

Demographic characteristic of respondents

With respect to the marital status of respondents almost all of them experienced marital life. However 16.7% reported that they are single widowed who lost their husbands by death, while 83.4% said that they are in the wedlock of which 6.7% reported that they are under the mercy of polygamy. Majority of the single widowed households belong to the lowest and medium wealth category and all those who experienced polygamous marriage life belong to the highest and medium wealth categories.

Regarding age distribution of respondents, 61.3% were less than 50 years old while 38.7% were more than 50 years old. The average age

distribution of respondents was 45.58 years with a standard deviation of 18.2. The average age distribution for male respondents was 52.29, which was 6.61 years more than the total average. While the average age distribution of married women was 35.08, which was 17.12 years less than that of men.

With respect to age distribution of respondents by wealth category, 57.1% of respondents belonged to the highest wealth group; while 61.3% of those who belonged to the middle age group belonged to the lowest wealth category.

It was observed that 55% of the household members were below the age of 15 year whose labor contribution is very minimal except for livestock herding. There is therefore a strong indication that in the near future the pressure on land in the area will be too high even to maintain the present status quo. Hence it calls for intensive birth control education and practices. Efficient and effective NRM is equally important to reduce further land degradation and to improve the carrying capacity of the environment

The average household size of the respondents was 6.4 persons. However 55% of respondents had six and more persons in their household. Forty-five percent of the respondents had a household size of 5 and less; 36.7% of respondents had a household size of 6-9; and 18.3% of respondents' household size was 10 and above.

Socio-economic conditions of respondents

Education level

The majority (65.1%) of the respondents have never had any schooling (illiterate), while the rest (34.9%) had access to formal education. The educational level of the respondents was not affected by their asset possession (wealth). For instance, among the respondents who belongs to the highest wealth group the majority (71.4%) were illiterate. On the other hand, those who were in the lowest income group (64.5%) were illiterate, which was 6.7% less than the highest income group. Regarding the educational level of respondents by their gender, however; women are the most illiterate groups as compared to men respondents. The illiteracy rate of the female-headed and married women respondents was 91.7% and 70.8% respectively. However the majority (54.1%) of the men respondents had attended formal education during the survey. This

clearly shows that the level of education has a significant effect in the level and efficiency of women participation in NRM practices. Therefore there is a need to support women strongly in getting access to education. Forty six % of the male respondents were illiterate and where as 65.8% were grade 1-6 while the rest were 7-8 grade. Out of the female household respondents, 91.7% were illiterate and 8.3% were between grades 7 and 8. Out of the married women respondents, 70.8% were illiterate, and 29.2% were between grades 1 and 6.

Income

The most important sources of income of the respondents were crop production livestock husbandry, tree products and some off-farm activities such as daily labor and domestic works. Sixty-five percent of the respondents had no income from off farm activities. Only 15 % of the respondents earn 350 birr per year from off farm activities per year. The rest (8.3%) earn 45-100 birr and 10% and 1.7% generated an average of 150 and 250 birr, respectively annually from off-farm activities.

Expenditure

Even the total expenditure of the high wealth category was greater than any of the wealth category; it was found that the medium groups were more interested in investing on food than the high wealth group. Similarly the interest of different genders and wealth categories varies according to their diverse interest. Respondents have also pointed out that the major reasons for the ever increasing of household expenditures were as follow:

- rising of land tax;
- ever-increasing of the price of agricultural inputs;
- increasing of expenses related to education, health, and clothing;
- increasing in family size; and
- increasing food price items like oil, sugar, vegetables, and fuel.

The socio economics conditions of the respondents have an implication in their participation in the collective action institutions. Their educational background, wealth category and gender has implication in their involvement in collection action institutions and at the same time one aspect of the socio economic condition has impact on the other aspect of the socio economic condition

Collective action institutions in the watershed

The most important forms of collective action institutions and their social and economical benefits also were identified by the survey. These institutions are local institutions and external institutions. The following are local institutions identified in Galessa watershed:

Debo

Depending on traditional roles and responsibilities, participants of debo are men and women youth and mixed. Men are usually participating on Debo for farming activities such as plowing, weeding, harvesting, and threshing. It has been also employed in non-farming activities such as house construction, fencing. Women also participate in weeding and transporting produces from field to home. The non-participants are the old, the disabled, children, the poor and those who have small plot of land but enough labor. Debo has a benefit of experience sharing and establishment of friend ship. Access to labor for agriculture and other activities is also considered as economic benefit from Debo. Those who have arranged the debo gets access to assets via timely operation of the activity.

Men's Idir

Participants are every man in the village who has interest and can afford the payment and no body is excluded from idir because of wealthy and social status. None participants are those men who do not have interest regardless of their social and economic status. It has also friendship and moral support benefit. Financial, food and labor assistance for funeral and labor assist on agricultural and other activities are the economic benefit of this institution. Respondents mentioned out that this institution has no effect in discriminating the participants, as far as the individual is the member of the institution.

Young men's idir

It has a benefit of friendship and moral support. Financial, food and labor assistance for funeral and labor assistance on agricultural and other activities, are the economic benefit. Respondents mentioned that this institution doesn't discriminate the participants, as far as the individual is the member of the institution.

Women's idir

Participants are almost all married and widowed women in the village. Women's Idir has a benefit of friendship and moral support as social dimension. Financial, food and labor assistance for funeral, wedding and

other ceremonies are the economic benefit of this institutions. It doesn't discriminate participants as far as the members obey the bylaws of this institution.

Senbete

The participants are Orthodox Christians who are interested including male and married women and widowed. The non participants were non-Orthodox religion follower, the poor who can not afford food and drink. Like other institutions, it inspires friendship and moral support as social aspect. Financial, labor contribution, material contribution during crisis were also the economical benefit of this institutions.

Iqub

The participants are those with continuous income mostly merchants, traders and women who sell local drink. The non-participants are those who have no continuous income and wealthier farmers who prefer to keep their assets in kind. Iqub helps to gain knowledge on saving and other business activities. Members who utilize the money efficiently could accumulate assets over time.

Qallu/ Jabir

Qallu/ Jabir has spiritual importance and the spiritual leader gets respect and followers get spiritual satisfaction. The economic importance of this institution is that the spiritual leader accumulates assets over time since follower offer for him.

Jarsuma

The participants are wise elders (male) who are believed to judge those parties equally who have involved in disputes. Jarsuma also generates a benefit for elders and people with high social status.

Kitee

Those individuals who do not have enough land but have enough labor, oxen, seed and cash on one side and those who have enough land but do not have enough labor, oxen, seed and cash on the other side usually accept the kitee arrangement. It helps the landowner to get access of labor, the landless to get access to land and as a result both can get access to inputs depending on the arrangement. Both parties get access to assets via access to land, labor, oxen, seed and other inputs. This institution has no social benefit since it emphasis on economic aspect.

Kira/ Contract

Kira can be of contract-out or contract-in. Lazy, old, weak, poor farmers and female headed households usually contract out their land whereas those individuals who do not have enough land for farming but with labor, oxen and other inputs usually contract in their land. This institution has no social benefit since it emphasis on economic aspect.

Ribi

Wealthy farmers usually give ribi to save labor and fodder while poor farmers take ribi and manage livestock on own land. Those medium farmers do not give ribi and the not trusted poor do not take ribi. Since ribi takers are poor and givers as wealthy, those who take ribi will access to livestock and livestock products.

Wanfal

The participants are every one who has interest in labor sharing. This institution helps to establish close relationship. One assists the other turn by turn and there will be equal benefit among the members.

Perceived benefits from collective action and external institutions

This study indicated that different collective action institutions have different purposes and respondents had different views about the benefits of these institutions. Forty-seven percent of the respondents ranked sharecropping as the first priority; whereas 28 %, 13 % 9 % and 3 % of the respondents preferred debo, ribi, iqub and contracting respectively. The perception about the support generated from social institutions varies across gender and wealth category.

Involvement and role in collective action institutions

Only 35 % of the respondents have leadership role in collective actions institutions. The rest (65 %) of the respondents do not have any leadership role in collective action institutions. The involvement of male respondents (45 %) is better as compared to female household head (41.7%) and married woman (20.8 %). This finding clearly indicated the existence of inequality in relation to leadership role in collective action institutions between male respondents and female respondents. The role and level of involvement in the collective action institutions also vary according to wealth and gender variations.

Lin and Nugent (1995) elaborated the theoretical variables affecting collective action and indicated that the time group members spent together and 'geographical or sectoral concentration' makes the nature of collective action more dynamic. The Galessa case could not be addressed in the way. Rather the involvement frequencies of respondents have been scored and tried to be analyzed. The involvement frequencies vary across gender and wealth group from the different collective action activities. The involvement of respondents in one of the collective action institutions vary across gender and wealth category. From the result, it was clear that male involves better in all of the collective action institutions compared to other groups. However, in the case of wealth category it was difficult to find out a clear cut conclusion. Rather the different wealth category has different level of involvement in the different collective action institutions. For instance in sharecropping the high wealth group was more active whereas in Jarsuma the low wealth group was more active participant.

Willingness to invest in collective action activities

The willingness of farmers to invest on different collective action activities were assessed in Galessa watershed. Accordingly, 73% of the respondents were very willing to invest in improved management of trees on field boundaries, around springs and in the outfields. Ninety one percent of the respondents were very willing to participate in spring management, 55 % were very willing to participate in soil and water conservation and grazing land management. However, only 36 % of the respondents were very willing to involve in broader dissemination of technologies as collective action. This could be due to the perception of the respondents about technology dissemination as something difficult task or this may show that most respondents are not willing to share the benefit they get from improved technologies for other farmers. Although members try to organize themselves and coordinate collective action, the external support in providing technological facilities is necessary to increase benefits from collectively produced good. The willingness to invest on natural resources management was also influenced by education level of respondents. For instance, 88.9% and 100% of grades 1-6 and grade 7-8 respondents were willing to invest on natural resources management. Still the willingness levels of the respondents were affected by gender and wealth status. Seventy nine percent of male respondents were very willing to invest on boundary tree management but only 42 % of the female headed respondents were very willing to invest on the same

activity. According to farmers, the main limiting factors to invest on natural resources were lack of confidence on the benefits of most natural resources management activities, for example, soil and water conservation due to long gestation period, lack of knowledge on best practices, and poverty. Thus, poverty reduction and natural resources management need to be complementary.

Traditional rules, practices and beliefs

The survey has identified the following traditional rules, practices and beliefs as far as natural resources management is concerned:

- In the valley bottoms and outfields the traditional rules and practices are that grazing of cattle on individual grazing land is during cropping period, which is usually July to November and open grazing during the rest of the year. The benefit of this practice is to protect crops and pasture from animals and reduce labor to keep livestock during the off season;
- Field plots (around homestead) are privately managed and utilized all the time. The benefit of such rule is security of property rights and it also reduces the burden on grazing areas of the outfield;
- Tree planting along farm boundaries especially eucalyptus is forbidden. From this traditional rule neighboring farmers are advantageous by avoiding shading and allelophatic effect of trees on annual crops; and
- A traditional rule on spring management also prevents washing of clothes around the spring. So the water is kept clean.

Meinzen-Dick, et al. (2004) clearly indicated that understanding the role of collective action in enforcing different forms of property rights in circumstances when multiple sources of rights to a resource exist is also essential. In the same line, the findings in Galessa watershed has shown that the different rules, values and beliefs existing in the collective action institutions in relation to NRM must be well linked with external policies and institutions to bring effective and sustainable change.

Lin and Nugent (1995) have also indicated that positive selective incentives can encourage members' participation and negative selective incentives discourage free-riding in the form of violating group decision. The findings from Galessa watershed showed that community can be visualized in line with selecting and enhancing the most feasible

traditional rules and values with the external policies and institutional values.

Barrett and Lee (2004) emphasized on institutional arrangements for reconciling rural poverty reduction with renewable natural resource conservation in developing countries. Their synthesis of various cases reflect that conservation projects of similar basic design have shown different results due to variable degree of the functioning of rules across different communities. They indicate choice of rules being less important than the way the community monitors and enforces them. Therefore, local institutions' values and rules in Galessa must be integrated and with the higher level rules and values.

Conclusion

Collective actions institutions in Galessa watershed were highly appreciated by respondents. However, involvement and willingness to invest on collective action institutions vary according to the respondents' socio economic background, gender and other related factors. And this variation was clearly depicted when we see across the institutions taking diverse factors that exist among the respondents.

According to the respondents, collective action institutions are good entry point for NRM. Thus, for their effectiveness and sustainable impact on the community action, integrating them with external policies and institutions is very vital. The attention to analyze collective action institutions must be strengthened and the local institutions values and rules must be integrated with the higher level rules and values, so that poverty reduction through effective NRM and utilization is realized.

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