AGROFORESTRY AS A TOOL FOR INTEGRATED LAND RESOURCES MANAGEMENT: IMPROVING FARMERS’ LIVELIHOOD, PROVIDING WOOD PRODUCTS AND MINIMIZING FOREST ENCROACHMENT

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Declaration

I, the undersigned, hereby declare that this is my original research work and has not been submitted to any other educational institution to attain any academic degree. All sources of materials used are duly acknowledged. Any mistakes and misrepresentations, if any, are solely mine.

Name: Lalisa Alemayehu Duguma

Signature:

Place and Date: Vienna, 2010
This work is sincerely dedicated to my late step-grandfather Bichaka Wayu, my parents, my wife, and Herr Karlheinz Böhm (Founder and Director of Menschen für Menschen).
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Abstract

Ethiopia’s forest resources are gradually declining both in spatial coverage and in quality. The decline is mainly due to: 1) the exploitation because of strong demand for forest products by the society; 2) the intensified forestland encroachment for agricultural expansion to feed the rising human population. To minimize the forest depletion, measures like legal protection of the forests (declaring forests as ‘state forests’ or ‘protected forests’) and participatory forest management have been tried. However, the outcome, i.e., in terms of reducing the forest depletion is minimal. Besides the previous measures, enhancing farmers’ onfarm wood production potential by using agroforestry practices could help to minimize the problem. Nonetheless, this approach gained less attention from the practitioners working in the agrarian communities. Hence, the various benefits and products these practices generate for the community are not addressed. This study has tried to investigate how influential agroforestry practices are in terms of improving rural livelihoods while minimizing forest resources depletion. It assessed the financial, social, ecological, and soil amelioration values of agroforestry practices in comparison to the dominantly practiced cereal farming. Data were collected by using interviews, questionnaire surveys, and direct measurements. The study also used a participatory approach to evaluate the social and ecological values of the land uses included in the study. The results show that forest encroachment in Menagesha Suba area is mainly driven by poverty, forest products scarcity, land shortage and what farmers see as an unconvincing forest management style. The assessments of the forest products demand for fuelwood and construction wood indicated a wide scarcity gap. The community selected woody plants growing (agroforestry) as the superior means to reduce the scarcity gap. Agroforestry practices had exceedingly high financial returns, which would minimize the financial constraints of the farm households in Menagesha Suba area. The practices were also strongly preferred for the social and ecological values they provide. Moreover, they had significant positive effects on soil chemical properties; especially organic carbon, nitrogen, phosphorus and potassium were drastically higher under agroforestry practices as compared to other land uses. The high concentration of these nutrients in agroforestry practices is vitally important, as most soils in the Ethiopian highlands are deficient in the aforementioned nutrients. The study also demonstrated that agroforestry practices may have a strong potential for providing forest products for the farm households if the available land is efficiently utilized. This provision of forest products from within the farm plots may relieve the remnant forests from being encroached severely. Hence, expansion of these practices among the farm households may have crucial implications for the management of the nearby state forest.

Keywords: Agroforestry, livelihood, forest encroachment, income, social and ecological value.
Zusammenfassung

Farmhaushalten hätte somit essentielle Auswirkungen auf die Bewirtschaftung der benachbarten Landesforste.

**Schlüsselwörter:** Agroforstwirtschaft, Lebensunterhalt, Waldabbau, Einkommen, soziale und ökologische Werte.
# Table of Contents

Acknowledgements iv
Abstract vi
Zusammenfassung vii
Table of Contents ix
Dissertation Structure xi

SECTION 1: AGROFORESTRY AS A TOOL FOR INTEGRATED LAND RESOURCES MANAGEMENT 1

1 GENERAL INTRODUCTION 2

2 METHODS AND APPROACHES 4
   2.1 Overview of the Research Framework 4
   2.2 Research Strategy 6
   2.3 Overview of the Field Work 7
   2.4 The Data Collection: an Interdisciplinary Approach 8
   2.5 Study Site Selection 10

3 RESULTS: SUMMARY OF PAPERS 11
   3.1 Paper I: The Community-State Forest Interaction in Menagesha Suba Area, Ethiopia: the Challenges and Possible Solutions 11
   3.2 Paper II: Consumption and Species Preference for House Construction Wood in Central Highlands of Ethiopia - Implications for Enhancing Tree Growing 12
   3.3 Paper III: Fuelwood Use and Its Implications on Food Crop Production and Nutrient Transport from Forests in Central Ethiopia 13
   3.4 Paper IV: Woody Plants Diversity and Possession, and Their Future Prospects in Small-Scale Tree and Shrub Growing in Agricultural Landscapes in Central Highlands of Ethiopia 15
   3.5 Paper V: Effects of Land Use Types on Soil Chemical Properties in Smallholder Farms of Central Highland Ethiopia 16
   3.6 Paper VI: The Financial Return of Cereal Farming for Smallholder Farmers in Central Highlands of Ethiopia 18
   3.7 Paper VII: Financial Analysis of Agroforestry Land Uses and Its Implications for Smallholder Farmers Livelihood Improvement in Ethiopia 19
   3.8 Paper VIII: Farmers’ Assessment of the Social and Ecological Values of Land Uses in Central Highland Ethiopia 21
   3.9 Paper IX: The Potential for Woody Biomass Production for Rural Households with Efficient Land Resources Utilization in Menagesha Suba Area 23

4 GENERAL SUMMARY 24

5 IMPLICATIONS OF THE STUDY 26
   5.1 Policy Implications 26
   5.2 Methodological Implications 27
   5.3 Some Ideas for Further Research 28
6 REFERENCES ______________________________________________________________ 28

SECTION 2: PAPERS ____________________________________________________________ 31

Paper I: The Community-State Forest Interaction in Menagesha Suba Area, Ethiopia: the Challenges and Possible Solutions ______________________________________________________ 32

Paper II: Consumption and Species Preference for House Construction Wood in Central Highlands of Ethiopia - Implications for Enhancing Tree Growing ____________________________________________ 45

Paper III: Fuelwood Use and Its Implications on Food Crop Production and Nutrient Transport from Forests in Central Ethiopia ______________________________________________________ 56

Paper IV: Woody Plants Diversity and Possession, and their Future Prospects in Small-Scale Tree and Shrub Growing in Agricultural Landscapes in Central Highlands of Ethiopia __________ 68

Paper V: Effects of Land Use Types on Soil Chemical Properties in Smallholder Farms of Central Highland Ethiopia ____________________________________________________________ 85

Paper VI: The Financial Return of Cereal Farming for Smallholder Farmers in Central Highlands of Ethiopia _______________________________________________________________ 97

Paper VII: Financial Analysis of Agroforestry Land Uses and Its Implications for Smallholder Farmers Livelihood Improvement in Ethiopia _______________________________________________ 111

Paper VIII: Farmers' Assessment of the Social and Ecological Values of Land Uses in Central Highland Ethiopia ___________________________________________________________ 127

Paper IX: The Potential for Woody Biomass Production for Rural Households with Efficient Land Resources Utilization in Menagesha Suba Area ____________________________________________ 146

Short Curriculum Vitae ________________________________________________________ 153
Dissertation Structure

The dissertation is composed of two major sections. The first section gives overviews of the background of the work, the problem statement, the methodological frameworks, the summary of the findings and some recommendations. The second section is composed of different research articles, which mainly address the major thematic areas of the work as listed below.


I and Michael Gurber wrote the paper with revisions and inputs from Herbert Hager.


I wrote the first draft of the paper and Herbert Hager has reviewed and improved the contents.


I wrote the first draft of the paper and Herbert Hager has reviewed and improved the contents.


I wrote the first draft of the paper and Herbert Hager reviewed, added additional inputs and improved the contents.


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I selected the topic, analyzed the data and wrote the paper with inputs from Herbert Hager.
SECTION 1: AGROFORESTRY AS A TOOL FOR
INTEGRATED LAND RESOURCES MANAGEMENT
1 GENERAL INTRODUCTION

Ethiopia currently possesses less than 2.7% forest cover (Ethiopian Agricultural Research Organization [EARO], 2002). According to Bishaw (2001) and Cheng et al. (1998) the country had around 40% forest cover a century ago which were devastated due to the conversion into agricultural lands (Aregu and Demeke, 2006; Jagger and Pender, 2003) and consumption for fuelwood and construction wood. The extent of deforestation is severe in the highlands of the country (Berry, 2003) mainly due to the intense human and livestock population increment and demand for agricultural lands to sustain the food and feed demands of the aforementioned household components. Ethiopian Forestry Action Programme (EFAP) (1994) estimates that the country’s rate of deforestation (in the dominant forest types of dry Afromontane forests) is around 163,000–200,000 ha yr⁻¹. Despite the existing severe deforestation, efforts to restore the forests are limited and even the remnant ones are subjected to further exploitation because of shortage of forest products and uncontrolled activities carried out in the forested lands.

One of the prominent measures taken to reduce the depletion of the remnant forest resources is legally declaring them as ‘state forest’ or ‘protected forest’ where the impacts of the local community are intensely reduced (Bekele, 2001). Nonetheless, the lack of alternative wood product sources for the surrounding community has subjected the forests to extended periods of encroachment, which extensively damaged them. The pressing challenge is that the majority of the country’s population (~90%) is dependent on wood coming from the remnant forests for both construction and fuel wood (Bekele, 2001). Hence, such challenge puts the future of the remnant forests in uncertainty.

Under such circumstances, efforts should have focused on additional means of providing wood products for the dependent community by considering tree and shrub growing practices, which can be implemented under the existing land shortage problem. One of the recommended approaches was promoting agroforestry practices to raise the potential of the community to supply itself with wood products. Nevertheless, this approach gained less attention and consideration among policy makers and practitioners operating in the agrarian communities. Rather, currently, participatory forest management (PFM) is being implemented by many NGOs in different protected forests (Kassa et al., 2009) with a plan to bring most forests (mainly protected forests) under its umbrella. But as PFM lacks any recognized policy basis in the country (Gobeze et al., 2009), many challenges, which even threaten the remnant forests, are arising e.g. competitive exploitation by members, encroachment from nonmembers and corruption in benefit sharing. Though proper consideration and alleviation of these challenges could substantiate the effectiveness of PFM in minimizing forest encroachment, still the mismatch between the potential of the forests to supply the necessary forest products and the strong wood demand from the large and increasing population is a crucial issue to consider.
seriously. Despite the constraints and challenges, PFM still can be a complement to other methods, which could be used to save the remnant forests, to provide forest products for the community and to improve their livelihood.

The need to depend on multiple measures/options in forest management and conservation is to enhance the accommodation of the two crucial entities: the forest and the society. Options that favor only the forest may inflict negative attitudes from the people and those that are biased to the people may harm the forests. For example, the declaration of some forests as state forests or protected forests in Ethiopia has even ignited further encroachment and degradation of the resources. Thus, there is a need to search for the optimum balance where both the society and the forest can be handled together because it is hardly possible to attain the win-win situation (both for conservation and community livelihood) (Agrawal and Redford, 2006) under the prevailing severe deforestation and poverty in developing countries especially.

In dealing with the human dimension of forest management in Ethiopia, one has to consider the prevailing poverty, high rate of unemployment, shortage of forest products and land shortage. Hence, when devising forest management options a due emphasis should also be given to improving the livelihood of the surrounding community. Poverty significantly affects forestland encroachment (Sunderlin et al., 2005), illegal forest products extraction and the wood use behavior of households. For example, poor people may cut any woody plant whether it is endangered species or not as far as it can be used for household purposes or sold to generate income. Due to poverty, the dependence of the community (either living near or far) on the forest resources is increasing. Therefore, it is mandatory to take into account people who are living away from the forest resources too.

Agroforestry practices are one crucial means of dealing with most of the challenges that have existed in central highlands of Ethiopia (Bishaw and Abdelkadir, 2003; Bishaw, 2001; Environmental Protection Authority [EPA], 1998). Bhagwat et al. (2008) also mention that agroforestry practices are an alternative means of conserving tropical biodiversity. The embedded potentials of the practices e.g. providing forest products (Kidanu et al., 2004), minimizing soil degradation (Rao et al., 1998), relieving the nearby forests from intense demand for forest products, ameliorating the microclimates of the living environments (Georgi and Zafriadis, 2006; Shashua-Bar and Hoffman, 2000; Cleugh, 1998) and generating income for the community make them very ideal in the region. Despite the previously mentioned potentials of the practices, less emphasis is given to them and hence there is scanty information about their roles in the central highlands of Ethiopia. The contribution of these practice to the livelihood of the agrarian community in the region is never addressed. The social and ecological values the practices render to the society have never gained attention and thus remain widely unknown. Its role and contribution as wood source for the farm households is barely known. However, in order to facilitate the advancement of these practices among agrarian communities especially living
nearby remnant forests, showing them the relative advantage and performance of the practices is mandatory by comparing them to the dominant land uses.

The current research bases on the concept that enhancing the onfarm wood production potential of farmers may minimize forest resources depletion and forestland encroachment while improving the livelihood of the society through income generation. At first, this necessitates addressing the extent of the existing problems regarding forest encroachment and its underlying causes, the status and demand of the different forest/wood products among the community and the perception of the community about the scarcity of the forest products and their recommendations to the problem. Secondly, it is important to assess the existing practices of growing woody plants including their features, challenges and prospects, contributions to the livelihood of the society and effect on soil conditions. Thirdly, the existing practices of land resources utilization should be known in order to identify potential areas for woody plants growing. Thematically focusing on these points, the objectives of this dissertation work are:

I. To investigate the interaction between Menagesha Suba state forest and the surrounding community (Paper I)

II. To describe the demands and scarcity gaps of the major forest products (construction wood and fuelwood) in the study community (Paper II and III)

III. To assess the woody plants diversity and possession and their future prospects in the agricultural landscape (Paper IV)

IV. To assess the effects of agroforestry land uses on soil chemical properties compared to cereal farms (Paper V)

V. To investigate the financial attractiveness of agroforestry land uses compared to the dominant cereal farming land use (Paper VI and VII)

VI. To investigate the social and ecological values of agroforestry land uses in comparison to cereal farming land use (Paper VIII)

VII. To preliminarily investigate the potential for wood production by using proper utilization of the available lands (Paper IX).

2 METHODS AND APPROACHES

2.1 Overview of the Research Framework

This research work followed a systematic pattern sketched in Fig. 1 with reference to its thematic scopes. The first section deals with the interaction between the state forest and the surrounding...
community targeting on the identification of the existing challenges regarding the management of the state forest and livelihood improvement of the community in the study area. And hence, it assesses the interaction between the two entities (the forest and the society), effects of the interaction on the state forest, causes of forest encroachment and possible mechanisms to alleviate the problem by considering both the community and the forest with equal views.

![Diagram of Community-state forest interaction]

Figure 1 The main framework of the study

Taking forest products scarcity as one of the major drivers/ causes for forest encroachment, the second part of the research dealt with the availability, demand, current usage and preferred wood types for construction wood and fuelwood—the most important and frequently utilized forest products by the community in the study area.

Under the existing challenges of land shortage especially in central highlands of Ethiopia, agroforestry practices remain the most viable mechanisms by which farmers can supply themselves with wood by producing it on their farm plots. To do so, first it is compulsory to assess the effects, characteristics, potentials and constraints of the already existing practices. Assessing the various attributes of the existing practices has various advantages. For example, it is easy for other farmers to adopt the practices if they are performing well as they can see it
from their neighborhood. Moreover, it costs less when seen in terms of money, time and human resources as compared to introducing new technologies. Additionally, as the community is aware of the constraints of the existing practices, they can easily monitor such challenges in case they appear in the future. Thus, prior focus on existing practices is influential for successful implementation of the practices in the future. That is why this study focused on assessing the different features and characteristics of the existing agroforestry practices. This assessment encompassed four major aspects: 1) the effect of the land uses on soil properties; 2) the woody plants diversity and possession and the future prospects of such small-scale agroforestry practices; 3) the financial attractiveness of the agroforestry land uses relative to the dominant cereal farming land use and; 4) the social and ecological values attributed to agroforestry practices relative to the cereal farming land use.

The subsequent part of the research focused on assessing the existing potentials for wood production within the possession of the farm households taking into account different scenarios of tree growing. This section attempted to identify the potentials of onfarm wood production using agroforestry practices if proper and efficient land use practices are implemented and an inference was made on how much relief this could be to the state forest, which is often encroached due to shortage of forest/wood products.

At the end, a comprehensive summary of the findings and the implications of the study with regards to policy measures and methodological procedures were indicated in order to enhance the application of the findings within the community in the study area.

2.2 Research Strategy

The current research relies on two types of research approaches: qualitative and quantitative assessment. The qualitative research method included case studies and participatory analysis. Case studies were used to assess the interaction between the community and the state forest and in eliciting how the daily activities of the communities interrelate with the state forest development or degradation. This research strategy involved the use of interviews, focus group discussions, direct observation, diaries, expert opinions and discussions with key informants. The ability of the research strategy to accommodate the experiences of the community makes it so appropriate for this type of assessment.

The participatory approach is appropriate when the investigation needs the intense involvement of individuals/groups from the community covered by the study. It is a means of getting detailed information through the heartfelt involvement of the people and the researcher in the investigation being carried out. This approach was used to assess the social and ecological values of the different land uses and to assess the species preferences for different forest
products. The Bao game (Dridiger, 1972) was one of the participatory tools used in the evaluation of the aforementioned values of the land uses.

All other parts of the study were based on a quantitative research approach, which focused on measuring different variables as a means of testing the different hypothesis related to the study. For example, the effects of the land uses on soil properties, the woody plants diversity assessment and the financial analysis of the land uses all relied on the quantitative research approach.

The use of such a multiple research strategy is an attempt to accommodate most of the relevant issues and information that could lead to comprehensive conclusions and recommendations which embrace the diverse and multiple problems existing in the study area. And, the overall analysis bases on the information and data collected using the previously mentioned research strategies.

2.3 Overview of the Field Work

Generally, two data sets were used for this study (minor and major data sets). The minor data set is from the data collected in 2004 during the preliminary assessment of the agroforestry interventions existing in the study area and investigation of the community-state forest interaction. The second and major data set was collected in 2008 (January – May). The focuses of the second data collection activity were: 1) to collect soil samples in different land uses (small-scale woodlots, homesteads, cereal farms and pasturelands); 2) to make a woody plant inventory in different land uses where trees and shrubs are grown; 3) to collect data on species preferences and seedling demands of the community in the study area with an aim to promote agroforestry practices; 4) to collect data on the financial returns of the agroforestry land uses and cereal farms; 5) to assess the social and ecological values of agroforestry land uses and the dominant cereal farming land use.

The major field work was deliberately made during the dry and harvesting period so as to easily collect the data on financial returns of the land uses especially the cereal farming. This timing also made the collection of the soil samples easier as the soil is relatively dry. Such dry season data collection timing also reduces the damage that may be caused by soil sampling in land uses like cereal farms during the growing seasons. This is because crops are often grown during the rainy seasons. More importantly, at this time of the year farmers are relatively free of agricultural workloads and hence are easily available for interviews, discussions and participatory activities.

The field work was conducted by a team comprised of the principal researcher, a graduate researcher (resource economist), experienced interviewers, soil science experts, development agents, and technical assistants. All involved personnel were able to speak the major local
languages (Afan Oromo and Amharic) in order to minimize the effects of language barrier on
data collection.

The detailed procedures for the selection of the sample households, land uses and soil sampling
points and methods are given in the respective papers presented in Section 2.

2.4 The Data Collection: An Interdisciplinary Approach

The data collection was one of the critical steps in conducting the research. Due to the nature of
the current study, it was compulsory to use interdisciplinary data collection procedures. These
procedures involved methods of data acquisition from both the natural science and the social
science aspects. The natural sciences data collection methods were used for assessing: 1) the
effect of the different land uses on soil properties and; 2) the woody species diversity and
possession by the farm households included in the study. The social sciences data collection
methods were used for assessing: 1) the use and demand for different forest products; 2) the
financial analysis of the land uses and; 3) the social and ecological values analysis of the land
uses. The existing situation i.e. the interaction between the community and the state forest, the
current status of the different forest products and the effect of different socioeconomic and
physical factors on forest depletion were all assessed by using both natural and social sciences
data collection approaches. In general, in most cases, combinations of both data collection
approaches were used to achieve the intended objectives (Table 1).
<table>
<thead>
<tr>
<th>The research steps</th>
<th>The respective research themes</th>
<th>Major types of data collected</th>
<th>Data collection method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Assessment of the existing situation</td>
<td>Community-state forest interaction (Paper I)</td>
<td>Temporal change in forest area; Access of the community to the state forest across years; Illegal cutting of trees in the forest area; Identifying conflict indicators; Dependence level of the community on the state forest</td>
<td>Literature review; Field observation; Interview with 12 forest guards; Direct measurement on 14 random forest plots (0.25 ha each); Participatory mapping and access to the forest evaluation with three PRA groups.</td>
</tr>
<tr>
<td>2. Assessment of the current wood usage and demands</td>
<td>Forest/wood products demand and usage assessment (Paper II and III)</td>
<td>Construction wood use, demands and sources; Future prospects of this wood product</td>
<td>Direct measurement of wood use for 24 iron-roofed and 28 thatch-roofed houses; Face-to-face interview and discussion with 10 randomly selected farm household heads; Questionnaire survey with 381 households (96 insiders, 212 border farmers and 73 far outsiders); Field observation</td>
</tr>
<tr>
<td>3. Assessment of the current practices</td>
<td>Onfarm woody plants diversity and possession in agroforestry practices (Paper IV)</td>
<td>Types and number of stems of trees and shrubs grown; Woody species preferences across use types; Future plans for woody species growing; Height, diameter at breast height and diameter at stump height of trees and shrubs grown;</td>
<td>Direct measurement and enumeration on land holdings of 74 farm households</td>
</tr>
<tr>
<td>4. Roles, effects and potentials of agroforestry practices</td>
<td>Effect of agroforestry land uses on soil properties (Paper V)</td>
<td>Soil samples for macro and micro nutrient analysis</td>
<td>Systematic collection of 64 composite soil samples from cereal farms, homesteads, woodlots and pasturelands</td>
</tr>
<tr>
<td></td>
<td>The financial analysis of agroforestry land uses (Paper VI and VII)</td>
<td>Input and output types and their respective quantities for cereal farm operations</td>
<td>Interview-based input-output data collection from 75 cereal farms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input and output types and quantities for three types of agroforestry practices</td>
<td>Interview-based input-output data collection from 82 agroforestry land uses belonging to three major agroforestry types</td>
</tr>
<tr>
<td></td>
<td>The social and ecological values of agroforestry land uses (Paper VIII)</td>
<td>Criteria selection for social and ecological values of land uses; Scores for land uses based on their social and ecological values; Score justifications;</td>
<td>Bao game-based scoring with 91 farm household representatives followed by individual scoring justifications.</td>
</tr>
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2.5 Study Site Selection

This study is carried out in and around Menagesha Suba state forest (Fig 2). Menagesha Suba is selected as the study site for three main reasons. First, as the main aim of the paper is to reveal the role of agroforestry practices as mediating technologies between forest resources conservation and farmers livelihood improvement, it is compulsory to have a community and forest resources adjacent to each other. For this, Menagesha Suba is ideal as the big state forest is under severe encroachment while at the same time the community is facing forest products scarcity and living in poverty.

Figure 2 The relative location of Menagesha Suba in Ethiopia

Second, the existence of supplementary data and outputs from our previous works were basis for the current research, and it is pragmatic and practical to utilize this profound basis rather than finding a new research site. Lastly, I am very familiar and acquainted with the society and the state forest management bureau due to the existing collaborations from previous activities conducted in the area.
3 RESULTS: SUMMARY OF PAPERS

3.1 Paper I: The Community-State Forest Interaction in Menagesha Suba Area, Ethiopia: The Challenges and Possible Solutions

LALISA ALEMAYEHU DUGUMA, HERBERT HAGER and MICHAEL GRUBER


People depend on resources in their area for various purposes. Forests have been the basic resources from which humans have been collecting wood for house construction, fuel, fencing, etc. The level of interaction of a given community with resources in their area determines the future of the resources significantly. For example, if the utilization of the resource exceeds its development, the resource will be at risk. Community – resource interaction is influenced by both internal and external factors. Internal factors are factors within the community that influence the way the community interacts with the resources. Those include: human population increment, poverty and inefficient utilization of the resource. On the other hand, external factors are those factors, which emanate from outside the community but still have a considerable impact on the interaction of a community with the resources nearby. Such factors include policies that change the way the community utilizes the resources and market forces that may add impulse to the illegal extraction of the resources for fulfilling ones ‘greedy’ demands. To advance the proper management and conservation of the resources, it is mandatory to understand the interaction between the community and the resources, the underlying factors behind the different interactions, the existing challenges, and possible solutions. This paper has assessed how the interaction between the community and the nearby Menagesha Suba state forest looks like and what challenges exist and what possible solutions could be recommended.

Data were collected using interviews, participatory rural appraisal, direct counting of illegally cut trees, and personal observation. Secondary data from the forest management office were also used.

The interaction between the community and the state forest is generally negative. Forest encroachment is a major problem in the state forest. The identified underlying factors for the encroachment are: 1) expansion of the state forest into farmers’ lands; 2) use right complexity; 3) forest products scarcity; 4) population increment and increasing wood demand; 5) poverty and; 6) a community unconvinced about the forest management. The findings also indicate that the access of the community to the state forest can be broadly categorized into: legal or illegal access or utilization. Legal access is the access granted from the forest management office workers for the community, while illegal access is entering the state forest for any use without
legal permission. Legal access of the community to the state forest has declined gradually and the illegal access is reaching maximum during changes of the government, which creates a power vacuum, and hence may render the forest to open access for any one to use it.

Involving the community in the forest management programme may be one possible solution to alleviate the encroachment problem but the potential of the forest to fulfill the demands of the large human population dwelling in and around should be considered carefully. Moreover, there is a need for multidisciplinary programmes to support and fortify forest management to resist the pressures rising from the rural economy, e.g. the need to use the forest for household purposes and income generation.

3.2 Paper II: Consumption and Species Preference for House Construction Wood in Central Highlands of Ethiopia - Implications for Enhancing Tree Growing

LALISA ALEMAYEHU DUGUMA and HERBERT HAGER


Housing is one of the basic necessities of human beings. In Ethiopia, the majority of houses are built from wood. Despite this fact, forests and tree cover in the agricultural landscapes are sharply declining especially in densely populated areas like the central highlands of Ethiopia. Hence, the supply sources for house construction wood are diminishing gradually. In order to design mechanisms for the improvement of these forest product sources, it is important to know the current utilization patterns (sources, availability and future prospects) and the species preferences among the society. The current study has focused on the aforementioned aspects in the community living in and around Menagesha Suba state forest.

Data on amount, type of wood, tree species used, top and bottom diameter, height and sources of the wood were collected from twenty-four iron-roofed houses and twenty-eight thatch-roofed houses belonging to thirty-six farm households. The farm households were classified into three wealth categories (poor, medium and rich) with the help of local authorities using criteria like land holding, livestock size and house type. The information about the species preferences for the different woody components of a house were obtained by interviewing the household head or involved members of the household. At the end of the data collection, ten farmers were randomly selected from the surrounding and discussions were held concerning the type of construction wood, the variability in consumption among farmers and within house types and their future perspectives on construction wood under the prevailing severe deforestation.
It was found that the average house floor space owned by a farm household is 57 m² with average wood consumption of 13.7 m³. The floor space and wood consumption of a house depend on the type of the house. An iron-roofed house has an average floor space of 51.9 m² consuming 16.8 m³ wood and the thatch-roofed house has a mean floor space of 28.6 m² consuming 3.2 m³ wood. Family size, wealth status, and floor space were the major factors influencing wood consumption. The wealthier the household is the bigger the floor space and the construction wood consumption are. An average living house was composed of 39.3% Juniperus procera, 5.6% Cupressus lusitanica, 29.2% Eucalyptus globulus and 26% Eucalyptus camaldulensis woods. The first two species and half the volume of the third species were obtained from the state forest while the rest was from onfarm tree growing practices, purchase and illegal cutting. However, the state forest has banned any extraction of construction wood and hence around 59.2% of the supply does not exist anymore.

To minimize the scarcity arising from the supply reduction, it may be necessary to enhance tree planting programmes in the agricultural landscapes. For example, use of abandoned lands for tree growing, promotion of agroforestry practices on private lands and establishment of community silvopasture could be important actions worth considering. Moreover, the use of local materials like soil bricks should be encouraged.

3.3 Paper III: Fuelwood Use and Its Implications on Food Crop Production and Nutrient Transport from Forests in Central Ethiopia

LALISA ALEMAYEHU DUGUMA and HERBERT HAGER

Submitted to Biomass and Bioenergy

Fuelwood is the basic cooking and heating energy material in Ethiopia (Bekele and Berhanu, 2001). It is used by 71.4% of the country’s population as the sole and major energy source. This is also due to the low availability of alternative energy sources like electricity and solar energy (Wolde-Ghiorgis, 2002). Despite such dependence, there is a severe deforestation in the country due to the conversion of forests to agricultural land, illegal exploitations, and increasing demand for forest products due to human population increment. This gradual decline of forest cover (the major source of fuelwood) is forcing farmers to use cattle dung in central highlands of Ethiopia.

The consumption of fuelwood and cattle dung has far-reaching implications on nutrient export from forest ecosystems and on crop production within individual farm plots. As fuelwood mostly comes from forests, there are enormous amounts of nutrients transported from the forest to the farms and latter on to the fields. This may damage the growing niches of the tree and shrub
seedlings in the forest ecosystem as the wood and small branches (which after decomposing would enrich the soil) are taken away. This hampers the forest development and thus expected to have a considerable impact on the forest ecosystem dynamics in general. Moreover, the use of cattle dung for fuel, which otherwise would have been used for enhancing the fertility of the soil, has also a crucial impact on the society’s food self-sufficiency. Thus, it is important to assess the consumption, sources, and impacts of fuelwood use on the livelihood of the community at large. This study has tried to assess the consumption properties of fuelwood and cattle dung in communities living in Menagesha Suba area. It also explored the implications of the consumption on food crop production and nutrient export from forest ecosystems.

Data were collected using questionnaire surveys and key informant interviews supplemented by nutrient analyses of wood and cattle dung samples. The farm households were clustered according to distance from the state forest. The interview covered 381 farm households (96 insider farmers, 212 border farmers and 73 far outsider farmers). Males and females were alternatively interviewed from the respectively selected households to control the gender balance. However, when the required gender was not available, any member of the household older than 18 years was used as respondent.

The results indicated that with increasing distance from the state forest, the reliance of the households on the state forest for fuelwood declines while the reliance on trees and shrubs grown on the farms increases. This is mainly due to the long distance to be traveled for getting the fuelwood from the state forest. The findings also show that with increasing distance from the state forest, fuelwood consumption decreased while cattle dung consumption increased. Of the fuelwood demands of a household, only 35% is fulfilled on average. Cheng et al. (1998) also showed that due to the scarcity, people (especially women) are walking around six hours to collect fuelwood in Ethiopia.

Annually, 1.2x10^6 kg of fuelwood containing 1.4x10^5 kg N, 6.1x10^5 kg C, 39.44 kg Al, 2x10^5 kg Ca, 3.33 kg Cu, 131.5 kg Fe, 766.5 kg K, 130.9 kg Mg, 92.07 kg Na, 50.57 kg P, 131.06 kg S and 8.17x10^4 kg Zn was extracted from the state forest and 3.22x10^5 kg cattle dung containing 6.14x10^3 N and 1.1x10^3 Kg P was burnt annually by the studied households. The nutrients contained in the burnt dung could potentially produce 4.2x10^4 or 5.9x10^4 kg of wheat or maize respectively, which could fulfill the annual cereal demand of 39 or 55 households with the respective crops.

Generally, fuelwood scarcity is beyond the energy issue itself, having direct impacts on food self-sufficiency and nutrient transport from forest ecosystems. Hence, alleviating fuelwood scarcity problem should get priority in the development programs conducted in the study area for promoting food crop production and enhancing the development of the nearby forest. One
potential mechanism to do so may be using agroforestry practices, i.e., enhancing woody plants growing on farmers fields and unused lands.

### 3.4 Paper IV: Woody Plants Diversity and Possession, and Their Future Prospects in Small-Scale Tree and Shrub Growing in Agricultural Landscapes in Central Highlands of Ethiopia

**LALISA ALEMAYEHU DUGUMA and HERBERT HAGER**


Farmers grow different types of trees and shrubs for various purposes. Though their main intention is geared towards supplying their households with various wood products and services, such woody plants growing practices also play a vital role in the conservation of the genetic resources of the grown plants. Especially in countries like Ethiopia, where deforestation is the major threat to the conservation of biodiversity, agricultural landscapes where such onfarm tree and shrub growing activities are practiced have a crucial importance for such conservation. Assessing the various diversity indices of the existing woody plants, i.e., their amount, density, frequency and species diversity play a vital role in eliciting the potential of such practices for supplying the demanded products and services for the community and for the conservation of the genetic resources of the diverse woody plants. The assessment of the future prospects of the onfarm woody plants growing is also equally necessary as it shows how the future trends of this practice look like and what constraints and opportunities exist associated with it. Altogether, such assessments contribute to enhancing the growing of woody plants in agricultural landscapes.

Woody plant diversity and possession in small-scale tree and shrub growing practices among farmers of central highland Ethiopia were assessed by using a complete census of the trees and shrubs existing on farmers’ lands. Additionally, the future prospects of diversity and possession of the woody plants in the agricultural landscapes were also investigated by using the farmers’ species preferences and seedling demands as indicators. Comparisons were made across wealth classes, land uses and proximity clusters to a nearby state forest. The diameter at breast height, height, species, growing niche, primary and secondary uses of all trees and shrubs grown by the farm households were recorded. In addition, the seedling demands for the various species and the species preferences for the various uses of woody plants were assessed by using a questionnaire-based interview with the household heads. The assessment was conducted on holdings of 74 farm households.
It was found that 27 tree and 21 shrub species exist on lands possessed by the studied households. With increasing wealth status of the households, the tree and shrub species richnesses increased. Tree and shrub species richnesses were highest in boundary plantings and homesteads respectively. Small-scale woodlots had the highest number of tree stems while homesteads contained the highest number of shrub stems. The number of tree stems households possess is strongly influenced by distance from the state forest, family size, educational level of the household head and number of iron-roofed houses owned. In addition, the possession of shrub stems is significantly influenced by wealth status, distance from the state forest, land holding size, family size, livestock holding, age of wife and possession of off-farm income sources.

The species preference analysis and seedling demand computations indicated that the woody species diversity is less likely to change in the future because there is no difference between the currently existing species and the preferred ones. Nonetheless, the number of tree and shrub stems on the farmers’ holdings could increase if the seedling demands of the preferred woody species are met.

3.5 Paper V: Effects of Land Use Types on Soil Chemical Properties in Smallholder Farms of Central Highland Ethiopia

LALISA ALEMAYEHU DUGUMA, HERBERT HAGER and MONIKA SIEGHARDT


Different land uses influence soil properties differently depending on the management type and the components harbored in them. The management practices undertaken are also influenced by the managers. Though in most cases, knowledge about the effects of different land uses under various management regimes are available, there is still a deficit of knowledge about the influence of land uses managed solely by smallholder farmers. Despite this gap, such knowledge is crucially important for promotion of land uses, which may improve the soil properties within the rural landscapes. Such knowledge is also very helpful in land use planning and sustainable land resources management. It is due to these important aspects that this study made an emphasis on comparing different land uses in relation to their effects on soil chemical properties. The paper focused on the soil chemical properties because soils in the central highlands of Ethiopia are severely degraded due to the intensive extractive utilization of the resource for a long period. Hence, there is a deficit of the very essential nutrient elements (e.g. N, P, and K) for plants growth urging farmers to use inorganic fertilizers like DAP and Urea as growth promoters. Therefore, it is crucial to look at land uses that promote the accumulation and pumping up of such soil elements for improving the soil properties to enhance the agricultural productivity and
thereby improve the livelihood of the agrarian community. The main goal of the paper is to see whether agroforestry land uses really have a significant effect on soil chemical properties compared to the cereal farms under farmers’ management. This study assessed the effects of homesteads, small-scale woodlots, pasturelands, and cereal farms on soil chemical properties and investigated their relative soil improvement effects under farmers’ management.

Soil samples were collected at two depth levels (0–15 cm and 15–30 cm) from four land uses. At every sampling plot, soil samples were collected from five spots (north, south, east, west and center of the plot) within the land use and composite samples were prepared by hand-mixing according to the depth strata. Totally, there were 64 composite soil samples. The samples were weighed and air-dried for four days at ~23 °C. Soil samples were sifted through a 2-mm sieve and ~200 g of every composite samples was packed in a plastic bag and transported to Vienna, Austria for laboratory analysis at the Institute of Forest Ecology, University of Natural Resources and Life Sciences. The samples were analyzed following standard laboratory procedures as detailed in Section 2 (Paper V). The comparison of the land uses was done using the Relative Soil Improvement Index (RSII). This index compares the different land uses in relation to the dominantly practiced land use and it elicits how much the different land uses improve the soil properties relative to the dominant one.

The results showed that pH (H₂O), organic C, total N, exchangeable K⁺ and exchangeable Na⁺ showed significant differences across land uses (\(p < 0.05\)) while only organic C, total N and Mg²⁺ concentration had also significant difference across depth (\(p < 0.05\)). The soil organic C, total N, exchangeable K⁺ followed a trend of homesteads > small-scale woodlots > pasturelands > cereal farms. The RSII computation showed that homesteads (RSII = 332.02%) and small-scale woodlots (RSII = 197.56%) are very rich in soil organic C, total N, total P and exchangeable K⁺, which may be due to the management effect through input of degradable materials and nutrient pumping of woody species from deeper soil horizons (especially for K⁺). Cereal farms and pasturelands showed no difference in RSII which might be due to the effects of nutrient removal through cereal crops and through grazing in the latter.

This study has shown that agroforestry land uses are superior to other land uses and lead to improvement of some soil chemical properties. Thus, it is wise and practical to consider the expansion and promotion of such land uses to enhance the production potential of the available land and facilitate sustainable land management for optimal production of wood and food for the farm households. Moreover, practices like crop residue management and pasture improvement using legumes should be in place in addition to the use of the agroforestry practices.
3.6 Paper VI: The Financial Return of Cereal Farming for Smallholder Farmers in Central Highlands of Ethiopia

LALISA ALEMAYEHU DUGUMA, IKA DARNHOFER and HERBERT HAGER


Ethiopia’s economy mainly relies on agriculture and is the major economic activity of over 85% of the country’s population. It has a 53% share of the GDP and contributes around 90% of the export earning (Bekele, 2001). Cereal farming is the most dominant agricultural practice especially in the highlands of the country. Despite the dominance of the practice and its significant contribution to the nation’s economy, agricultural activities in Ethiopia are characterized by their traditionality (Shiferaw and Holden, 1999) and hence low productivity (Adenew, 2004). The low productivity is also exacerbated by soil erosion, intensive cultivation without fallowing and the lack of proper soil conservation practices. Hence, the potential of the practice to support the sharply increasing human population is declining; finally resulting in food insecurity for the large proportion of the population.

Various studies have given attention to the productivity of agricultural practices, e.g. Demeke et al. (1998) and Holden et al. (2001) though little is known about the net returns of this practice for the farm households. Assessing the net return helps to know whether the farmers are really getting a positive return or are practicing it because of lack of alternative livelihood options in their area. It also helps to know the potentials and constraints associated with the practice regarding its financial returns for the farm households. In this specific area, i.e., Menagesha Suba, the current study was conducted in an effort to assess whether or not cereal farm land use is financially attractive for the farmers relative to the agroforestry practices (Paper VII). The aim of this study was to assess the net return, land and labor productivity and the return to scale of cereal farming practice among smallholder farmers in Menagesha Suba area.

Seventy-five farm households belonging to three wealth classes (poor, medium and rich) were randomly selected and interviewed for inputs and outputs related to cereal farming for the production year 2007/2008. First, the relevant information was put down in a data sheet, which was then pretested with nine randomly selected household heads, to check whether the data sheet comprised all the input and output items familiar to them and existent in their area. At the end, a group discussion was held with 15 farmers to check the production status of the year under consideration, i.e., whether the production was poor, optimal or very good. Farm soil properties were investigated to check the variability in soil quality among the wealth classes. Benefit: cost ratio (BCR), net returns and annual profit were used to indicate the worthiness of the cereal farming activity. The return to scale was estimated by using the Cobb-Douglas
production function. A sensitivity analysis was also conducted using changes in inorganic fertilizer prices and rise in input and output values.

The study showed that the major input items to cereal farming with their decreasing share of the total input cost are labor cost > seed cost > draught power cost > fertilizer cost > land tax > herbicide costs. The major outputs were grain, straw and green feed in decreasing order of their total output share. It is found out that cereal farming is a rewarding practice (BCR = 1.21; average net return = 463.45 ETB ha\(^{-1}\) yr\(^{-1}\)), with the rich households getting more profit than the poor ones mainly due to the decline in the per unit area costs of production with increasing farmland possession. Farm size was the most important variable that affects the net return. Land productivity has declined while labor productivity increased with increasing wealth status of the households. Cereal farming in Menagesha Suba area has an increasing return to scale. However, due to farmland shortage, it is less likely to implement it in practice. The sensitivity analysis has indicated that proper supply of mineral fertilizers at the farm gates has a vital effect on the net return farmers gain. A 25% reduction in mineral fertilizer costs at the farm gates (if proper administrative and technical measures are implemented for the supply of mineral fertilizers at the farm gates) results in a 25.67% increase in the net return for the farmers.

In general, it is imperative to give attention to minimizing the costs of production through proper regulation of domestic mineral fertilizer costs and increasing labor productivity especially for the poor and medium households. The use of manure and compost as additional fertilizers should also be made more popular.

### 3.7 Paper VII: Financial Analysis of Agroforestry Land Uses and Its Implications for Smallholder Farmers Livelihood Improvement in Ethiopia

LALISA ALEMAYEHU DUGUMA

Submitted to Agroforestry Systems (Under review)

Income generation from agroforestry practices was of less priority among farmers in former times due to the sufficient availability of both wood and non-wood tree products. The basic focus was on local consumption as there was only a small market for wood products due to the minor demand for these products. But with the wide spread deforestation taking place in the country, there is a scarcity of wood products and hence, the market values of the outputs of the agroforestry practices are increasing. These days, the financial contributions of the outputs of the agroforestry land uses are attaining extraordinary attention by the farmers because of: 1) the increasing market demand for the products of the land uses and, 2) the increasing demand of
income resources by the farm households’ to supply and maintain the their basic necessities (especially food and wood). However, the financial analysis of such farmer-managed land uses has little attention in Ethiopia. Hence, it is vital to conduct the financial analysis of the agroforestry practices to show farmers the relatively realistic estimates of what the land uses can produce and whether it will be profitable for them to implement such practices.

Franzel et al. (2001) state that profitability is one of the determinants for the potential adoptions of agroforestry practices; hence, focus should be given to it in agroforestry researches. Mercer and Miller (1998) also indicated that improved cost-benefit and profitability analyses are some of the future priorities of socioeconomic research on agroforestry practices. Nair (1998) also states that proper economic evaluation of agroforestry practices was the least priority research area in the 1990s but stressed that now there is a need for the appropriate assessment of the economic, social and environmental costs and benefits of these practices. The current study assessed the profitability of practicing agroforestry land uses and the associated challenges and opportunities for the promotion of the land uses. Moreover, the study tried to evaluate the impact of implementing these practices on farmers’ livelihoods.

The assessed agroforestry practices include small-scale woodlot, homestead tree and shrub growing and boundary tree and shrub growing. Eighty-two parcels of different land uses (21 small-scale woodlots, 35 homesteads and 26 boundary plantings), which were older than 15 years and established by the current owner, were selected for the financial analysis. The input and output data were filled in a data sheet by face-to-face interview with the owner. The financial performance was based on benefit-cost ratio (BCR), net present value (NPV), equivalent annual income and aggregate compounded costs of the land uses.

The results showed that all the agroforestry practices have a very high and positive NPV, which indicates their financial attractiveness. And also, the BCR analysis showed that small-scale woodlot is the most attractive agroforestry practice followed by boundary plantings and homesteads with respective BCR of 16.95, 9.44 and 2.54 at 10% interest rate. An *ex-ante* analysis of implementing the agroforestry practices showed that with minimum land area allocated for these practices, a household can generate net discounted revenues ranging from 5908–26021 ETB (532–2342 USD) in 15 years at 10% interest rate. Hence, the expansion of such agroforestry practices could have vital effects on farm household’s income. Lack of proper planning and in-depth understanding about the roles of trees and shrubs for household income, land and seedling shortage, financial constraints and labor scarcity were identified as major problems for the expansion of agroforestry practices in the area. A thorough extension service comprising both efficient land resources utilization and proper planning practices could enhance the expansion of agroforestry practices and thereby positively influence the farmer’s livelihood.
Human well-being depends on the goods, functions and services provided by the ecosystems they live closely or in (Millennium Ecosystem Assessment, 2005; Ranganathan et al., 2008). The level of such contributions of ecosystems to human well-being in the tropics and subtropics depends on the land use behavior of the community, as changes in land uses directly influence the outputs (products and/or services) expected from the ecosystem. Land uses, like other ecosystems, provide multiple benefits, which can be broadly categorized into economic, ecological, and social (De Groot et al., 2002; Pagiola et al., 2004). Various land uses provide either of the benefits to varying degrees depending on characteristics of plants growing on them and the management activities that take place in them. In an agrarian community largely dependent on the products of the land (e.g. Ethiopian farmers), the three major benefits have their own positions in the livelihood of the community. However, often attention is only given to the economic aspects and hence there is scanty knowledge about the social and ecological values of land uses. Pagiola et al. (2004) state that ecosystem benefits are widely recognized but poorly understood. Moreover, Millennium Ecosystem Assessment (2005) also indicates that most management decisions regarding natural resources are made based on goods from the resources that enter into the market and hence the non-marketable services and functions are often overlooked and gradually degraded. For a community facing multiple challenges (economic and environmental problems), a land use that tackles only a single problem is most likely to be of less importance. Hence, not only the economic merits of land uses matter but also do the ecological and social services.

Not all services and values of a land use can be easily assessed (e.g. social values and some ecological values) while being very important in decision-making processes. For such values and services, Lette and de Boo (2002) recommend the use of multi-criteria approaches in order to elicit the underlying values. The implementation of this approach in a participatory way will further increase the validity of the results as most of the intangible values of a land use are in the minds of the farmers, i.e., can not be easily known by other methods like measurement or experimentation. Thus, participatory approaches have a critical importance in assessing the social and ecological values of land uses because the community is the one that knows more about the benefits they get or expect from a land use they want to implement (see Cleaver
[1999] for the detailed views on participatory approaches). Moreover, the participation of the farmers is mandatory as the social and ecological values of land uses are influenced by the socioeconomic and environmental conditions of the area. On the other hand, the social values of land uses cannot be precisely known if the farmers do not express it because social values are mostly determined by the way one perceives about it. Thus, such values can have a high degree of variation from one farmer to another depending on their social status, economic level, and religious believes. Hence, for such assessments, in order to get results that are more reliable, approaches in which the farmers can easily participate and evaluate the land uses are mandatory.

The current study, using a participatory tool called the bao game, assessed the social and ecological values of four land uses (small-scale woodlot [SSW], boundary tree and shrub planting [BTP], homestead tree and shrub growing [HTG] and cereal farming [CF]) existing in Menagesha Suba area, central highlands of Ethiopia. Concurrently, the effects of local wealth status and proximity to a nearby state forest on the social and ecological values of the four land uses were also examined.

For each of the social and ecological values, five comparison criteria were selected by the farmers. For each of the selected criteria farmers gave values on a scale of 0–10, where 0 designates the smallest value and 10 representing the maximum value. The scores were treated as quantitative and analyzed using descriptive statistics, cross-tabulation, and ANOVA. Every farmer did the scoring independently. Totally, 74 farmers took part in the participatory evaluation.

The results indicate that agroforestry practices are superiorly preferred both for the social and ecological values compared to the dominant cereal farms. Among the agroforestry practices, HTG was strongly preferred for both values of land uses but no big difference was observed between HTG and SSW. The social and ecological values of the agroforestry land uses generally decreased with increasing household wealth status though significant decrease was only observed for SSW. Distance from the state forest failed to affect the scorings for the ecological values of the land uses while it considerably affected the scorings for the social values of land uses. It was also observed that most ecological values explanations are matching the scientific reports from various studies, and thus, indicating an in-depth understanding of farmers about such values. This study also shows that the social and ecological values of land uses have a vital role in farmer’s decision-making on implementing and managing land uses besides their financial return. Thus, it is worthy to consider such values during land use evaluation studies for a holistic understanding of the associated values. The strong preference for tree and shrub-based land uses has a positive implication for enhancing the cultivation of woody plants in the agricultural landscapes.
3.9 Paper IX: The Potential for Woody Biomass Production for Rural Households with Efficient Land Resources Utilization in Menagesha Suba Area

LALISA ALEMAYEHU DUGUMA and HERBERT HAGER

Submitted to Journal of Sustainable Development in Africa (Under review)

Previous studies showed that forest products scarcity is one of the major reasons for forest depletion in the central highlands of Ethiopia. This paper tries to address the efficient utilization of available land resources as a means of providing forest products for the rural community to lessen the exploitation of the remnant natural forests. The study was conducted in central highlands of Ethiopia where a remnant 3530 ha Juniperus - Podocarpus dominated Menagesha Suba state forest exists.

Eighty-one farmers belonging to three wealth classes (poor, medium and rich) were randomly selected and the land holding and land use sizes were assessed using interview and field verifications. In assessing the size of land holding, attention was given to the lands which are currently not used and which could be potentially used for growing woody plants without competing with the farm land use of the households. Four scenarios (no action [Scenario A], growing Eucalyptus globulus [Scenario B], growing Eucalyptus saligna [Scenario C], and growing Grevillea robusta as an agroforestry technology [Scenario D]), which could be applied on the inefficiently used lands were hypothetically developed and compared for their wood production potential by using the mean annual increment of the respective tree species.

Almost all households included in the study own cereal land and a homestead. But the number of farmers owning private pasturelands and small-scale woodlots declined with decreasing wealth status of the household. This is because the poor and medium households focus on producing their food rather than other options like grazing areas or woodlots. The results also showed that Scenario B and C have a potential to provide 20.5 – 61.6 and 69.9 m³ wood respectively in 7 years time, which is around five times the average construction wood demand of a household every two decades. This study shows that there could be a great local potential mobilized to grow trees on farms and to minimize the depletion of the remnant forests of the country. Thus, such potentials should be considered in future efforts to reduce the exploitation of the remnant forests due to forest products scarcity.

Hence, this study shows that there is still a possibility for increasing forest products supply even in the densely populated highlands of Ethiopia if the available land resources are thoroughly
explored and used efficiently. If implemented, such onfarm wood production potentials may reduce the pressure on the nearby remnant forests.

4 GENERAL SUMMARY

Forest encroachment in Menagesha Suba state forest is due to scarcity of forest products, poverty, unconvincing forest management style implemented in the area and the subsequent expansion of the state forest into the lands of the farmers (Paper I). The possible solutions could be designing proper management options, involving the community into the state forest and enhancing onfarm woody biomass growing. The subsequent parts of this work showed that there is a severe scarcity of forest products especially construction wood and fuelwood (Paper II, III). For this, the best solution recommended by the community was growing different trees and shrubs that could subsidize the forest products supply to minimize the scale of the problem (Duguma and Hager, 2009). Meanwhile, the prevailing land shortage problem poses a great challenge to advance the growing of woody biomass on a wider scale (Paper IV). Thus, the most feasible option identified could be the wide spread application of agroforestry practices which would lead to a compromise in the competition of land uses for cultivation of cereals or woody species.

As indicated in Table 2, the performances and preferences for agroforestry practices always exceeded that of the cereal farming for the four evaluation criteria used. This study clearly demonstrated that agroforestry practices could have an overriding potential in providing forest products for the farm households by efficiently utilizing the available land resources. This forest products provision potential from within the farm plots may relieve the remnant forest from being encroached severely. Hence, expanding these practices may have crucial implications for the management of the nearby state forest. These practices also have exceedingly high financial returns, which could minimize the financial constraints of the farm households in Menagesha Suba area where poor livelihood is one of the major causes of forest encroachment (Paper VI, VII). Agroforestry practices were also strongly preferred for the social and ecological values they provide (Paper VIII). Moreover, agroforestry practices had significant positive effects on soil chemical properties; especially organic carbon, nitrogen, phosphorus, and potassium were drastically high under agroforestry practices compared to other land uses (Paper V). The high concentration of these nutrients in agroforestry practices is vitally important, as most soils in the highlands of Ethiopia are deficient of the aforementioned nutrients. In general, the performances and preferences of agroforestry practices exceeded that of other land uses practiced by smallholder farmers in Menagesha Suba area.
Table 2 A rank-based comparison of the agroforestry practices and conventional cereal farming by using the analysis results reported in Paper V, VI, VII and VIII

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<th>Cereal land use</th>
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<td>Soil improvement</td>
<td>2</td>
<td>1</td>
</tr>
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Thus, the multifunctional characteristics of agroforestry practices may make them optional approaches to minimize the various problems faced by the community in managing the land resources of their area. The contributions of the practices have also shown that they may be good approaches to handle both the human and forest resources at the same time. This could be a new perspective in forest management schemes in the country whereby the management of the forest resources should not only focus on the area under forest cover. This implies that it may be necessary for forest management to go offsite (i.e., outside the forest area) too by using practices like agroforestry and at the same time helping farmers to promote and practice it. Thus, in addition to other schemes of forest management like PFM, community forestry, etc. advancing agroforestry practices among the smallholder farmers should be included as a mechanism of reducing forest encroachment and improving the livelihood of the community living in and around the remnant forest resources. This could strengthen the efforts being made to save, conserve and develop the very small forest resources of the country.

Though agroforestry practices are such rewarding practices, their establishment and expansion within the community is very low due to various bottlenecks. The prominent problem identified by many farmers was the lack of proper planning for tree and shrub growing and the poor in-depth knowledge about the values of such perennial components of a land use for the farm household’s income. The second major constraint identified was land shortage, which the farmers explained in terms of competition for land against cereal farms. Financial constraints (for the purchase of seedlings and payment for the daily laborers for households with labor shortage), tree and shrub seedling shortages and labor force scarcity were also listed among the major bottlenecks for the expansion of agroforestry practices within the community.
5 IMPLICATIONS OF THE STUDY

5.1 Policy Implications

The approach and the findings of this study have some important implications for forest management and rural development especially in communities where poverty and forest products scarcity are prominent problems. From its approach point of view, this study is based on the premises that forest management (and conservation) should seriously take into account the livelihood of the society in and near the resource. Hence, forest management under such socioeconomic preconditions like in the Menagesha Suba area should be more of a holistic management (where humans, i.e., the society and the concerned ecosystem are integral components of the management planning) rather than a forest-centered conservationists approach.

Moreover, this study has explicitly indicated that off-site resource management interventions could have a significant effect for the forest resource conservation. That is, enhancing the supply of the demanded forest products may result in significant contributions by relieving the forest from unplanned utilizations and illegal exploitations for extraction of forest products. Hence, this concept of potential off-site resource management interventions should be given a due consideration comparable to the on-site resource management and development activities. This is because resources (especially remnant forests in developing countries) are under stress due to illegal interventions from the community excluded from the resource management plans.

Beyond its contribution for nearby forest resources conservation, this study has proved that agroforestry practices—even under poorly developed conditions—may have a very significant income generation potential and soil improvement effect besides the high preference among the farming community for their ecological and social roles. For these reasons, such practices should be promoted in regions with favourable agroclimatic conditions and should be given priority within rural development strategies and natural resources conservation effects.

Based on the proven outcomes in this study, it can be argued that agroforestry should come onto the agenda for livelihood improvement, forest resources conservation and land resources management. Hence, policy-makers, decision-makers, and all other relevant stakeholders should give due attention to this practice as a tool to foster the development of the local community and to enhance the conservation of land resources such as soil, forest, water and associated biota. Failure to do so may result in: a) further degradation of the forest resources due to encroachment because of demand for forest products and income generation; b) aggravated soil degradation which the perennials in agroforestry practices could have mitigated; c) the prevalence of poverty in the local community due to the omission of these practices.
Especially in rural Ethiopia, where infrastructural development is poor, there is a need to consider these tools for integrated management of the natural resources on which the community relies extensively for daily demands.

The major bottlenecks identified for the establishment and expansion of agroforestry practices among the community also require some policy measures. For example, there is a need to provide proper extension services to the farmers to combat the lack of detailed knowledge about the roles and functions of the perennials for the household economy. At the same time, this can also promote proper land use in the society in order to fulfill the various demands of the households. To address the problem of lack of proper tree and shrub seedlings, focus should be put on extension programmes and participatory means for assessment of the preferred perennial plants by the farmers and on the creation of nursery capacities and pertaining practices. To encourage farmers to grow more such perennial plants, it is also necessary for the government to consider some incentives for those who are interested in planting trees and shrubs. Such incentives may involve the provision of the preferred tree and shrub seedlings with reduced prices at the farm gates. It is also possible to encourage the farmers by making the lands grown with perennials exempt from land tax.

5.2 Methodological Implications

This study has two basic methodologically innovative outcomes: 1) the use of the bao game as a tool for the valuation of the social and ecological values of the land uses is a recent and easy-to-use method. This tool is familiar to the farmers and thus helps to have a good valuation results especially for comparison of different land uses. This has also minimized the predominantly existent challenge in getting the necessary information from farmers in participatory studies. Moreover, in this study, during the evaluation of the social and ecological values of land uses, the scoring tasks were accompanied by justifications, which help to understand the underlying reasons for the valuations of the land uses by the farmers. This, at the same time, helps to know the existing local knowledge regarding the assessed values by the farmers. 2) In the analysis of impacts of land uses on soil properties, we used a new index, the Relative Soil Improvement Index (RSII), which compares the alternative land uses with the dominantly practiced ones. Today time and situation are enforcing the study of land uses practices which have positive effects on soil properties while providing the services demanded by the society dwelling on the land. This requires the appropriate methods of evaluation which fit to the prevailing local situation. In developing countries—especially those having high human and livestock populations in the agricultural landscapes—the speed of degradation of the natural ecosystems (e.g. natural forests) is very high. In some places like the central highlands of Ethiopia, the woodlands cover less than 5% of the land area. Hence, it is less likely to use the estimator Soil Deterioration Index (SDI) (Adejuwon and Ekanade, 1988; Islam and Weil, 2000) which compares
the effects of different land uses on soil properties relative to adjacent woodlands. But due to deforestation, especially in highly populated agricultural landscapes, it is hardly possible to find the undisturbed ideal land use types (e.g. natural forests). In RSII, comparison is made against the dominantly practiced land use type rather than using the undisturbed 'ideal' land use as in SDI. Therefore, to avail a useful information for proper land use planning in the study area, it was vital to capitalize on RSII to show the relative importance of the rarely practiced land uses (e.g. agroforestry practices) as compared to the predominant cereal farms.

5.3 Some Ideas for Further Research

The basic concern in most forestry related activities is how to handle the short-term demands of the society until the practice begins to supply a product and/or generate an income for the farm households. The same is true in the case of agroforestry practices. This study revealed that agroforestry practices perform very well and are also highly preferred relative to the dominant cereal farms. Even if it is so, the knowledge about proportional allocation of land for the agroforestry practices and the cereal farms is mandatory and this information is still not addressed. Hence, this issue has to be researched further in order to determine the scale at which agroforestry expansion should take place in the community. On the other hand, even if the performance of the agroforestry practices is superior (as shown in this study), the practical action of the farmers in implementing their decision is also one essential point to be addressed. Other points to address may include: 1) how the price of forest products is influenced if agroforestry practices commence to expand in the society and, 2) how the probable forest products price fluctuation may influence the income generation potential of the agroforestry practices.

6 REFERENCES


SECTION 2: PAPERS