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In many areas of the developing world, the continued overexploiting forest resources has the potential to have significant detrimental impacts be placed on sustainable forest management (SFM) can help communities and organizations responsibly manage and utilize the remaining forests over the long term. Ethiopia's forest lands provide tangible benefits from wood fiber production, non-timber products, and intangibles products like soil and water resources. Current practices and uses must be adjusted in order to meet the basic needs of the people and land today and into the future. Timber harvesting operations have not been adequately documented and therefore movement towards SFM is is lagging.

Data was collected to report the baseline information on timber harvesting in Ethiopia, including harvesting locations and organizations in both the natural forest of the southwestern regions and the plantation regions of the Rift Valley area. The overview establishes both the activities included in the harvesting process, but also the broader social, economic, and environmental context of the operations.

This overview of harvesting was used to help develop a decision framework to support decision making in the area of harvesting improvements that

can help lead to SFM. The decision framework utilizes participatory data collection and coding processes that establishes a ranking of activities that can then be implemented on the ground. The issues surrounding harvesting are funneled down into solution categories that cover areas such as planning, tools and equipment, research, social programs, extension and training, and political change. Implementation of this decision framework on forest sites in Ethiopia identified potential adjustments to current operations and illustrated some of the challenges and accomplishments of the different forest areas and different managing organizations.

A Decision Framework for The Implementation of Appropriate Logging Practices in Developing Countries: Case Study -- Ethiopia

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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CONTRIBUTION OF AUTHORS

Dr. Loren Kellogg has provided significant guidance throughout the overall project and has assisted with design and review of the research and reporting presented in this dissertation.

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1.0 INTRODUCTION

"Sustainable forest management aims to ensure that the goods and services derived from the forest meet present-day needs while at the same time securing their continued availability and contribution to long-term development" (FAO 2007).

Timber harvesting is one of the tools that can be implemented to work towards sustainable forest management (SFM). Although harvests that are not well planned or organized, may lead to deforestation, land conversion, erosion, and other impacts unfavorable to SFM. These concerns are of critical importance in many developing countries where there are often fewer controls on forest usage and a closer dependence by local people on a wide variety of wood and non-wood resources. As a case-study example, the country of Ethiopia faces many of these issues that require new approaches to integrate logging practices into SFM.

Ethiopia is a large impoverished country in East Africa. It is surrounded by Somalia and Djibouti to the east, by Eritrea and Sudan to the north and west, and by Kenya to the south. In the early 1900's, forest coverage there was said to be at least 40% (Abate 2004; Tadege 2001). While the accuracy of that reported level is debatable (Nyssen et al. 2004); more recent estimates are significantly smaller -- 5.6% of the land area and projected losses of up to 200,000 ha per year (EFAP

1994). Regardless of the exact percentages, it is clear that forested lands in Ethiopia are shrinking, with real consequences for that country and its people.

The forests of Ethiopia provide significant benefits to its citizens. Rural villagers depend on these resources for sustenance, fuel, shelter, livestock grazing, and minor forest products, while urban Ethiopians receive building and construction materials, furniture, handicraft supplies, and other products. Unfortunately, the current use and demand for wood exceeds local forest capabilities as well as the industrial capacity to process and deliver these products to market. This disparity can result in the overexploitation of existing forests and the need to import those products or replace them with others. Both unsustainable forest utilization and substitutions help perpetuate a cycle of poverty, food insecurity, and continuing degradation of this natural resource (EFAP 1994). For example, when fuelwood becomes scarce, local communities then rely on burning manure for heating and cooking. Although such a substitution solves these short-term deficiencies, it causes nutrients in the manure to be burned rather than being re-incorporated into fields and gardens to maintain soil productivity. Then, without fertile soils, crops are less vigorous and can become water-stressed, leading to smaller harvests. These lower yields threaten local food security and the wealth of the communities, creating a need to plant larger land areas the next season in order to have sufficient crops. These new plots often arise from cleared forests, further decreasing the availability of fuelwood, i.e., the initial trigger of the problem. To break that cycle, sustainable solutions to these complex natural and social interactions must be developed and implemented.

Ethiopia has one of the largest populations in Africa, with over 73 million people and an annual growth rate of 2.36% (CIA 2005). The demand for forest products and land uses that are incompatible with forestry will only increase in the coming years. Because the formal industry is very limited in its size and output, it has received very little attention, resulting in poor funding, stagnant government policies, and the perpetuation of barriers to new investments. Nevertheless, a strong, sustainable program could help provide the raw materials that feed growing local and regional economies, and assist in rural development throughout the country. Industrial wood production in 1994 was estimated at 150,000 to 200,000 m^3, but could fulfill only half of the demand (EFAP 1994). Although good data are lacking for current overall production, many mills in the natural forests have shut down, and those facilities that work with plantation wood have maintained or only slightly increased their production, exacerbating the gap between local availability and greater demand.

To slow and eventually reverse this trend of overexploiting forest resources in Ethiopia, additional emphasis must be placed on SFM and development of the remaining natural and plantation forests. These lands provide tangible benefits from wood fiber production, coffee, spices, gums, and other non-timber products, as well as intangibles, such as protection for soil and water resources, wildlife habitat, and many others (Bishaw 2001; Mengistu 2002). To capture these benefits in a sustainable manner, resource management and development are required. Current practices and uses must be adjusted in order to meet the basic needs of the people and land today and into the future.

With millions of people living in both rural and urban areas involved with informal forestry activities (including illegal harvests), the collection, sale, and trade of fuelwood and other non-timber products have a very large effect on these resources. While the magnitude of impacts from the formal industry is smaller, these organizations have measurable influences in that environment. Each entity maintains records and has direct, quantifiable financial interests in forest management, positioning this industry as an appropriate first target for implementing change. If they can lead by example through extended educational opportunities and demonstrations, such modifications will then reach the broader, but less easily accessible, informal sector.

Understanding the opportunities and limits of harvesting procedures is instrumental if one is to fulfill a management plan. While many forested areas do not have documented schemes, those that do often have difficulty in their execution (EFAP 1994) due, in part, to logging constraints. Current and historic processes have not been adequately recorded for felling and cutting trees into logs, moving them to a road site and then to the mill. Without this baseline information, opportunities to improve management options and progress toward SFM are stymied in the existing paradigm.

1.1 LITERATURE REVIEW

1.1.1 FOREST HARVESTING IN DEVELOPING COUNTRIES

The developing world is a major consumer of forest products, especially fuelwood and construction materials. As populations and demand increase,

industrial operations are modified to facilitate supply to the consumer. For example, in many parts of Africa, many loggers use modern harvesting and extraction equipment, including chainsaws, skidders, and bulldozers (Dykstra and Toupin 2001; FAO 1997, 2003a). On the other end of this technology spectrum, loggers are attempting to meet demand through manual methods, where human labor is required for the cutting and transport of logs (Dykstra and Heinrich 1996; Seymour 1996b).

Many developing economies are located in tropical or sub-tropical regions, where forests consist of species with unique structures that often dictate how those trees are to be commercially harvested. In natural forests, very few boles are harvested per hectare because loggers typically remove only the most valuable trees (Dykstra 2003). Nevertheless, their felling and skidding often cause significant damage to the residual stand. For example, a study in Congo has shown that 30 remaining stems may be injured during the felling of a single tree (FAO 1997). Such severe impacts can destroy current and future commercially valuable stock. Likewise, soil disturbances, erosion, compaction, and the amount of land surface needed for skid trails, roads, and landings -- all concerns for SFM – often receive little planning to minimize their effect (Mengistu 2002). In many cases, a harvesting organization's main focus is simply to maintain log supplies to mills or markets, with little regard for other peripherals (Applegate et al. 2004).

In the past 15 years, there has been great interest in developing methods for decreasing the effect of harvesting on tropical forests. Some of the most researched and studied approaches are collectively termed 'reduced-impact logging'. RIL is

the “intensively planned and carefully controlled implementation of harvesting operations to minimize the impact on forest stands and soils, usually in individual tree selection cutting” (Bull et al. 2001). Because many of these basic concepts are commonly practiced already in temperate forest areas, RIL has now targeted tropical operations for improvements. Its acceptance and on-the-ground implementation require forest managers to approach harvesting with a different attitude and behavior (Enters and Durst 2003). However, its adoption often does not require expensive retooling and specialized equipment (Putz et al. 2000).

When compared with conventional logging, RIL provides a two-fold advantage -- less environmental damage and potential cost and efficiency benefits. Unfortunately it is unclear whether these are possible in every situation; many studies (Holmes et al. 2002) have shown conflicting results, with significant savings in some operations but additional costs in others. Part of this variability arises because RIL is not a fixed process, but is based on the best set of techniques for meeting specific social, environmental, and marketing conditions at the harvest site (Dykstra 2003). While the prescription is not fixed, a typical RIL protocol usually include the following (Durst and Enters 2001; Landrot 2004):

- Inventory and mapping of individual crop trees
- Planning and development of low-impact road, trails, and landings
- Cutting of vines prior to final harvest
- Appropriate felling and bucking practices

- Suitable planning and use of yarding systems that will minimize disturbances off the designated skid trails.
- Monitoring to document the level of success in meeting RIL goals

While planning costs are significantly higher for RIL than conventional logging, savings can be found in the enhanced efficiency of yarding and transportation, log recovery, and improved quality of the residual stand. Because a typical harvest involves very few trees, increased processing of species not commonly removed can significantly improve productivity. To realize these gains, additional research and development must focus on appropriate harvesting methods, utilization, and marketing of other forest species and products such as bamboo (Embaye 2000).

1.1.2 SUSTAINABILITY AND TIMBER HARVESTING

Harvesting is an important component of sustainable management in the developing world. Although such activity generates more revenue than from all other forest uses, it also has the most significant short- and long-term impacts on the site (Applegate et al. 2004). Many local and international groups have become aware of poorly planned and implemented logging schemes, as well as their effects on the local environment and the people who live in and around these forests. Increasing pressure is being placed on personnel and agencies to protect and manage those lands in a more sustainable manner (Applegate et al. 2004). Responsible approaches to harvesting, such as with RIL, are necessary if one is to

avoid the alternatives of either completely “locked-up” reserves or the over-exploitation, then abandonment, of forested lands (Putz et al. 2000).

Organizations such as the Food and Agriculture Organization of the United Nations (FAO) and the International Tropical Timber Organization (ITTO) have established SFM guidelines and specific harvesting practices that can work within an SFM program. Those of the FAO are described by Dykstra and Heinrich (1996) in their FAO Model Code of Forest Harvesting Practice. As general recommendations, they can be applied under both temperate and tropical conditions. The goal of this Model Code is to decrease and manage any negative social and environmental impacts of harvesting operations while also improving efficiency and increasing economic benefits to a wide range of constituents.

Advancements in policies, techniques, and technology are being used to help forest managers work toward an SFM goal. For example, in Bolivia and Costa Rica, tax credits, carbon offsets, and certification are being tested as means for encouraging the implementation of responsible logging (Putz et al. 2000). In other regions, harvesting organizations must obtain certain legal instruments, e.g., performance bonds, that hold them responsible for their actions (Boscolo and Vincent 1998). However, such policy tools are often very problematic in developing nations because the necessary government oversight and control are often inadequate to conduct these programs successfully. In addition, their institutional capacities are often under-developed, presenting insurmountable hurdles for operators and companies who try to gain access to capital, loan opportunities, and progressive marketing tools, such as carbon credits. In Ethiopia,

a different type of policy is in place that reduces taxes on the import of forest products in an attempt to relieve the pressure to harvest local forests (Bekele 2001).

New harvesting techniques and technologies are also being used to help meet SFM goals. In many areas, loggers now use chainsaws (Landrot 2004) rather than manual axes and cross-cut saws, even though efforts are still being made to increase the efficiency and maintenance of hand tools (Seymour 1996b). Improvements in equipment and methods can decrease the amount of energy, wasted material, and (if done correctly) even some of the danger involved with timber felling. The process of yarding now includes new machines that range from helicopters and forwarders to inexpensive, locally constructed sulkies (Seymour 1996a) and animal traction-powered machinery (Hanekom 2000; Jurvélius 1997). When techniques other than pit-sawing (with its recovery rate as low as 10%) are applied, significant advancements can be made in overall utilization while logs are being both felled and milled (Schmitt 2003). Portable sawmills, chainsaw milling (Pasiecznik 2006), or transport to stationary sawmills allow foresters to utilize more of the entire tree, thereby increasing recovered value and decreasing the need for additional trees in order to achieve the same volumes.

Other technologies are being adopted around the world to help meet SFM goals:

- Sweeping upgrades in remote sensing, mapping, and aerial and satellite imagery

- Technologies that enable the handling of more species, especially those traditionally unused or considered undesirable in local markets
- Improvements in primary and secondary processing to reduce the requirement for raw materials and increase the milling of small-dimension or poor-quality logs
- Mechanisms that encourage the promotion of non-wood forest products
- Enhanced understanding of ecosystems that leads to the refinement of management practices (FAO 2003c)

Unfortunately, the rate of access, acceptance, and adoption of these technologies in the developing world, especially in Africa, are expected to be slow. New methodologies are often based on foreign systems that are difficult to connect to other countries. This is typically a result of high costs and poor supply lines for providing service and products to less commercially active regions. Adaptations in many of those areas are often gradual, and institutional weaknesses and other constraints may hinder the mere establishment of SFM criteria and indicators. Even when those goals are set, logging operations and forestry in the Tropics often must implement many more changes compared with those in temperate areas, further inhibiting the achievement of SFM (FAO 2003c).

While SFM is a worthy objective toward which forest managers should strive, it is typically difficult to measure and often cannot be accurately assessed in the short term. Applegate et al. (2004) asserts that it is possible to claim SFM only in retrospect, when one has complete knowledge that a forest is being managed

sustainably. However, such uncertainty should not discourage progress towards the intent of SFM because alternative management practices can, at best, only maintain currently declining forest conditions and, at their worst, destabilize entire ecosystems.

1.2.3 DECISION-SUPPORT TOOLS

The options and possible outcomes of decisions in difficult, multi-faceted topic areas, such as SFM, are innumerable. Several means are available for helping one efficiently identify the best combinations of potential goals that are the most appropriate or have the best financial return and the least environmental impact. Support tools comprise a broad collection of techniques that facilitate decision-making by utilizing data and models for solving unstructured problems (Sprague 1980). Some have been specifically designed in cooperation with potential users for applications in natural resources (Grant and Sear 1999). These tools can improve the accuracy, quality, and speed of judgment when diverse respondents are processing and filtering data that can provide feedback for making better decisions. In the context of SFM, social, economic, and environmental data are amassed through participatory collection methods before they are evaluated and passed on to farmers, foresters, government policy-makers, NGOs, et al. (Grant and Sear 1999). From data-collection to the final decision, these procedures should include as many stakeholders as possible (ITTO 2002; Jeganathan 2003), so that each participant can use the recapitulated data to better understand the differences among proposed alternatives. For example, decision trees classify knowledge in an

organized manner, beginning with simple comparisons and building up to more complicated decisions that are supported and conditioned on previous decisions (Quinlan 1990).

While many decision-support tools have been developed over the years, most use numerical analyses for evaluations. Typically, one would start with particular criteria and options, to which quantitative measures or rankings are assigned before they are weighted with another alternative for feedback to the decision-maker (Triantaphyllou 2000). While such data are often easily utilized, the capacity to additionally incorporate qualitative data into a decision tool provides significant robustness to this process (Malczewski 1999).

SFM decisions are based on a complex mix of multiple criteria, different groups, economic data, and other inputs that combine both quantitative and qualitative data. This is a situation for which a well-designed decision tool may be very appropriate, transparent, and efficient (Jeganathan 2003). Nevertheless, those components must remain simple, rather than allowing such large, complex sets of data to disenfranchise users if they cannot comprehend how their input will be considered when the final decisions are being formulated. This is especially important when trying to integrate the management of many types of data with input from the public as well as the preferences and experiential knowledge of experts in the field (Komarov et al. 2002). The resulting decisions should be appropriate to the question and have high degrees of participant satisfaction, while also identifying areas for improvement in the next decision-making process (Sheppard and Meitner 2005).

Popular tools, e.g., the analytical hierarchy process (AHP) (Saaty 1980), have already been applied in a wide variety of industries and programs, including natural resources. In AHP, simple pair-wise comparisons between criteria help determine a priority that helps lead decision-makers to the best conclusion supported by the data. For more complex tools, such as those used by the United States Forest Service, many modules may combine multiple models with real-time spatial mapping, analysis, and other features (Rauscher 1999). Even so, shortcomings can restrict the usefulness of a product and often limit the types of problems that can be solved (Rauscher 1999).

When applied to projects in the developing world, where there is a component that integrates private enterprise operations, governmental policies, and community, such tools usually cannot be simply modified from robust western business models. For example, many systems rely on artificial intelligence and cognitive science, which are unsuitable for the average non-technical user involved in sustainable development (Grant and Sear 1999). This includes planning that is intended for farms (Negussie 2004), water supplies, and other natural resource issues. In this same context, timber harvesting and SFMs do not have established procedures for identifying many important questions, and they lack the tools that can help process the data required when devising solutions.

Although sites in Ethiopia were used in this research project, many parts of the developing world face similar challenges and situations that can be categorized within the decision-making areas presented here. By making minor adjustments for

local conditions, this process can serve to identify appropriate harvesting improvements in many other regions.

1.2.4 CONCLUSIONS

After one reviews the existing literature, an appropriate exercise is to connect harvesting in the developing world with SFM and decision tools. When logging is conducted in a careless or haphazard manner, especially in the Tropics, the chances for negative impacts are high. These may include the environmental effects of poor planning, implementation, and post-harvest reclamation, as well as other deleterious influences. Poor execution of a logging scheme is associated with high costs for equipment time and maintenance, and may be paired with less productivity that results in a lower realization of profits. In addition, potential social issues can arise, such as conflicts about land allocation, worker safety, and governmental regulations, all of which can increase the difficulty of sustainably removing timber. Fortunately, many methods are available for minimizing these impacts during the planning, preparation, harvesting, and rehabilitation phases.

Forest managers, especially in the developing regions of the Tropics, often make harvesting decisions based on existing resources and past experiences. This impedes the adoption of improved processes and perpetuates the challenge of achieving sustainable forest management. Even when SFM is the objective, managers may not have clear, simple procedures for evaluating which alternative practices will be most efficient in meeting set goals. Decision tools have already been effectively implemented in many areas of natural resource management,

where multiple criteria must be assessed in order to select an alternative. The feedback obtained when proven techniques are adapted can play a role in developing a framework for addressing the different layers of operations, sustainability, and personnel who will be involved or affected by adjustments to existing harvesting practices.

1.3 RESEARCH OBJECTIVE

The goal of this study was to help improve the sustainability of forest harvesting through the use of decision-making tools so that SFM can be achieved in developing countries. This project was developed in response to issues that arose while identifying and recording the state of the art for harvesting in Ethiopia's forests. The objective there was to create tools that could aid foresters in making appropriate choices that promote sustainability. The three primary topics addressed in this dissertation are components of a research approach that encompassed both natural and plantation forests as well as a variety of organizational structures and conditions. They include:

1) Harvesting technologies
2) Decision-support tools for SFM in developing countries
3) Appropriate, sustainable harvesting practices for Ethiopia forests

The data gathered here were used to establish a baseline that would describe the harvesting process in Ethiopia, as well as to formulate decision tools for identifying appropriate harvesting opportunities that are sustainable and possible to implement. Here, a decision framework is presented for assessing

sustainable operations in developing countries, along with a case study in Ethiopia that can be applied for improving logging practices within the limits of those research sites.

1.4 ORGANIZATION

This dissertation is organized into two primary chapters, each of which will be submitted to refereed journals for publication. Because both are designed to stand alone, there may be some redundancy.

Chapter 1 serves as an introduction that includes a literature review of the main topic areas, the overall research objectives, and questions to be answered in this research.

Chapter 2 has been prepared as a manuscript, “State of the Art in Ethiopian Timber Harvesting”, for the *Ethiopian Journal of Natural Resources*. While analyzing various logging and management practices in that country, the following research questions were addressed:

1) What is the current socio-political context for forest harvesting?
2) What tools and techniques are used in harvesting?
3) Do logging practices vary among different types of forests and ownership, e.g., plantation versus natural forest?
4) Are these current techniques and tools appropriate and sustainable?

Even though forest products are a critical component in the lives of most citizens, timber harvesting in Ethiopia has not been a focus of research or general

interest. Therefore, this collection of baseline information provides a starting point for initiating suitable improvements and supporting the creation of a sustainable forest products industry. This open research design can be adapted to meet local or other research objectives in other parts of the world where a similar body of knowledge is lacking.

Chapter 3 presents a manuscript titled “Forest Harvesting Decision Framework to Improve Sustainability in Developing Countries”, which will be submitted to the *International Journal of Forest Engineering*. Here, we describe the development and case-study application of a framework that can help move a country toward SFM. The research questions addressed include:

1) What are the critical operations, decisions, and issues that face forest managers in terms of SFM?
2) Can a decision framework be introduced to improve their decision-making capabilities?
3) How can decision tools be applied to an analysis of operations in Ethiopia?

This project is unique in that it combines management tools with participatory engagement by decision-makers and other interested people, with the result that the framework is sufficiently robust to provide valuable output, but simple enough to be implemented and trusted by those involved. Although sites in Ethiopia were used in this particular study, many parts of the developing world face similar challenges and situations that can be categorized within the decision-making areas presented here. With minor adjustments for local conditions, this

procedure could help identify the need for appropriate forest-harvesting improvements elsewhere.

Chapter 4 provides a summary and additional discussion of how these two manuscripts can work as the backbone that determines the implications for management organizations plus suggestions for future research. A full bibliography listing all the references cited in this dissertation is included at the end of that chapter.

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2.0 STATE OF THE ART IN ETHIOPIAN TIMBER HARVESTING

Ben Spong and Loren Kellogg[1]

2.1 INTRODUCTION

Ethiopia is a large, landlocked country in East Africa. It is surrounded by Somalia and Djibouti to the east, by Eritrea and Sudan to the north and west, and by Kenya to the south. Centuries ago, forests covered large portions of this country, especially in its highlands. Utilization of those resources continues to be an important component of the livelihood for local populations. Unfortunately, only 5.6% of the land area is currently in forest cover, with losses estimated at up to 200,000 ha per year (EFAP 1994). Although harvesting by commercial organizations is often blamed for this rampant deforestation, the overall volume removed via these legal channels is relatively small compared with that obtained through unorganized fuelwood collection and other unauthorized activities.

Given the public misconception that commercial forestry is the primary cause of deforestation, and the social, economic, and environmental importance of the remaining forestlands, the role of logging and associated activities in commercial operations needs to be documented. The small amount of existing harvesting information has been recorded only as side notes in research publications and government reports, with their primary focus being placed on

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other forestry issues. To address this deficit of material covering harvesting in Ethiopia, a project was developed to look at the current socio-political context for forest harvesting, harvesting in the different forest types and ownerships, as well as the tools and techniques and the impact on sustainability.

Here, we present a review of the organizations and contemporary harvesting practices used in commercial ventures. These data were collected from observations, interviews, and reviews of both published literature and industry documentation from the primary forest. Field data collection occurred during three to four week periods during six separate research visits to Ethiopia. Logging sites and organizations were visited in the southern half of the country, focusing on plantations in the Rift Valley region and natural forests in the southwest. Additional information, documentation, and reference materials were provided by the Wondo Genet College of Forestry, the Ethiopian Ministry of Agriculture, the Ethiopian Agriculture Research Organization, and cooperating forest harvesting organizations and contractors. By establishing a baseline, agencies can then use this information to begin developing appropriate improvements to the harvesting process and to identify the type of forest impacts that result from commercial operations in order to evaluate their sustainability.

2.2 BACKGROUND

Ethiopia has the second largest population in sub-Saharan Africa, at over 70 million people in more than 60 distinct ethnic groups (Tadege 2001). This country must support a heavy burden for its social, environmental, and physical

infrastructures. The median age is 17.8 years, with an ever-decreasing average life expectancy of 48.8 years, partially as a result of HIV-AIDS (CIA 2005). Despite relatively high mortality rates, population growth is rapid, i.e., 2.8% per year. Approximately 85% of the citizens live in rural areas. Although highland farmers are the most numerous, the lowland pastoralists occupy 60% of the land even though they comprise only 12% of the total population. The Ethiopian Central Statistics Authority calculates a density of 45 people per km^2 that is evenly distributed throughout the country, resulting in widespread, major effects on the land base (Ferguson and Romboli 2004).

Ethiopia has a varying topography that ranges from significant peaks of >4500 m to low-lying desert depressions that are >100 m below sea level. The land is dissected by eroded river valleys, some as deep as 1300 m (Swain 1952). An arbitrarily selected elevation of 1500 m is the accepted boundary between highlands and lowlands. These two regions are characterized by distinct climates, as well as by differences in their population density and distribution, lifestyles, and other physical and social characteristics (Tadege 2001).

Temperatures tend to vary with elevation, averaging 16°C in the highlands and 31°C in the lowlands (Ferguson and Romboli 2004). Although only narrow seasonal differences are found within each climatic zone (Swain 1952) precipitation amounts show very distinct fluctuations throughout the year. In most areas of the country, the dry season is between October and January while the rainy season occurs between June and September. Some areas also receive a short period of rain between February and May. Averages range from >2000 mm of rain

in the Southwestern highlands to <300 mm over the Southeastern and Northeastern lowlands (Tadege 2001).

Ethiopian soils are generally productive, but intensive agriculture and poor conservation techniques are depleting nutrients and limiting the usefulness of those soils (Dejene 2003). Topographic variations and concentrated precipitation intensify erosion, resulting in annual cropland losses of >100 tons of soil per ha (Kanshie 2002). With a rate of soil formation below two tons per ha (Taddese 2001), there is a large deficiency in the nutrient-rich soils needed for activities geared toward high-quality agriculture, forestry, and environmental protection.

According to the Ethiopian Mapping Agency (1988), the most common land-use classification (>50%) is for grazing and browsing, which occurs in cultivated areas, woodlands and forests, bushlands, shrublands, and grassland. Cultivation accounts for another 23% of land use, with forests and woodlands covering about 7% of the country. Over 16% of the terrain consists of exposed rock, salt flats, and sand. As with climate and topography, the vegetation in Ethiopia shows wide variety, from barren sand to lush tropical forest. In general, the northern and southeastern portions have less vegetative cover than in the southwest.

Approximately 15% of all citizens live in urban areas (Tadege 2001). The capital, Addis Ababa, is the largest city, with a population estimated at 3 million. Smaller urban centers are distributed throughout the country. Semi-developed lands include communities in the regional states, each of which is broken down into woredas (lowest regional level of formal government) and then into peasant

associations, kebelles, tabias, and village councils (Bekele 2001). Land is allocated to individuals for commerce, agriculture, and grazing. Places of worship also occupy significant lands. Of particular interest are the Ethiopian Orthodox Tewahedo churches, many of which maintain compounds containing remnant blocks of indigenous forestlands that are utilized for a wide variety of products, ecological demonstrations, and spiritual services. These church lands comprise much of the forest that still remains in the northern portion of the country.

2.2.1 PLANTATION FORESTS

Outside of agriculture and other semi-developed lands, forest plantations have been established to provide wood fiber for a variety of uses. These cover >200,000 ha, based on estimates by the FAO (2003d) and Tadege (2001). Of these, almost 50% are industrial plantations, 18% peri-urban plantations, and 35% community woodlots. The history of these plantations started when Ethiopian Emperor Menelek brought *Eucalyptus globulus* from Australia in the early 20th century. At that time, fuelwood and construction timbers had been over-harvested in and around Addis Ababa. Rather than move the capital city to an undisturbed area with new resources, the Emperor encouraged the use of fast-growing eucalyptus for wood fiber in construction and heating, which would then allow permanent settlement in Addis Ababa.

Whereas the peri-urban and community plantations primarily produce construction timbers and fuelwood, industrial plantations concentrate on saw timber and poles. The minimal amount of advanced plantation technology and

management applied in non-industrial plantations often leads to neglect, over-utilization, and less output. The reduced value of those products, as well as the investment costs and relatively simple growing cycle of species like eucalyptus, keep these plantations at lower levels of productivity. Likewise, industrial plantations struggle to be competitive, often because of inadequate linkages with end users, markets (FAO 2003c), poor infrastructure, and difficulties in dealing with local and national regulations and governance.

2.2.2 NATURAL FORESTS

An estimated 4.4 million ha of Ethiopian lands are categorized as undisturbed natural forest, disturbed natural forest, or woodlands (FAO, 2003c). These forestlands are more numerous than those of the plantations, with most of the former areas being located in the south-central and southwestern portions of the country.

2.3 FORESTRY GOVERNANCE

Because of internal and external conflicts over the last century, many adjustments have been made in forest governance. While some of these changes have brought advancements, others may have helped hinder the establishment of a strong, productive industry and healthy, expanding forest developments. When the current government assumed responsibilities in 1991, there was a push to decentralize much of their operations, passing their obligations down to the regional states. In the forestry context, those responsibilities moved to the regional agricultural development bureaus. Individual states now had the responsibility of

preparing their own forest plans and budgets, raising revenues, and implementing development activities in accordance with the overall policies of the federal government. Additional charges to develop and enforce bylaws and governance responsibilities were delegated to the local woredas, kebelles, and village councils (Bekele 2001).

2.3.1 NATIONAL LEVEL

Ethiopia uses a state organization structure, in which the country is divided into regional administrative states and woredas. At the federal level, a prime minister and the Council of People's Representatives are the highest legislative and policy-making bodies, with their responsibilities to the people being fulfilled through federal ministries, including the Ministry of Agriculture. They, along with the Ministries of Water Resources and of Environmental Protection, have some influence on national forest policies and practices (Ferguson and Romboli 2004). Forestry work in the Ministry of Agriculture is poorly funded, with annual expenditures in that sector accounting for less than 1 million Birr. However, the Federal Government also gives grants directly to the regional states for forestry and wildlife efforts, at a level 30 times greater than what it provides for national-level policy, administration, and leadership (Bekele 2001).

2.3.2 REGIONAL LEVEL

Ethiopia is divided into 11 Regional States and Special Administrative areas, organized around traditional ethnic and language boundaries. These states include Oromia, Afar, Tigray, Amhara, Somali, Benishangul Gumuz, Harari,

Gambella, Southern Nations Nationalities and Peoples, Addis Ababa City Administration, and the Dire Dawa Administrative Council. Each state has great autonomy from the federal government to execute socio-economic programs and policies, administer lands and other resources, maintain public order, collect taxes, and fulfill other responsibilities (Federal Negarit Gazeta 1995). Regional bureaus parallel the topic areas of the federal ministries, and are charged with the execution and administration of all programs and activities (Ferguson and Romboli 2004).

2.3.3 LOCAL LEVEL

The Regional States are further divided into 556 woredas (or districts) that are coordinated by 66 zonal administrations. Woredas are structured to be the hubs of the decentralized government, each serving an average population of 100,000 citizens. Individual woredas have an elected council, a president chosen from among the council members, and a set of offices or agencies that carry out their policies. Kebelles and peasant associations are organizational subsets of the woreda structure, working with smaller populations that typically comprise a couple of small villages or neighborhoods. Elected members of the kebelles and peasant associations generally are unpaid, full-time government employees.

2.3.4 LAND TENURE

In many areas of the world, the government gives legal permission to its citizens to hold and manage land that is within the sovereign boundaries of that country. This provides individuals or groups with shelter, sustenance, and the opportunity to be productive members of a society, as well as associate rights of

ownership. In all cases, however, the land is generally still owned by that government, but a tenure relationship is maintained between occupant and governmental body. Different interpretations may exist concerning the level of rights provided, their possible costs and benefits, and the roles and responsibilities of both parties. In the past half century, Ethiopia has experienced some drastic adjustments in its land tenure system, significantly impacting the role and potential for productive forests and associated wood-based industries.

In the late 1800s and early 1900s, Emperor Menelek II ruled an expanding Ethiopia with the cooperation of powerful war chiefs, troops, and dignitaries. As a gesture of his appreciation, many were provided with large estates and regions, including the tenants living in those areas (Negussie 2004). Following this period, the country was now predominately owned by private landlords who strictly controlled land use and access through sharecropping agreements (Schmitt 2003). Residents were required to submit payments based on productivity in exchange for using this land. These altered relationships led to major changes, with new agricultural lands being carved out of the forests and grazing capacity being increased to support the landlords. Along with these shifts, soil conservation and natural resource supplies were negatively impacted (Negussie, 2004).

Beginning in the early 1970s, during the period of the Socialist government, sweeping changes were made to almost all aspects of Ethiopian life. Private land ownership was abolished and peasants were given usufructuary rights for up to 10 ha (Negussie, 2004). The intent was to allow farmers to cultivate crops while providing land to everyone in the country in a fair manner. While the state

still maintained ownership of the land, Peasant Associations served to administer its allocation and redistribution (Bourn 2002).

A change in government in 1994 brought further clarity to the land tenure system. The Federal Constitution now stated that “the right to ownership of rural and urban land, as well as natural resources, is exclusively vested in the State and in the peoples of Ethiopia. Land is a common property of the Nations, Nationalities and Peoples of Ethiopia and shall not be subject to sale or to other means of exchange” (Bourn 2002). Rights to agricultural land, including the trees, was now inheritable and transferable, although the natural forests were still owned by the state (Bourn 2002). While possession of natural resources was now very explicit, management responsibilities were not (Teketay and Bekele 2002).

2.4 FOREST UTILIZATION

2.4.1 GRAZING

With up to 97% of households owning livestock in rural areas (Schmitt 2003), the impact from grazing animals is a very important component of forest utilization. Their increasing density and the extent of vegetated landmass required to support these animals have affected forest cover, particularly in the woodland types. Over 80% of these livestock rely on already degraded highland areas (Dejene, 2003), which exacerbates problems with vegetative and forest cover, soil stability, compaction, and other environmental concerns.

2.4.2 NON-TIMBER FOREST PRODUCTS

Many non-timber forest products are harvested from both natural and plantation forestlands. The variety of ecological conditions means that a great diversity of indigenous flora and other products are used for food, traditional medicines, spices, etc. Deffar (1998) has reported that 75 to 90% of the rural population depends on locally collected medicinal plants from forestlands for their primary health care. While many of these products are used in the household, many are also commercially traded with organized groups that coordinate the export and other marketing of such goods as honey, incense, gums, essential oils, fruits, spices, dyes, coffee, and tool handles (Abate 2004; EFAP 1994; Schmitt 2003). Unfortunately, little national data are available for documenting the overall importance of these products.

2.4.3 FUELWOOD

At over 91 million m^3 of wood fuel per year, Ethiopia is the fourth largest global user, after China, India, and Brazil (FAO 2003b). This primary resource is exploited for cooking, heating, lighting, and other purposes by >90% of the population (Abate 2004). In 2003, over 96% of all wood consumption was for fuel (FAO 2003b). Because this demand continues to increase, plantations have been established exclusively for its production. However, the numbers and success of these plantations are limited by the availability of land, difficult governmental policies, and a lack of expertise in commercial forestry enterprises (Yirdaw 2002). Most fuelwood is collected from farm-planted trees and surrounding forestlands that are owned and controlled by the federal government. Although this wood is

usually the property of the state, there is little enforcement and control of that type of harvesting.

2.4.4 INDUSTRIAL FOREST OPERATIONS

A few industrial forestry operations exist in Ethiopia, with most being solely or partially controlled by the federal government. These are usually organized under an enterprise structure, in which milling operations are combined with an office for harvesting, marketing, and business. Some plantation-based organizations have land-management responsibilities while others, especially in the natural forest, rely on administration by the regional states. Many industrial entities have failed to re-invest in their operations, resulting in antiquated equipment and facilities. Moreover, the difficulty of obtaining raw material has become an issue, further hindering the ability to sustain a productive and successful industry.

2.5 COMMERCIAL FORESTRY ORGANIZATIONS

2.5.1 LARGE-SCALE

Commercial forestry activities involve the legal cutting of timber, processing logs into lumber, and selling the product in the market, all of which make up a small but important component of the Ethiopian economy. Locally produced lumber and other wood products are the primary materials used in construction, woodworking, and other industries. Because the demand for lumber has increased, some additional supply is now being imported into commercial

centers. These materials are often of higher quality, more precisely milled, and offered at lower cost than are the local products.

The majority of the commercial forest industry is supported by sawmills that were installed over 40 years ago to process large logs from the natural forest. Although most of those mills are now obsolete and in need of condemnation, a few remain active, being minimally maintained to manage production levels of around 3500 m^3 per year (Bekele 2000). Compounding their infrastructure issues, many mills have been inactive for months and years as legal access to raw logs has become scarcer.

Most of these legacy mills belong to the Sawmill and Joineries Enterprise (SJE), a state-controlled, public program. SJE is responsible for many phases of the lumber production process, including:

- Logging and transport (permits issued by state forests)
- Manufacture of sawn goods and derived products at mills and joineries
- Marketing of final products

The majority of these goods are sold directly to end users, e.g., government organizations and private contractors, as well as to industries that use sawn goods. The joineries side of the operation works on a per-order basis, with output only when their products are requested. SJE is administered through their main office in Addis Ababa, with almost all decisions on budget, operations, etc. being made there before being sent out to the field mills (Jarvholm and Tivell 1987).

Enterprises that work in plantation forests appear to be more progressive than those operating in the natural forest. Because plantations were more recently established (1968), most of their sawmills and equipment installed for processing the first rotation are in much better condition. These bodies were founded to "conserve and wisely utilize the natural and the plantation forests" (Abate 2004). Plantation enterprises have management control over the land base, and are able to retain and use revenues to re-invest in their operations (Bekele 2001). Management of plantation lands, harvesting, sawmills, marketing, and the business and financial sectors all require significant investment in permanent and contract personnel. Furthermore, such enterprises still face many of the same challenges as do operators within the natural forest, especially those dealing with the availability of imported equipment, employee safety, and land management adjacent to population centers.

Figure 2.1 Mobile sawmill used for processing plantation forest logs.

Enterprises use mobile sawmills, which have an annual capacity of about 45,000 m^3 of sawn wood (Figure 2.1). However, their production is often limited by the available supply of logs. Those mills are sized to work with the smaller-diameter logs normally harvested from plantations. Timber is obtained primarily from exotic species that have been planted on cleared natural forestlands and on former agricultural lands. Although trials using some indigenous species have also been included in the plantations, many of those native species are slow-growing, with many lacking the proper form and structure for maturing under plantation conditions. While lumber from exotic species is generally less desirable in the

market, the higher volumes, increased uniformity, and availability of plantation grown wood ensures that there is often greater demand for than supply.

2.5.2 SMALL-SCALE

2.5.2.1 PRIVATE SAWMILLS

A few small, private sawmills have been established to provide sawn lumber for commercial distribution. These operations have problems similar to those of the large SJE mills, e.g., in securing access to a consistent flow of raw material. The private mills do not have a secure wood supply, but must, instead, rely on logs from farms, small private woodlots, and others that have not been claimed by the public enterprise sawmills.

For example, a small, private mill in the Oromia region can receive logs from plantation lands that are managed by Enterprise-level organizations. However, the Enterprise has the first option on any log that is harvested and brought to the mill site. Only logs that are rejected because they are of low quality or an unmarketable species ever become available to the smaller private mills. These rejected logs are then offered to the highest bidder at auction, where demand can be high because few other legal sources are available for securing suitable raw material. In many cases, the cost for these rejected logs is significantly higher than the royalty paid by the Enterprise for first rights.

Unfortunately, when mills must begin with very poor quality logs, a great deal of milling is required to produce marketable boards. Mill operators must invest significantly more time, energy, and money to avoid waste and secure the

greatest value possible. With this high cost of raw material and low recovery potential, these small, private mills often have difficulty covering their costs. Many shut down for long periods when few logs are available, while others invest significant amounts of time and money in finding and transporting logs from farms, woodlots, and other small holdings.

2.5.2.2 PIT-SAWING

Pit-sawing has been practiced for hundreds of years throughout Ethiopia. The traditional technique involves cutting boards by pulling a saw down through the log. This requires the "pit sawyer" (bottom person) to be located below the log, either in a hand-dug hole (pit) or with the log suspended in the air by supports (Figure 2.2). The second person, on top of the log, pulls the saw back up and is responsible for ensuring that the cuts are straight and even. The initial slabs are often removed with an axe. Although pit-sawing is very difficult work and the recovery of lumber from each log is very low, a large number of pit-sawn boards are produced every year because costs are low and other employment opportunities may not be available.

Figure 2.2 Stands used to elevate large native species logs during pit-saw operations.

Most pit-sawn boards are obtained from immense, indigenous hardwood trees because the business of sawing a large log into boards is usually more lucrative than working with smaller, exotic species. These raw logs are usually felled, without permission or authorization, from natural forests and woodlands owned by the federal government. Although the most common pit-sawn species, e.g., *Cordia africana, Juniperus procera, Podocarpus falcatus, and Hagenia abyssinica,* are legally protected from commercial and non-commercial harvesting, little law enforcement is done to safeguard these trees, such that the majority of the pit-sawn lumber in the marketplace is from unauthorized lands or protected species. The demand is high for this resource because carpenters, woodworkers,

and others are very familiar with its coloring, working properties, and other characteristics. In addition, the more abundant and familiar, albeit, exotic species, e.g., eucalyptus, are considered by local citizens to be of lower quality and primarily useful as fuelwood and poles. The higher status of native wood species by both the secondary manufacturers and many consumers makes it difficult to promote increased use of exotic species for a broader range of commercial products.

2.6 HARVESTING PRACTICES

2.6.1 LABOR

Most commercial timber harvesting in Ethiopia is completed by contract loggers, who are paid based on their production levels. A group of laborers is headed by one leader who holds the contract with a mill, Enterprise, or other organization. Contractors generally provide only the manpower and possibly some basic tools, while the mill is responsible for all other equipment and operational support. The mill may also supply housing, food, medical care, or transportation while crews are active at a work site.

Individual mills establish a set value per cubic meter produced and delivered for all of their operations, regardless of the difficulty, distance, season, or other conditions. The only variance in unit price might occur if log transportation is provided by the mill, in which case a slightly lower rate is paid to the contractors. Nevertheless, it is usually to the loggers' advantage to use mill

transport because the additional compensation is usually not sufficient to cover the extra cost and time required for the contractor to do this work.

Pre-harvest planning for plantation forests also includes the hiring of contract loggers, who are generally in good supply because such work is relatively constant, dependable, and close to local villages. In contrast, the scattered locations and sporadic nature of the job in natural forests means that laborers are not as numerous. Therefore, it is common for a sawmill enterprise to employ long-term, experienced crews from other regions of the country.

2.6.2 ACCESS

The timber-harvesting process begins with planning, which, in both natural and plantation forests, is usually limited only to area and access identification. If the agency is working with a management scheme, the harvest area is selected based on established directives. These plans are very closely followed, and many foresters are cautious to stray too far from the document. However, adjustments are made when issues arise that must be controlled, e.g., insect and disease treatments or recovery from natural disturbances such as fires or floods. Harvesting in natural forests is planned by the regional state government authority, who also assesses the overall distribution of wood in a certain region to ensure an adequate supply before allocating areas. The particular method employed for determining forest stocking is not always clear because many areas do not have the personnel and other infrastructure to inventory or assess volumes. Often, a decision to restrict harvesting is based on the inability to obtain good data that can

indicate sustainability of the resource. Furthermore, although natural forests may require that the vines linking tree canopies be cut many months before timber felling can start, this step is often overlooked.

Planning for access to the site usually consists of analyzing useful, all-season public roads, trails, or paths. Those already in place often can also be used in harvesting and log transport, even if their routing is significantly longer or more difficult. Networks within the natural forest are frequently in very poor condition because those areas may not have been harvested recently. Remnants of past networks might be identifiable, but most require some level of new road construction for access to logging units. If such access cannot be achieved without physical improvements, plans are then made to develop routes or animal traction methods that can bring logs to the closest existing road point.

In plantation situations, some harvest units can use their own in-place road systems. However, little or no improvements or routine upkeep are normally done, so that, in wet weather, those truck and tractor roads may become impassable. Their construction and maintenance is generally considered too expensive, requiring specialized engineering and heavy equipment, e.g., tracked bulldozers, that is not available to any other than the largest mills. Moreover, although labor may be adequate for moderate construction and maintenance projects, no well-developed supply of contractors for major road development can usually be found outside of the government, NGOs, or foreign companies. When possible, however, mills may be able to share those resources with organizations that can fully utilize them for construction of public roads and other projects outside of the forest.

Regardless of the situation encountered, these road systems are almost exclusively natural-surfaced, simple paths that lack formal drainage structures. When used by truck, tractor, or animal traffic following severe or even minor rainfall events, large ruts fill with mud, typically shutting down any movement of logs to the mill. Likewise, other public road networks are often in poor condition, although most are capable of some level and speed of traffic year-round.

Most harvesting operations in Ethiopia lack even the most basic maps, photos, inventory, and other information integral to the planning process. As a result, many of the important decisions are left to the contractors, equipment operators, and other personnel, who are not responsible for operations beyond those at a particular site. This leads to higher harvesting costs, less efficient use of resources in a given forested area, and lower productivity in getting logs to the mill. For example, a well-considered transportation plan could dramatically decrease secondary times and distances, resulting in reduced fuel costs, machine wear, and labor. For very minimal investment in road improvements, an operation can deliver logs to the mill in less time, cut down on issues associated with the rainy season, and provide additional community benefits by upgrading the route normally used by many villagers for other purposes.

Poor access to logging sites often limits the overall productivity of harvesting. Misunderstandings exist as to the benefits, costs, methods, and maintenance requirements for road construction and improvement projects. With little to no investment in access, operations often require additional time to complete activities under poor weather conditions or because lengthy routes are

required for primary transport systems. Finally, poor access planning can have dramatic effects on the environment because of the lack of structures to control water flow, including waterbars or ditches.

2.6.3 FELLING

The most prevalent timber-felling methods in Ethiopia rely on manual skills. Loggers often have little or no formal training, but have many years of on-the-job, field experience. In most operations, an axe is used to put in a face cut or notch before a crosscut saw makes the back cut to complete the felling process (Figure 2.3). Although these basic techniques are usually appropriate, loggers often disregarded the lean of the tree and underestimate how entangled its canopy is with the remaining stand. Such oversights can create significant safety problems if trees either fall in an unplanned direction or remain hung-up in the canopy after being severed at the stump. Moreover, felling is usually performed without appropriate personal protection equipment and techniques that can limit the potential for dangerous or fatal accidents.

Figure 2.3 Manual felling of plantation trees using axes, cross-cut saws, and ropes.

Many loggers are more comfortable using an axe for the entire felling process rather than combining this tool with the crosscut saw. However, such reluctance often requires the fellers to then cut a straight section off the butt log to make it acceptable to a mill. Although the perceived amount of time and required work seems shorter to most loggers who use only the axe, they often fail to consider the extra time involved as well as the log volume that is wasted when they must then re-cut the edge of that end log.

Felling equipment can be obtained from both local tool manufacturers and through importers. The latter is generally preferred because such equipment is regarded as being of higher quality, longer-lasting, and more efficient.

Furthermore, such imported tools are often provided by the mill, at no cost to the contractor. In contrast, locally constructed axe heads, although of apparently adequate quality and available at a much lower cost, are normally used only as a secondary tool, when the usual equipment is either being utilized by other laborers or that preferred tool is out of service for maintenance. Although crosscut saws are usually imported, local saw sharpeners can be hired by contractors for on-site servicing. Likewise, once other logging tools are broken or have passed their economic life, most are fixed with locally crafted patches, handles, and other means to extend their usefulness. Often these fixes significantly impact ergonomics and effectiveness, yet, to avoid new purchases, most contractors continue to use those tools until they are replaced by the mill.

In Ethiopia, significant opportunities could be taken to improve the efficiency and value-recovery of felling operations through the use of chainsaws. However, few of these, or other saws, maintenance materials, and trained operators are currently available there. Nevertheless, chainsaw training and investments are beginning to be developed through programs at Wondo Genet College of Forestry, the Ethiopian Agricultural Research Organization, and newly available, local retail sources in Addis Ababa.

When numerous logging contractors are available, manual felling methods can be very effective. However, poor safety management can seriously influence local operations. For example, groups that fell trees right next to each other, using techniques that do not necessarily control the direction of fall, put everyone on the site in danger of injury or death. Although personal equipment can provide one

layer of safety, few contractors have access to or utilize hardhats, boots, or other protective clothing. Furthermore, equipment is not always well maintained and tools often are not sharp, properly adjusted, or fixed with appropriate materials.

2.6.4 TIMBER PROCESSING

Primary timber processing usually occurs at the stump with limbing, removal of the tree top, and segmentation into logs. This normally is begun immediately by the laborer responsible for the initial felling, along with at least one partner. While smaller limbs are easily severed, the removal of larger branches may require significant effort with an axe. Working from the butt end, logs are cut into four-meter sections, a process that is repeated up to the smallest usable diameter. Although such a standard log length is preferred by the mills, shorter segments may also be accepted. These standard sections are cut regardless of the quality, defect, or other characteristics that might otherwise classify a piece of timber as either a saw log or firewood. Because the contractor is paid at a lower rate for the latter, however, there is incentive for them to produce saw logs whenever possible.

Log segmentation can be completed with an axe or a two-person crosscut saw. While the latter is preferable because the kerf is smaller and less wood is wasted, laborers often perceive that this takes more time and effort than simply chopping through the log. However, for larger-diameter logs, significant volumes can indeed be lost. For example, using an axe for bucking (Figure 2.4) typically results in an average kerf of 25 cm in the natural forests of southwestern Ethiopia,

thus accounting for a loss of greater than 0.5 m^3 of merchantable wood per tree (Abebe and Holm 2003). Finally, the residue that remains from processing at the stump usually has no value in natural areas because of their distance from villages. In contrast, almost all wood residues from harvesting in plantation forests is collected and utilized by local villagers as fuel, fodder, or for profit in the marketplace.

Figure 2.4 Wide kerf on large, natural forest tree as it is segmented into logs. (Photo by Tarekegn Abebe)

Manual methods make the processing of logs very difficult. Again, personal protective gear and proper maintenance of the cutting equipment can enhance safety, productivity, and ease of work. In natural forest areas, where axes are used for segmenting, large kerfs reduce the amount of usable wood for the mill, requiring additional trees to be felled to attain the necessary volume.

Similarly, large amounts of fiber can be lost when the initial processing does not involve techniques for removing log defects and ensuring that crosscutting is straight and clean, so that no additional cuts must be made at the mill.

2.6.5 PRIMARY TRANSPORT

Primary transport of logs from the stump to the landing mainly depends on log size, distance, and the difficulty of their movement. The most common method used in plantations, and occasionally in the natural forest, is a manual system of lifting and rolling (Figure 2.5). For smaller logs, contractors rely on their own strength and levers, crafted on-site from harvest residue, to push and roll logs to the landing. While this is strenuous work with serious potential for injury-causing accidents, it is a very common practice that is effective over short distances (usually <25 m) on gently sloping terrain. For larger logs, primary manual transport involves lifting one end of the log onto another, then pivoting the top log toward the landing, using levers and rolling where appropriate.

Figure 2.5 Manual primary transportation of logs from the stump to the landing.

Some logging operations use specialized tools to improve safety and decrease the difficulty and amount of labor required. For example, a sulky can be manually employed by contractors or with the assistance of animals to elevate one end of a tree off the ground and move the log to a landing using the sulky's wheels to minimize drag and resistance. Animals, such as oxen, can also be harnessed to pull logs that are rigged directly behind. This method enables workers to move timber over longer distances and under conditions where manual methods are too difficult. Nevertheless, while oxen can be used in forest operations, this is uncommon because they are much more valued for their work in agriculture fields.

Ground-based, heavy equipment is also implemented in situations where manual methods are inadequate. In the natural forest, a bulldozer, front-end loader, or rubber tire skidder is usually needed for moving large-diameter logs through the residual stand (Figure 2.6). Mills may own a wide variety of equipment, most of which has been imported and is in varying states of repair. Many operations, however, have access to only one piece of machinery, and will use it regardless of its appropriateness, i.e., capability and impact, on a specific site. This heavy equipment also is often used for duties besides logging, such as road construction, maintenance, or other governmental projects. It is usually configured with either the very basics only or so that it will do the broadest range of work possible. Because logging-specific attachments and configurations are uncommon, site impacts and the considerable effort involved in log transport make this a difficult trade-off when operators are forced to utilize only the equipment at hand.

Figure 2.6 Alpine brand log loader used for primary transport of natural forest logs.

Although many tools and techniques are available that can minimize the labor required to lift and roll awkward logs, these are not widely implemented. Instead, sticks found at the logging site are improvised into tools that are often improperly sized, rough, and dangerous to use when many people are nearby. Furthermore, relying on certain vehicles for primary transport can mean that little effort is made to minimize the environmental impact, and large equipment can compact, disturb, or displace the soil and contaminate water resources.

Ethiopian forest-harvesting organizations struggle to receive the investment capital and distribution networks required to purchase, service, and productively use most modern equipment. Nearly all heavy machinery must be imported from

abroad, and many items that arrive as one-time purchases often have little or no follow-up service or support for maintenance and repair. Even when local groups are able to build many of the tools needed for sustainable harvesting, there is still some difference in quality (whether real or perceived) between imported and domestically developed equipment.

2.6.6 LOADING

Logs brought to the roadside are often measured first to calculate their volume before being loaded onto a trailer or truck for transport to the mill. Manual loading methods rely on loggers physically lifting these logs. Loading the larger logs that are too heavy for this manual lifting usually requires a simple ramp that helps the workers roll the log up onto the vehicle. These ramps can be constructed from sawn wood, with small steps to facilitate rolling and lifting, or they can be smaller logs sourced from the harvest site that are simply propped up on the trailer. These types of ramps are free, and do not require equipment to be transported from the logging site; however, they are more difficult and dangerous to use. For larger logs from the natural forest, earthen ramps (Figure 2.7) are often constructed that allow the logs to be rolled up a much more gradual slope for loading onto a truck or trailer that is pulled to one end of the ramp.

Figure 2.7 Manual loading system using earthen ramp, eucalyptus pole guides, and wooden levers to push log into truck.

Manual loading is very difficult, and the lack of appropriate tools and personal protection can endanger contractors. Many ramps are not appropriately sized and, in the case of constructed earthen ramps, large volumes of soil are displaced, increasing the potential for erosion. Even though some of these issues disappear if mechanical types of equipment are used instead, most locally available machinery is not built specifically for log-loading. When make-shift loading equipment is utilized, unsafe techniques are often adopted and undesirable large clearings are required for maneuvering.

2.6.7 SECONDARY TRANSPORT

Throughout Ethiopia, road access is difficult and distances to the forest often are great. Mills must then invest in transportation equipment that can efficiently move raw logs. Currently, workers utilize heavy-load Fiat/Iveco trucks, light-duty commercial trucks, or general farm tractors with trailers that have been built or imported specifically for log transportation. These trailers have many different configurations, but most have removable stanchions to support the load, and can carry approximately 6 m^3. Such vehicles may be better able to access remote areas, but they require much fuel, time, and labor. Farm tractors commonly haul logs for >20 km, usually at slow speeds and at great cost (Figure 2.8). When an increased volume of wood is required by the mill, contracted light-duty vehicles not specifically designed for log transport often fill this need. Although these trucks are much more efficient over long distances, loading and support of the loaded logs is difficult and often dangerous. Some, especially the common Isuzu models, cannot run on poor roads, especially when heavily loaded. All of these situations can result in accidents, damage to the road and the vehicle, and potential degradation of the environment from leaking fuels and soil displacement. Furthermore, drivers and laborers may not follow safe driving and passenger practices, increasing the risk of personal injury.

Figure 2.8 Farm tractor and log trailer used for secondary log transport from the landing to the mill.

In the natural forest, mills may need to possess their own larger, heavy-load trucks for secondary transport. With a log capacity of approximately 10 m^3, they can carry large loads over relatively poor roads. These vehicles, however, are often oversized for the small access roads that are constructed for reaching those natural sites, which are more remote than plantations. Such trucks must also be relied upon for transporting lumber to markets in Addis Ababa, a circumstance that often delays the retrieval of new logs from forest landings for months or even longer. Even though mills must purchase and maintain their own supply vehicles, they have no backup arrangements for breakdowns, increased mill demand, etc. as

efficient systems are not available to hire additional transportation services from the local area..

2.7 CHALLENGES TO CHANGE

The current land and natural resource tenure systems tend to discourage communities and individuals from developing their forests (ETC East Africa 2002). This has increased the rate of conversion from forestry to agriculture in order to secure possession of the land and trees (Teketay and Bekele 2002; Yirdaw 2002). Such insecurity of forestland tenure means that people are prompted to harvest everything possible before the system changes and access to forest resources is possibly closed. Furthermore, the current system has discouraged investments in forest management and industries because the risk and uncertainty is too high without promises of continued, clear access to the land and existing resources.

At the federal, regional, and local levels, governmental organizations have different responsibilities, interests, and abilities in managing and developing forest resources. For example, the Forestry division in the federal Ministry of Agriculture has only negligible financial support and authority to oversee the use, management, and revenue generated from nationally owned forests (Million Bekele, Personal Communication, March 2003). Instead, the majority of the influence in forestry is based at the regional and local levels, where very little investment is made in managing those lands. Moreover, managers in these organizations have very little funding and data to make decisions and properly

understand the breadth and potential for forestry in their regions. Unsatisfactory coordination between organizations at all levels also complicates management plans and activities. For example, one region might have extensive harvesting areas while the adjacent region may completely ban commercial logging. Although data relating to forests are collected at the federal level, there is little incentive for interregional cooperation, and the federal organization has scarce recourse to force compliance with their requests. Organizationally, forest management responsibilities have been passed onto the regional authorities without sufficient oversight and coordination by the federal government. This has resulted in a fractured approach to administration and resource utilization.

2.7.1 ENTERPRISE BUSINESS ORGANIZATION

Harvesting operations and facilities for processing wood products are organized by the federal government as state-developed and -managed industries. The government maintains many organizations and industries in many areas of the economy as “Public Enterprises.” A few plantation forest enterprises have some private ownership, but the federal interests are still very much present. With extensive financial backing from the state, few incentives have existed for these organizations to perform competitively with other industries. Over time, this structure has led to lowered production levels, over-mature forest inventories, and equipment and facilities that are well beyond their economic age. Consequences from the federal government historically have not been severe, leaving little reason to develop and improve these organizations. However, the sustainability of

enterprises with very significant federal backing is uncertain, thereby exposing many economic, social, and potential environmental concerns.

Without the reinvestment and development of enterprise facilities, resources, and production, these operations stagnate and decrease in efficiency. Many mills have bottlenecks that constrain their functioning at different places along the supply chain. The beginning point is the timely supply of logs for the mill. Rainy conditions and wet soils, an inadequate supply of skilled labor, poor availability of equipment for log transport, and other limitations can shut down mill operations, stopping the entire process.

2.7.2 TECHNICAL AND PROFESSIONAL EDUCATION AND TRAINING

Technical and professional education and training is well developed for people working in the forestry sector in Ethiopia. These include the offering of diploma technical programs and professional BSc, MSc, and PhD level university courses both at home and through agreements with universities abroad. Students who receive diplomas in forestry have employment opportunities with wood-industry enterprises, government agencies, and other outlets. Those with BSc degrees and higher also can have careers with NGOs and in forestry education. While studying in the areas of forest management and harvesting, students are presented with the appropriate methods, skills, and knowledge base for running efficient operations. However, once employed, many abandon these previous lessons or modify them to the point where they are no longer effective. Most field work is completed by contractors and laborers hired for a particular job. Because

contractors often learn the necessary skills from their co-workers on-the-job, they are not trained in the correct use of equipment, management methods, and expectations by those responsible for their oversight.

A model has been expanded throughout the country for extension education that can disseminate outreach and developmental skills outside the typical university or technical school environment. Many NGOs and governmental agencies offer some basic training, and are enhancing the understanding of rural communities with regard to the forest and its resources. In some areas, very significant programs are being implemented to encourage models of participatory forestry management that provide economic, ecological, and social benefits to the community. Nevertheless, with a weak formal forest-industry sector currently in place, such programs often fail to promote the use of this resource for sustainable timber production as well the necessity for proper training of the labor force.

2.8 RECOMMENDATIONS

Timber acquisition influences various social, economic, and environmental issues. In its current state, it is not a sustainable practice in Ethiopia. The social aspect of harvesting is perhaps the most important area in which modifications could have a dramatic impact on this industry. Regulatory changes to land tenure, enterprise organizational structures, and forest governance would provide additional investments and interest in managing forests for timber production. Although the current region-based management of natural forests confers local control over resources, little coordination is done among states, and many barriers exist to

strong leadership from federal organizations. Other social improvements must be implemented in the areas of worker health and safety. For example, the manual methods used in most harvesting operations may be very appropriate for the conditions, but little protection is afforded to the crews. Better personal equipment, safer tools, and an emphasis from management on planning and designing appropriate working conditions would decrease injuries and ease the difficulty of required tasks.

Concurrently, economic adjustments can improve the sustainability of harvests. Just as in the social context, all operations associated with commercial timber production would benefit from additional security in land tenure in order to lower the risk of investing in the forestry sector. Without those investments, however, the current infrastructure will continue to decay, forcing the need for more imports of raw material, fewer employment opportunities in rural forest-based economies, and a loss of the funding already in place. Such is the case with some of the existing state enterprise organizations, who have relied on federal backing for their previous success. Some of these organizations are currently viewed by the government as “financially weak” public enterprises (Negatu 2005), and may see significant changes in their operations. Organizations have the potential to improve the productivity of their operations and supply more of the wood required by this growing population (Silvi Nova AB 1996). Those improvements, combined with more reliable land tenure and legal access to raw materials, would provide a foundation for strong growth in the forest industry.

The natural environment, including its soil and water resources, can be protected and even enhanced through appropriate logging operations. To do so, plans should include approaches that avoid harvesting in and near streams, and care should be taken to minimize soil disturbance and displacement. While these operations can have impacts on the environment, the conversion of forestlands to agriculture can have an even greater effect. Therefore, promoting a healthy forest industry and secure land tenure means that forestland can be managed long-term, providing environmental benefits from the local site up to the landscape level.

2.8 CONCLUSION

Numerous social, economic, and environmental benefits can be derived from Ethiopian forests. Commercial harvesting plays a small, but important, role in the protection and utilization of those resources. Forests serve several purposes, including grazing, collection of non-timber forest products, fuelwood, and commercial logging. Although most related activities are carried out by individuals and small-scale operations, commercial industries have an effective organizational structure for improving harvest sustainability. Forest operations incorporate many different types of participants, from government officials and enterprise managers to logging contractors, drivers, and security guards. Those current practices, methods, and equipment are usually adequate for moving logs to the mills, albeit often by slow, dangerous, and inefficient means.

A recording of the state-of-the-art in Ethiopian forestry practices provides the baseline data required for assessing future improvements and innovations in

harvesting. Forest operations are an important component in the sustainability of resources, resulting in enhanced economic benefits, a supply of wood fiber for various purposes, and, in many cases, protection against the conversion of forestland to agriculture. Therefore, it is critical that proper management approaches be applied to maintain and improve these Ethiopian forests.

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3.0 Forest Harvesting Decision Framework to Improve Sustainability in Developing Countries

Ben Spong and Loren Kellogg[2]

3.1 INTRODUCTION AND JUSTIFICATION

The forests of Ethiopia provide significant benefits to its citizens. Rural villagers may depend on these resources for sustenance, fuel, shelter, livestock grazing, and minor forest products, while urban Ethiopians receive building and construction materials, furniture, handicraft supplies, and other products. Unfortunately, the current use and demand for wood exceeds local forest capabilities as well as the industrial capacity to process and deliver these products to market. This disparity can result in overexploitation of the existing forests and the need to import these products or substitute with others. Both unsustainable forest utilization and substitutions help perpetuate a cycle of poverty, food insecurity, and natural resource degradation (EFAP 1994).

For example, when less fuelwood is available, local communities then rely on manure for heating and cooking. Although such a substitution solves this short-term lack, it causes nutrients in the manure to be burned rather than being reincorporated into fields and gardens to maintain soil productivity. Then, without fertile soils, crops are less vigorous and can become water-stressed, leading to smaller harvests. These lower yields hurt the food security and wealth of the

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communities, so that larger land areas must be planted the next season. These new plots often arise from cleared forests, which further decrease the availability of renewable fuel wood, the initial trigger. To break that cycle, sustainable solutions to these complex natural and social interactions must be developed and implemented.

Ethiopia has one of the largest populations in Africa, with over 73 million people and an annual growth rate of 2.36% (CIA 2005). The demand for forest products along with contradictory land uses incongruous with forestry will only increase in the coming years. Because its formal forest industry is very limited in its size and output, it has received very little attention, resulting in poor funding, stagnant government policies, and the perpetuation of barriers to new investments. Nevertheless, a strong, sustainable industry could help provide the raw materials that feed growing local and regional economies, and assist in rural development throughout the country. Bekele and Berhanu (2001) reported that industrial wood production, estimated at over 200,000 m^3 but less than 400,000 m^3, fulfill only a portion of the 400,000 m^3 demand. Although current data of overall production is not available, many mills in the natural forests have shut down, and those that work with plantation wood have maintained or only slightly increased their production, which has exacerbated the gap between local availability and increased demand. Therefore, advancements in harvesting, transportation, and other components of the log-supply process can provide the raw material necessary to improve existing operations and promote new investments.

Many of the challenges facing commercial forest harvesting in Ethiopia are not unique, as many of the same issues are being addressed around the developing world. The selection, implementation, and monitoring of improved timber harvesting practices begins the process for forest managers to achieve the goals of sustainable forest management. Currently there are not well defined formal processes to understand the existing conditions surrounding timber harvesting operations. Consequently, the difficulty in identifying and selecting different options to improve timber harvesting operations can perpetuate the existing practices that help establish the existing sustainability challenges. Here, we describe an investigation of the critical decisions and issues facing managers in forest operations (Figure 3.1). These results have been used to build a decision framework for identifying and selecting the specific timber harvesting improvements for enhancing their sustainability. Social science research methods combine aspects of ethnographic, grounded, and participatory research theories to create that method for making decisions. The framework itself is based on the elementary concepts that draw upon multi-criteria decision making (MCDM) and prioritization techniques to develop meaningful solutions that are possible to implement.

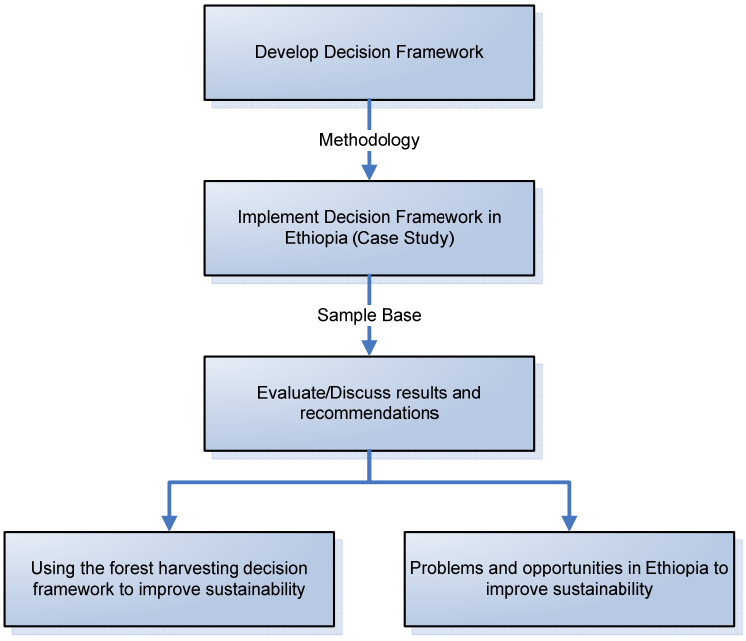

Figure 3.1 Overview flow diagram of project layout.

We then present a case study implementation of the decision framework on Ethiopian harvesting operations to verify that the framework efficiently identifies appropriate harvesting improvements. While Ethiopia forests were used for the initial development and case study presented in this research project, many areas of the globe face analogous challenges and situations that can be categorized within the decision-making areas presented here. The framework incorporates specific local conditions into the process, allowing for use in other regions.

3.2 STUDY METHODS

We applied ethnography, Grounded Theory, and participatory research to identify the salient timber-harvesting issues. A combination of these methods

provided locally relevant data that could be incorporated into a decision framework to provide practical solutions suitable to local sustainability.

Ethnographic methods involve the investigation of a group based on immersion within that group. From inside, researchers attempt to report and understand the values and connections between member behavior and interactions. This is commonly carried out through observation and participation, but may also be supplemented with other published methods (Constable et al. 2005). Typically, such studies have phases of data-gathering and identification (coding), which are followed by reflective and interpretive phases that blend this data to gain a better understanding of the group or situation. Data-collection employs procedures such as introspection, external observation, participant-observation, and interviewing (Saville-Troike 2003).

Grounded Theory research methods, developed by Glaser and Strauss (1967), employ an on-going process of data-collection and analysis to derive a conclusion directly. In contrast to ethnographic methods, the researcher provides insight into why certain observations are made (Constable et al. 2005) and continually tests the resulting theory through further data-gathering (Barker et al. 2006). Participatory research methods rely on information received from the members of a community, who discuss their problems and implement solutions (Park 1999; Sutherland 1998). This bottom-up approach enables outside researchers to better understand local priorities, perspectives, and possible outcomes (Cornwall and Jewkes 1995).

Collected data are integrated into a decision framework that draws its structure from the concepts and methods of MCDM. In the most basic sense, decision-support provides guidance and assistance to facilitate that process. Prioritization is a simple tool for gauging solutions, objectives, or other components. Nevertheless, it is often difficult to rank techniques that will accurately consider complex relationships, large-scale components, and mixed-data types. MCDM is a specific approach that incorporates multiple, conflicting criteria into the planning activity (Miettinen 2006). This may include an analytic hierarchy process (AHP) (Saaty 1980), which provides a structure that can assess both quantitative and qualitative data for developing solutions to more complicated or improperly transcribed objectives. By making simple comparisons among these criteria, one can then determine priorities that will lead to meaningful results.

3.2.1 PROJECT SITES

We arranged study opportunities in Ethiopia that characterized inherent differences in the size of trees being harvested as well as other operational conditions in both natural and plantation forests. Field data were collected during four site visits (four weeks each) between 2003 and 2005.

3.2.1.1 NATURAL FORESTS

To illustrate the current approaches to harvesting and milling from a natural site, we selected areas near the towns of Meti and Tepi in southwestern Ethiopia (Figure 3.2). Typical conditions there include indigenous stands of widely scattered, large-diameter trees, at a density of <5 commercial stems per ha. The

production of coffee by local communities has affected these natural forests, with trees being felled in some places to allow more growing space for that crop, with preference for leave-trees being given to species that provide adequate shading. Although coffee is found naturally in these forests, enrichment plantings and understory management are often conducted to increase its yield, with little thought given to the overstory forest cover.

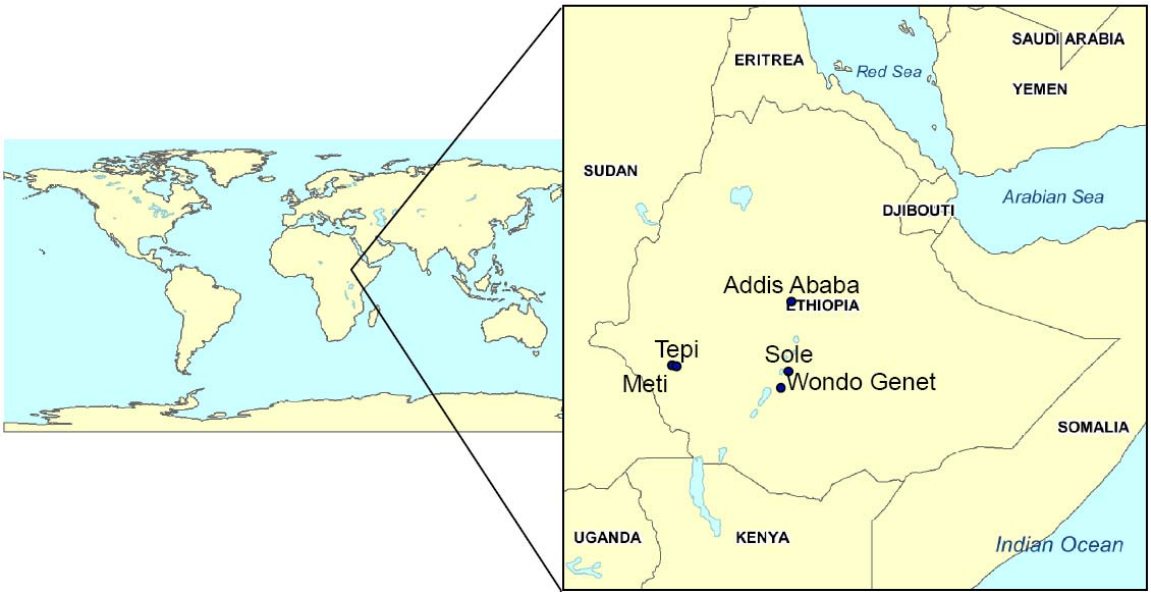

Figure 3.2 Map displaying study sites.

The Sawmill and Joinery Enterprise (SJE), headquartered in Addis Ababa, is the primary organization responsible for the milling and supply of wood products from the natural forest. SJE owns and operates 22 sawmills throughout the country, but functions primarily in the southwestern region (Negatu 2005). Most of that sawmill infrastructure is 40 to 50 years old, well beyond the typical economic lifespan for this type of equipment (EFAP 1994). We included this enterprise in our study project because they are the only organization focused on

timber production from natural forests in the country. Most other harvesting is done by small, unorganized groups or individuals, and the majority of their activity is not authorized by the regional governments who are commissioned to manage these lands. SJE is the foremost, official organization with the experience and infrastructure to harvest and process logs from natural areas. However, the informal sector provides significant competition through illegal felling, pit-saw processing, and sales in local and regional markets.

One study site, in the eastern portion of the Gambella State near Meti, is at an elevation of ~1000 m, with a gently sloping topography. Average annual temperatures range from 20 to 25°C, with a mean annual rainfall of approximately 200 mm that occurs throughout the year, but primarily in September (Abebe 2002). The local Bebecka sawmill (within SJE), is responsible for harvesting and milling large trees from the Godere State Forest.

Here, we investigated aspects of harvesting to understanding the current concept of logging. During the period of field-data collections, no active operations were being conducted by SJE or other legally recognized groups, at either the mill or on adjacent lands. In fact, the sawmill had been closed and the few remaining employees were waiting to hear from the Addis Ababa head office whether operations would be re-started. Therefore, we relied on interviews with the sawmill management and staff, analysis of their historical records, and site inspections to gain knowledge about the challenges associated with natural-forest harvesting.

3.2.1.2 PLANTATION FORESTS

Large-scale plantation forestry projects were established in the late 1960s in south-central Ethiopia. These are now supervised by the Shashemene Forest Industry Enterprise. SFIE currently manages over 98,000 ha, of which about 6,100 ha are in plantation forests, while an estimated 8,000 to 9,000 ha comprise natural or disturbed stands. The plantations contain *Eucalyptus*, *Cupressus*, *Pinus*, and other exotic species, but with some trials also including indigenous species (Silvi Nova AB 1996). Although SFIE has some governmental ties, it is primarily headed by a board of directors and investors. Its objectives are to manage the enterprise's forest resources for sustainable use and the generation and reinvestment of revenues for further advancements (Bekele 2001). In addition, the enterprise recognizes its role in rural development and overall improvement of Ethiopia's forest products industry.

SFIE was included in our study because they are the largest and most organized plantation-forest operation in the country. They have resources and production schedules that are relatively dependable and a desire to improve their functioning. Their current operations are simple, but the potential exists for appropriate investments in human and financial resources that can implement new techniques and procedures for enhancing harvest sustainability.

The plantation study site is located in the southern part of the Oromia State near Sole (Fig. 1). This village has two semi-permanent portable sawmills, and is less than 10 km east of the central Rift Valley town of Shashemene. We selected a compartment that was to be logged during our data-collection period and which

was typical of harvesting areas in that district. The Ansawae Plantation, approximately 1 km from the sawmill, is at an elevation of approximately 2200 m, with gently sloping topography. The average annual temperature is approximately 16°C, with a mean annual rainfall of about 1,075 mm. The primary rainy season is in July and August, with another, shorter, season in March (Abate 2004).

Here, we observed SFIE operations, interviewed many different parties, and engaged in collaborative participation throughout the harvesting and planning process in order to gain insight and details about their logging practices, as well as opportunities and constraints that pertain to improving sustainability.

Our study also assessed smaller-scale plantations that had been established on the campus of Wondo Genet College of Forestry (WGCF), a part of the newly formed Debub University. The WGCF campus is at the base of a large escarpment on the edge of the Rift Valley in south-central Ethiopia. It comprises over 490 ha of natural forestlands plus 110 ha of plantation forests that are managed for revenue, as well as opportunities for field exercises and research by college students and faculty. We included these plantations because they utilize more advanced harvesting techniques that have resulted from interactions with local and expatriate researchers involved in forest management planning. They also have access to high-quality maps and imagery, and other appropriate tools and equipment. These additional resources have enabled researchers to investigate alternative harvesting processes that may not yet have been implemented in other areas of the country, and they also help identify barriers that might impede the transfer of knowledge to clients of the College.

The specific WGCF site selected here is near the village of Washa. Those compartments were being harvested while we were collecting field data, and represented typical harvesting units on the campus. This plantation is at about 1900 m, and has gentle slopes. The average annual temperature is approximately 19.5°C, with a mean annual rainfall of around 1,200 mm (Gindaba et al. 2004) that occurs primarily in July and August, and to a lesser extent in March.

Our focus here was, again, to observe WGCF operations, conduct interviews, and participate collaboratively in the harvesting and planning processes.

3.2.2 DATA ANALYSIS

Data were organized and processed according to a defined strategy for maintaining their usability and integrity. Collection and analysis were conducted simultaneously to develop interpretations that would closely represent field experiences and interviews (Marshall and Rossman 1999).

An in-depth review and additional annotation were completed after the data were gathered to ensure that all pertinent information was properly recorded and clarified by identifying prominent themes, recurring ideas, and other patterns. These concepts were then stored in order to search for “the salient, grounded categories of meanings held by participants in the setting” rather than relying on the exhaustive and mutually exclusive classifications normally required by a statistician (Marshall and Rossman 1999). Data were manually coded via a generative scheme that focused on the nature and delivery of the content so that we

could develop the concept categories and minimize the influence of prior assumptions of possible results (Kerlin 2005). Emergent patterns and concepts were tested by searching for contrary situations and then constantly comparing them in order to build a stronger overall framework theory. As that theory unfolded, the triangulated, analogous data from multiple sources, locations, and time periods helped strengthen our confidence in the overall process.

3.3 DECISION FRAMEWORK DEVELOPMENT

3.3.1 FIELD DATA

Although some overlap occurred in our data, we noted distinct differences among the locations and types of harvests being conducted. In the natural forest, the most frequently raised issue concerned the uncertainty of securing raw materials. Comments from interviewees ranged from ‘not understanding why regional authorities would not allocate areas for logging’ to ‘complaints about the unfair advantage of illegal logging’. Additional issues included the difficulty in obtaining appropriate equipment and tools for efficient logging and transportation. Because these activities in natural forests are managed by the state Sawmill and Joinery Enterprise, much of their equipment was also being used for other government projects unrelated to SJE operations. In contrast, very few concerns were voiced about jobs, environmental impact (other than log supply), or economic viability. Nevertheless, review of the logging sites, facilities, and records exposed opportunities for significant improvements in social, economic, and environmental sustainability.

As with the natural forest setting, workers in the plantation forests expressed concerns about illegal logging and access to tools and equipment, although not to the same extent. Because managers there have more control over their resource base, the availability of raw material is relatively secure. However, many had questions about access to harvesting and transportation equipment and greater risks of log theft because these sites are located in areas with much denser populations. Other issues raised during interviews and discussions often focused on social factors, such as the ability of the enterprises or the college to provide work opportunities, promote good-neighbor relations and support for local communities, and help in dealing with adjacent villagers and landless people who illegally rely on the forest for their livelihoods. Likewise, those engaged in harvesting were concerned with the difficulty of that work as well as having access and maintenance for tools and other gear. University personnel also identified topics such as the use of personal protective equipment and opportunities to utilize chainsaws and some tools not commonly found in other local forestry operations. Again, except in discussions with management-level employees, little mention was made about productivity and operational economics, environmental impacts, or safety.

3.3.2 DESCRIPTION OF FRAMEWORK

Coding and analysis of the data revealed many prominent topics and themes, with the main categories being strategic planning, information resources, and harvesting (e.g., planning, access, in-forest operations, and landing and

hauling). These areas were constructed into a process that could identify specific issues and develop solutions for improving sustainability.

This decision framework combined core concepts of environmental, economic, and social responsibilities, thereby facilitating the collection of necessary site-specific information in order to provide a structure for developing appropriate, long-lived improvements to current practices. We divided this framework into five phases: 1) strategic guidance and purpose, 2) information and data (i.e., available resources), 3) harvesting process, 4) solutions and outcomes, and 5) ranking and prioritization (Figure 3.3). Here, we used the principle categories and themes identified during the data-collection period, along with decision-support concepts, to devise solutions that would meet the particular needs of an organization, site, or individual.

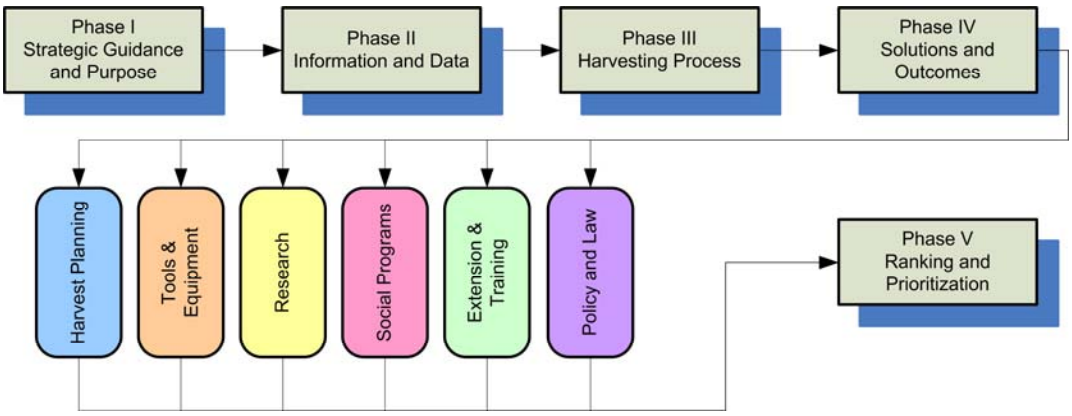

Figure 3.3 Five phases of the decision framework for improving sustainable harvest operations.

In order for us to assess the local problems, solutions, and needs, a process was developed to collect experiential and interview data at many different organizational levels during the earliest stages of the framework. We began with

Phase 1, “Strategic Guidance and Purpose” by having participants identify basic sustainability issues that relate to the strategic programs of the organization. Current strategic guidance purpose topics, conditions, concerns, and potential improvements are then identified for each of the identified sustainability issues (Figure 3.4). Following the collection and development of these data, expected outcomes from each level of data are expounded and recorded for processing in Phase 4. This same data collection process and specification of desired outcomes is followed for Phase 2 “Information and Data,” with the focus simply adjusted to the use and availability of information technology and data resources.

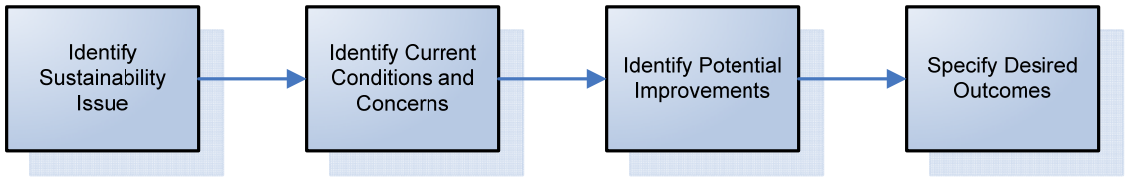

Figure 3.4 Progression of questioning during Phases 1, 2, and 3 in the decision framework.

Again, the same data collection process and specification of desired outcomes was utilized in Phase 3, “Harvesting Process”, however as shown in Figure 3.5 the general topic is broken down into many smaller units (sub-phases) that represent the detailed components of the overall harvesting process. For instance, in Phase 3.2 the topic of harvest area access is examined, looking first at sustainability issues surrounding access design – are the current design standards or procedures for the development of roads economically sustainable? Current practices are then collected to establish the baseline for the next step of the identification of improvements that will improve, in this case, economic

sustainability. Finally, the desired outcomes from potential improvements are collected to predict how these improvements and any side-effects may impact operations. Each sub-phase follows this same process to collect data and predictions.

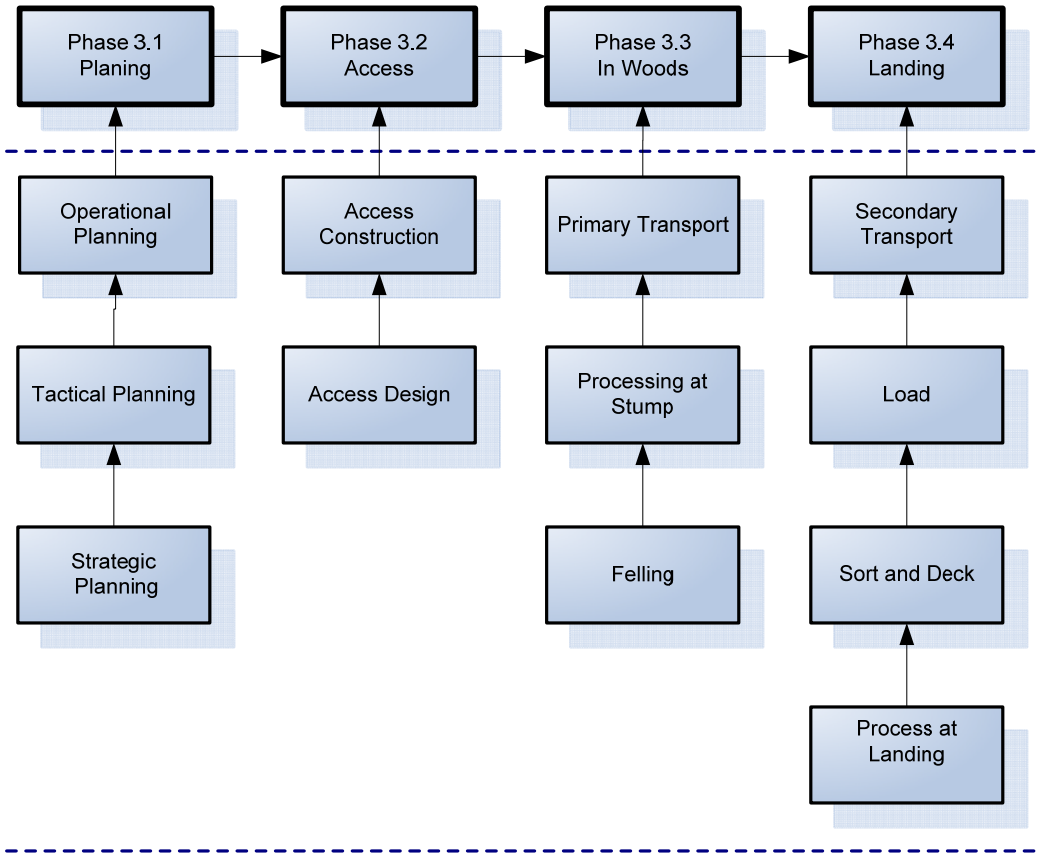

Figure 3.5 Operational sub-sections from Phase 3 of the decision framework.

Of course Phase 3 required significantly more effort in sampling, especially considering the range of operations and personnel that could provide input to the process. This phase produced large quantities of data from the organization and its contractors, although not all groups could provide information for all levels of the organization. For example, whereas both upper management and day laborers were

capable of giving feedback about harvesting itself, the latter group might have had only limited exposure and input for other aspects, such as strategic goals, long-term planning, and operational data requirements.

Based on the data collected during the first three phases, the identified potential solutions and the scope of their impacts as noted from the expected outcomes were the focus in Phase 4. These responses were grouped into broad categories of harvest planning, tools and equipment, research, social programs, extension and training, and politics. This process combined a diverse range of solutions into action areas that could be addressed by different individuals, approaches, or types of financing. Those in the policy and law category were probably more difficult to implement unless an organization had sufficient influence, whereas solutions concerning tools and equipment could be relatively simple to achieve by purchasing an inexpensive hand tool or a locally produced sulky (Seymour 1996a). Once these items were grouped, each category was ranked for implementation (Phase 5). While we utilized a simple ranking procedure, many other tools are available for facilitating this process, including composite scoring or more complex systems, e.g., procedures for the analytical hierarchy process and other MCDM tools.

3.3.3 FRAMEWORK IMPLEMENTATION

The framework developed for this project can be used by various forestry operations to identify sustainable and appropriate harvesting tools, techniques, and

policies. A small assessment team can coordinate the data and processing, then report the results. Such an implementation would follow seven basic steps:

I. *Identify or respond to a non-sustainable forest-harvesting situation* or organization that desires assistance in selecting and implementing appropriate operational improvements. An organization or group may determine that a particular practice cannot be sustained or an operation could benefit from an improved process. When such a group initiates the call for this decision framework, one can assume that the group has a favorable attitude toward developing a plan, and that there will be secure access to decision-makers and employees, as well as records and other useful data. In contrast, other outside organizations or individuals with an interest in forest sustainability may be ones that identify non-sustainable forest harvesting situations or opportunities for improvement in the enterprise. In such a situation, there may be controversy in accessing decision-makers and a limited ability to promote improved practices.

II. *Select a broad range of decision-makers* and individuals from different management levels within and outside an organization. Managers from within should be included who can identify key strategic issues and boundaries that will help recognize the limits of acceptability. Personnel from field-level management will have a better understanding of events on the ground and matters surrounding daily operations. They would encompass foresters and silviculturists, contract administrators (including those for transport, road construction, and maintenance), logging personnel, and others directly involved with the harvest. Administrative and finance employees might also provide insight. Finally, those

from the local community, e.g., families and residents in and around the interface between forest and agricultural/urban areas should also be allowed to contribute because they can potentially be affected by both sustainable and unsustainable forest operations.

III. *Assemble and train an assessment team* to collect data and feedback from respondents. Teams should comprise at least two people, one of whom is the "primary contact" or "PC", with the remaining persons considered "team members" or "TMs". The PC coordinates all data-collection, processing, and reporting. In most cases, that person will also help facilitate discussion with the respondents. Such duties will require someone with both strong data-management skills and technical knowledge about forest harvesting. At least one of the TMs will be responsible for recording and managing the information gathered during meetings. The assessment team should be kept small enough to maintain a certain comfort level with the respondents. If more than one language or dialect is spoken during those discussions, it is vital that a translator be selected who has rapport with the local community and understands forestry-related vocabulary.

Before collecting data from the respondents, team members must receive training that covers all the necessary procedural information and any required forms or other supplies. This program should include background on the forest harvesting organization, sites and environmental conditions, and social issues. This background should also be combined with the particular details about how to record information and promote discussion. Therefore, the PC must have a thorough understanding of the overall decision-framework process so that both

team members and respondents can be guided to produce meaningful data and results. Although each TM should receive a brief overview in order to put data-collection into context (i.e., by making available blank copies of preprinted forms with each question and answer space available (Appendix A), most of the training should concentrate on leading discussions and recording data for reports to the PC. TMs should also be encouraged to take additional notes, the accuracy of which may be enhanced through the use of a tape or video recorder. However, the presence of such electronic devices might make the respondents less willing to be open and honest in their discussions, such that simple, hand-written notes on preprinted forms or organized in notebooks may be best.

IV. S*chedule a period for discussions between the respondents and the assessment team*. All interviewees should first receive permission from, at least, the supervisor from the head office. Meeting times should be set during normal work hours so that the respondent does not have to take personal time and is more likely to already be thinking about many of the issues of interest to the team. Moreover, an employee will probably feel freer to talk openly if they know that the interviewer has already received approval from management. Whenever possible, the assessment team should try to meet at normal job locations so that the respondents do not have to travel and, instead, will have additional time and stimulus around them to help provide necessary detail. Finally, the interviewers may wish to utilize techniques (adapted from Prioritized Rural Assessment (PRA) and Rapid Rural Assessments (RRA) (Holtland 2001)) and tools, such as transect

walks (Oltheten 1995) that rely on the local environment and situations to facilitate these discussions.

V. An assessment team facilitates and records the discussion with respondents in order to negotiate a path through the decision-making framework. Not every respondent will be able to answer every question, so it is the TM's responsibility to cover the full range of concepts and ideas and minimize the amount of time spent on topics the respondent is not qualified to address or about which they have no opinion. Discussion should start with a description and reason for going through this procedure. The respondent should receive a clear explanation of what is required from him, and must be told that notes will be compiled for help in making future decisions. Once feedback from each respondent is obtained, the data are coded and analyzed by assigning each response into group of similar responses and continuing to refine and add to each of these categories as the emerging themes begin to solidify (Glaser and Strauss 1967). Through this process, the most prominent and appropriate themes or improvements to the harvesting process will surface. While the themes that are less sustainable, feasible, appropriate, or understood by the respondents are still included in the results, less effort is expended on moving these themes forward in the process based on their priority coming out of this coding process.

VI. All responses should be reviewed and additional feedback from respondents should be checked for clarity and completeness.

VII. Finally, the PC and TMs will further code and examine the combined data from all responses to identify a comprehensive, hierarchical list of appropriate small- and large-step improvements to be implemented.

3.4 EXAMPLE IMPLEMENTATION OF FRAMEWORK

3.4.1 NATURAL FORESTS

For our survey of harvesting operations on a natural forest in Ethiopia, we utilized an implementation team of two researchers for data-collection. Interviews were conducted over four days, and included discussions with employees and management personnel at the SJE mill in Meti and in Addis Ababa. At the mill, questions were designed to concentrate on existing harvesting conditions, the capture of historic data for such activities, and opportunities for harvesting operations improvements. Nine individuals were engaged in the interviews and discussions regarding the natural forest operations. Because the mill was not functioning during this period, we filled the decision framework with data from previous harvests, e.g., timber volumes, land area, tools and machinery, maps, labor pools, and finances. Observations were made of the sites and equipment to complement the information gathered from our semi-structured interviews with three enterprise representatives at the mill and two managers in the Addis Ababa office.

After the data from these sources were amassed and coded, we summarized the key issues into five thematic solution categories--harvest planning, tools and equipment, research, social programs, extension and training, and politics, with the

most salient being policy and law, social, and equipment. Although the other topics had not been mentioned as frequently by the respondents, additional observations and documentation reviewed by the researchers provided perspectives that allowed for focused questioning and background that would point toward a wide range of appropriate means for improving harvesting operations sustainability.

The top three identified priorities for natural-forest harvesting specific to the Meti operation began with the unanimous identification of the need to identify sustainable logging areas that are assigned by the regional government. The royalties currently being paid are not adequately supporting the continued management of those resources, and could lead to a halt in legal operations by the wood products industry. A policy and law solution is required to respond to this issue, as the current arrangement for the management of the regional forest lands has curtailed cutting, presumably as a response to a real or perceived scarcity of forest and the ability to manage the existing forest resource in a sustainable manner. A sustainable commercial forest industry that requires natural forest logs as its raw material must have access to harvestable forest areas. In the absence of a sustainable management program by the land managers, the commercial harvest of the forest should be minimized in order to avoid over exploitation. However the forest must also be protected from competing land uses such as agriculture, grazing, development, and other uses where the opportunities for forest protection are permanently lost. A solution to this problem must be made through the proper political processes, rather than unilaterally by anyone involved in the issue. In

theory, a political solution can help develop compromises that work to the benefit of multiple constituents.

The second priority issue identified by six of the respondents was the need for better scheduling and access to skidding and hauling equipment. Existing equipment was often commandeered for other government road and construction projects, significantly impacting the ability for the sawmill to efficiently manage its log supply. Additionally, access to parts, supply, and new equipment is difficult or even impossible. Improvement in the scheduling of existing equipment requires a focus on developing appropriate programs through applied research and training on the use of these programs through extension education. Acquisition of appropriate heavy machinery for sustainable harvesting operations requires the selection of the appropriate types of equipment, training on the use of the equipment, and securing funding for the support and purchase. While the acquisition of new tools and equipment falls squarely in the “Tools and Equipment” solution area, additional support from research, extension, and political solution areas can provide the foundation and implementation plan for new equipment installations.

Finally, the third priority issue presented in five of the nine interviews was a concern about the local availability of skilled labor as most workers are currently being imported from the Rift Valley and central highland areas. With most of the skilled natural forest harvesting labor coming from outside the community there are elevated labor costs and limited benefits on the local economy from the operations. In order to develop a local pool of skilled operators, extension and

training programs can be established. These programs would train local people in sustainable commercial forest harvesting practices that would provide additional employment opportunities in the region, as well as train the workforce from the beginning on sustainable practices, minimizing the impacts of previous experiences that often have a much greater impact on the forest sites. In addition to these top three identified topics, other lower priority topics were also analyzed for the practicality of their implementation, including those that were quite simple as well as others that would be nearly impossible to fulfill in these situations.

3.4.2 PLANTATION AND COLLEGE FORESTS

Decision framework case study data were collected on an SFIE plantation and from the WGCF campus over ten days, during two, one month long field visits. The implementation teams again consisted of two members responsible for data-collection, observations, interviews, and documentation from management and staff, foresters, and contractors. Both forests maintain active, year-round operations, which allowed for abundant access to field, sawmill, and office sites. Harvesting operation records, maps, and other resources were also gathered to help guide the interviews. In the case of the SFIE, 32 people were engaged in the interviews, most individually, but also including two groups of three contractors. At WGCF, 11 individuals participated in the interviews and discussions.

The same five categories for thematic solutions (harvest planning, tools and equipment, research, social programs, extension and training, and policy and law) that were used with the natural forest data were also used to summarize data from

the plantation/university operations. In the case of SFIE, the prevailing priority issues were social programs, tools and equipment, and extension and training. Although research and harvest planning were also mentioned, these were not identified at multiple levels within the organization or by as many groups or individuals. Policy and law issues and improvements also were not identified as a high priority solution area by the respondents in this study of plantation activities. Through observation and participation in harvesting activities additional areas were exposed for potential improvements that could spur alternative approaches and discussions by the implementation team during their interviews.

For SFIE, the highest-ranked priority issue identified in the data coding process in some manner by 25 of the interviewees was developing the status of that enterprise in local and regional communities. Specific issues included furnishing more jobs, developing outreach opportunities for publicizing the benefits of the enterprise to residents, and introducing new ways to preserve and use the land so as to protect resources while maintaining access and other benefits. Specific solutions described were “creation of value added local cooperatives to provide jobs and increase wood values” and “expand social outreach through donations of forest products to schools and the local community and improve feeder roads in the region.” These topics fit well in the social thematic solution area as potential improvements would include programs that engage local communities in the conservation and development of the local forest resources. Specifically, programs should be established that formalize beneficial access to the

land and resources by the public, while minimizing the effects on the revenue generating operations of the enterprise.

The second priority issue was improvements to harvesting equipment, which would help decrease the difficulty of the work and provide access to appropriate gear (e.g., chainsaws, imported hand tools, uniforms, boots and/or shoes), machinery, and maintenance supplies. Nineteen of 32 respondents had addressed this topic during interviews. Heavy equipment was identified by some as important, however many others recognized the difficulties of obtaining, maintaining, and efficiently using these expensive tools. Responses at all levels recognized that the current practices were using appropriate harvesting technologies, but many were of substandard quality and poorly maintained. One respondent expressed that "…loading machines be very nice, but they are very expensive and we would not be able to keep them repaired" for continued use. While this solution is focused in the "tools and equipment" solution area, improved access to the basic harvesting tools, equipment, and the supplies and training required to maintain and efficiently use these tools would provide many spillover social and extension opportunities and benefits to sustainable forest operations.

The issue receiving the third-highest priority ranking, with 16 total responses, was the desire to improve the transportation infrastructure and year-round access to harvest units and mills during in order to maintain steady production levels. Many of the mills and haul routes were very inadequate for use during the rainy seasons and require new investments in programs to begin to look

at road systems as an integral part of operations. These issues can first be treated in the harvest planning solution category, as initial planning and analysis needs to be initialized to develop processes, criteria, standards, and costs associated with road development for harvesting operations. Again, additional efforts in the research and extension can be used to support these planning improvements.

Many of the same or similar plantation issues were recorded during interviews about the WGCF operations, but as an educational institution, stronger emphasis was placed on extension and training, social issues, and planning. Ironically, high priority and attention were not given to solutions that could be addressed by research. As with the plantation forest enterprise, policy and law concerns also were not strongly expressed, but were raised only in the context of broader social issues. Again, observations and participation in harvesting activities exposed additional areas for potential improvements that could serve as sources for creativity by the implementation team during their interviews.

For the WGCF operations, the prioritized improvements included developing new programs to improve relationships with neighboring residents who were exploiting college property. All eleven participants in the data collection process discussed the many confrontations and tensions arose because people in areas surrounding sections of natural forest were illegally utilizing those resources while the college was attempting to protect and manage the last, small native forest remnant. One respondent from the college stated that "…plantation operations are often impacted as the workers must pull harvested logs from the natural forest if illegally cut trees are discovered." Others discussed "…the need for social

facilitators to lead discussions with local groups" in order to help come up with workable solutions to the complex social issues. Eight of the eleven respondents expressed a need for a more effective use of planning resources, such as GIS, aerial photos, and management schemes as the second priority improvement area. This college is uniquely positioned within Ethiopia because it has access to technology and expertise that enterprises and other organizations ordinarily do not have. One response highlighted that "…we have had a rough map of the forest for some 20 years and now there are new GIS maps, however they have not yet been used for harvesting activities." The final high-priority coded from the data, representing eight individual responses was the development of a training program for laborers and other workers to improve their job performance relative to production and environmental protection. "Chainsaws and other equipment that require special skills require some training" one interviewee responded, noting again that they are unique in their access to this equipment and training would have to come from internal sources with the experience.

3.5 DISCUSSION

The case study implementation of the decision framework provided experience and feedback that can help better understand the process as well as improve the process for future applications at other sites around the developing world. Improvements identified through this decision framework process were grounded in data provided via interviews, observations, and documentation reviews. While the framework process itself imposed some direction on the results,

the occurrence of overlapping comments from different respondents provided substantiation of the particular topics, solutions, or desired outcomes. Often these responses provided insight on the broader perspective of the forest industry and federal and local governmental programs and their interactions with the local communities and forestry projects. Therefore, if implemented, the improvements listed here as most desirable would help make forest practices more sustainable, with each improvement specifically targeting a specific deficiency in the social, economic, or environmental aspects within an operation. Nevertheless, no individual action should be considered a panacea that will convert a current activity into one of optimal sustainability.

The effectiveness of a framework is highly dependent on how it is used by the assessment team. Members and primary contacts must have knowledge of the terms and concepts related to forestry operations, as well as qualitative research principles and the ability to explain the project so as to gain the trust of study participants. If those skills or knowledge are absent, pertinent data and concepts may not be captured. Likewise, language plays a confounding role in this type of project. Because expatriates and others on a team may not speak the local languages and dialects or be familiar with cultural practices, researchers must rely on interpreters. However, subtle cultural differences and lack of equivalent terms between languages and cultures can introduce additional difficulty with the use of interpreters (Kapborg and Berterö 2002). Therefore, the assessment team should be able to interact through appropriate language and social contexts with the respondents, and must have the necessary technical background to help minimize

these impacts(Murray and Wynne 2001). Unfortunately, it is often difficult to find a fully qualified team member who has both the available time and the salary requirements that coincide with the project schedule and budget.

In most cases respondents were happy to discuss the operations with which they were affiliated, and were positive about potential improvements. Nevertheless, some reluctance was expressed by many of the people involved because follow-through is not always seen with many projects such as these. However, because the solutions identified throughout this process were generated from data collected directly from the organization, operations, and personnel, those ideas were local and specific, such that their effective implementation was more likely than if they had been directives from an outside group. It should be noted that the assessment team offered many observations and ideas from the process for framework data-collection simply to elicit discussions of issues that respondents may not otherwise have considered important.

In this study, answers to questions by the assessment team were often very shallow, requiring follow-up queries to help illuminate and connect issues outside of normal harvesting methods. For example, when asked what would make a certain situation better, most replied that they didn't know. In particular, discussions with contractors revealed that they had little knowledge of operations outside of their personal experiences or anything pertaining to enterprise or company-wide issues. The level of one's education and experience typically was correlated with the depth of discussions and data. Additional time to consider options and methods at different levels within the organization might have helped

broaden the perspective of each respondent, and may have provided a wider range of solutions that would be both appropriate and possible to implement. Likewise, discussions with local residents were of limited success because most had very little understanding of any of the enterprise's operations and it effects on their community. Typical comments included acknowledgement of the jobs and wood residue that were created, as well as relating their interactions with management and guards in regard to non-timber uses, such as grazing, fuelwood collection, beekeeping, and other sustenance or cash-generating activities.

This decision framework provides a process for the initial understanding of an existing situation, and then works with local groups, both within and outside of the forest enterprise, to develop ideas for improving operations. The utility of this process relies on prioritization techniques that rank different suggested improvements according to the importance assigned by respondents through the process of data coding. The grounded theory process utilized in these case studies provides a method to take respondent provided qualitative data and develop prioritized improvements that have been developed from the combination of the entire data collection. Additional structure and robustness might be obtained if the framework is integrated with MCDM techniques. These can often be automated to help weigh different issues and responses in a fair and equitable manner that is very difficult to achieve through manual coding. However, the additional structuring by MCDM must be done so that the process is not overly complicated and both the implementation team and the respondents are able to understand and follow the methods.

Specifically in this Ethiopian case study of the framework, the new harvesting options that were identified through this decision support process that can potentially have very positive, long-term impacts. For instance, using the decision framework, participants at both WGCF and SFIE, identified high-priority social issues that were centered on the role and influences of harvesting in and on local communities. Because the social license to operate is indirectly granted by those communities, timber must be harvested in such a manner that the enterprise or college is not the only one to benefit from such activities. Although this point is easily recognizable, the ability to develop programs and solutions to problems that arise is difficult without the help of prioritization tools such as the decision framework process identified in this study. While job creation and access to resources may be beneficial for some community members, others may be disenfranchised, left landless, or have other disagreements with forest managers. Therefore, programs designed to develop relationships with the community should reach out to both oppositional and accommodating community members in order to build a strong foundation of support for the forest industry.

The economic gains derived from improvements identified by this framework are both direct and indirect. Job creation and training can increase production levels and the value of an operation, while better transportation and planning can result in dramatic cost-savings. However, greater initial spending is often required if one is to achieve enhanced productivity and value, and organizations must weigh the economic and sustainability costs and benefits related to these endeavors when preparing to implement new activities. Even

though respondents did not specifically target environmental issues, many of the goals identified in other areas would have a positive, spill-over effect. For example, greater efficiency in transportation, although analyzed from an economic perspective, would contribute to better environmental conditions because of shorter haul distances, improved road drainage, and surfacing.

In this project, three different types of organizations, a government enterprise in the natural forests, a slightly more autonomous plantation enterprise, and a university forestry operation, were examined to provide a diverse set of data for our analysis. Although this wide focus resulted in effective collection of the required information, the identification of additional improvements might have been possible if more time and access had been available for studying a broader range of documents, operations, personnel, and communities. In future applications of this framework, more thorough probing might be possible if the focus is on only one particular organization. Instability within the existing forest industry also hindered some of our data-collection process because the closure of mills in the natural forest meant that one had to rely on document review and interviews for primary analysis. The serious problems associated with the status of legal harvesting in that setting compelled us to concentrate on governmental processes, and follow-up questions. Other methods for eliciting more information were largely ineffective because responses from those offices generally pertained to timber access and ignored other operational aspects that could have provided additional perspectives on governmental debates.

3.6 CONCLUSIONS

The sustainability of forest-harvesting operations is critical in Ethiopia as well as other developed and developing countries. The first and foremost step is to understand the local, pertinent decisions and issues surrounding those operations. A decision framework provides and organized structure to collect and process local information. Through the framework process, these data are amalgamated and filtered to identify specific improvements. The grounded data that is based on feedback from respondents and local conditions, improves the meaningfulness and the possibility to enact.

The implementation of such a decision framework in Ethiopia has now identified specific activities in plantations and natural forests that have the potential to overcome deficiencies in social, economic, and environmental settings. When such improvements are adopted, forest operations become better able to provide critical and desirable, multiple benefits to diverse groups over the long term.

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4.0 CONCLUSION

The decision framework presented in this dissertation provides a means for identifying possible improvements in timber harvesting activities as an integral step toward sustainable forest management (SFM). Participatory data collected in Ethiopia were combined with decision-making tools to create a process that not only fits local conditions and opportunities, but also incorporates input from many different individuals involved with these procedures. At the onset of developing this framework, it became apparent that harvesting operations in Ethiopia had not been well-documented, and their impacts on SFM were uncertain. Interviews, observations, and research of related documentation produced baseline data to help determine the current state of the art in Ethiopian operations (Chapter 2). With this background established, a decision framework was formed to draw on salient themes and target areas for improvements that could support SFM (Chapter 3). This framework was applied to three types of organizations: a State-controlled sawmill and joinery enterprise that harvests timber from natural forests, a State–private plantation timber enterprise, and a university plantation forest. The results of this implementation suggested appropriate and relevant opportunities for sustainable improvements to their harvesting operations. While this framework was developed using Ethiopia as a case study, its process is open and flexible, making it suitable for application in a broad range of countries and regions.

To improve resource sustainability in developing nations, proper methods and tools are required for decision-making and for management and harvesting operations, while also fitting in with local social, economic, and environmental

conditions. The decision framework developed in this program provides a way for foresters, government agencies, NGOs, local communities, and other interested groups to understand the concerns associated with logging and collectively develop prioritized issues that must be addressed. While the framework can be extended to incorporate complex decision-support tools, the basic process can be utilized by a small team that has a simple understanding of the general context, with minimal supplies and not requiring specialized computer systems. Its power is rooted in the data collected from diverse groups and individuals with an interest in those harvesting operations. Thereafter, issues and solutions can be developed that meet the specific needs for a particular instance while also moving toward the composite goals of SFM.

Chapter 2 describes the current situation in Ethiopian forestry. The large population, demand for agricultural land, and an almost exclusive reliance on forest products for heating, cooking, and even sustenance in rural areas have had impacts on forested areas. New cropping fields are now being established, and clearance of the remaining forests for fuelwood, construction materials, and other products by both legal commercial entities and unauthorized organizations has decreased the size and quality of those residual stands. At the same time, decentralized responsibilities for the administration of these forestlands have not provided the management plans and protection required for their long-term sustainability. In natural areas, legitimate harvesters struggle to obtain access to timber while wood continues to leave through illegal operations. Plantation forests are in a slightly better situation because their personnel have relatively secure

rights to project areas and the ability to manage their lands properly for timber production.

Harvesting techniques vary among different environments. In the natural forest, a mix of large, heavy equipment and manual tools and methods are used while, in plantations, lighter-duty machines, e.g., farm tractors and wagons, are combined with manual means. Nevertheless, both scenarios rely on certain protocols that require significant labor inputs and, often, poor-quality hand tools. Although these methods have been used for many decades, appropriate modifications could decrease the difficulty of this labor and enhance output. Improved planning would promote better utilization of heavy equipment in both forestry types, again resulting in positive impacts on overall productivity. The influence of harvesting on SFM in the natural forest is still quite negative, compounded by the challenges that regional administrators have in protecting those lands from unlawful exploitation or implementing sound management plans. Although plantation supervisors have somewhat better oversight capabilities, they are faced with additional social and illegal-utilization pressures from much larger adjoining population centers that have a real impact on the sustainability of those operations.

To determine the adjustments needed for developing harvest schemes that benefit SFM, Chapter 3 introduces a decision framework and a case-study application. This framework can be devised by an assessment team that collects and processes the required data in order to identify critical operations, decisions, and issues. These topics are then grouped into five thematic solutions categories:

harvest planning, tools, and equipment; research; social programs; extension and training; and policy and law. Within each of these areas, meaningful and feasible programs, improvements, or activities are generated. This formal process will assist decision-makers in their understanding of current issues and guide their data-collection and analysis.

When this decision framework was first applied to operations in Ethiopia, differences in priorities arose for those thematic categories, depending upon the organization and forest type. Their rankings are presented in Table 4.1. Within each of these areas, approaches were identified for improving operations in

	Natural Forest	Industrial Plantation	University Plantation
Priority 1	Policy and Law	Social	Social
Priority 2	Equipment	Equipment	Harvest Planning
Priority 3	Extension	Harvest Planning	Extension

Table 4.1 Comparison of priority thematic solutions categories among Ethiopian forest/organization types.

order to make them more sustainable. For example, in the case of natural forests, it was determined that the involved parties must engage the political process to ensure the availability of resources for harvest. In contrast, for both plantation settings, outreach efforts were deemed necessary that would involve the surrounding communities in developing symbiotic relationships to benefit everyone.

This proposed framework can be strengthened by integrating more complex decision-support processes that formalize these rankings and assessments. Given the qualitative nature of many of these results, it is important to select a

method that will still engage the participants and ensure that individual perspectives are valued in the analysis. Additional testing of the framework, especially in a region with different characteristics than Ethiopia, would confirm that the process is transferable to other populations and environmental conditions. Of particular interest would be a comparison of various implementations on diverse sites that might range from fully mechanized operations to those using semi-mechanized systems in both industrialized and developing economies.

This project is unique in that it combines management tools with participatory engagement by decision-makers and other interested parties. The result is a framework that is sufficiently robust to provide valuable output, but simple enough to be implemented and trusted by those involved. We may never know if we have actually achieved SFM because only in retrospect can we definitely assess the results. However, the process of examining harvesting operations in order to identify issues potentially detrimental to SFM and also developing solutions that can be implemented can only move us closer to a state of sustainable management.

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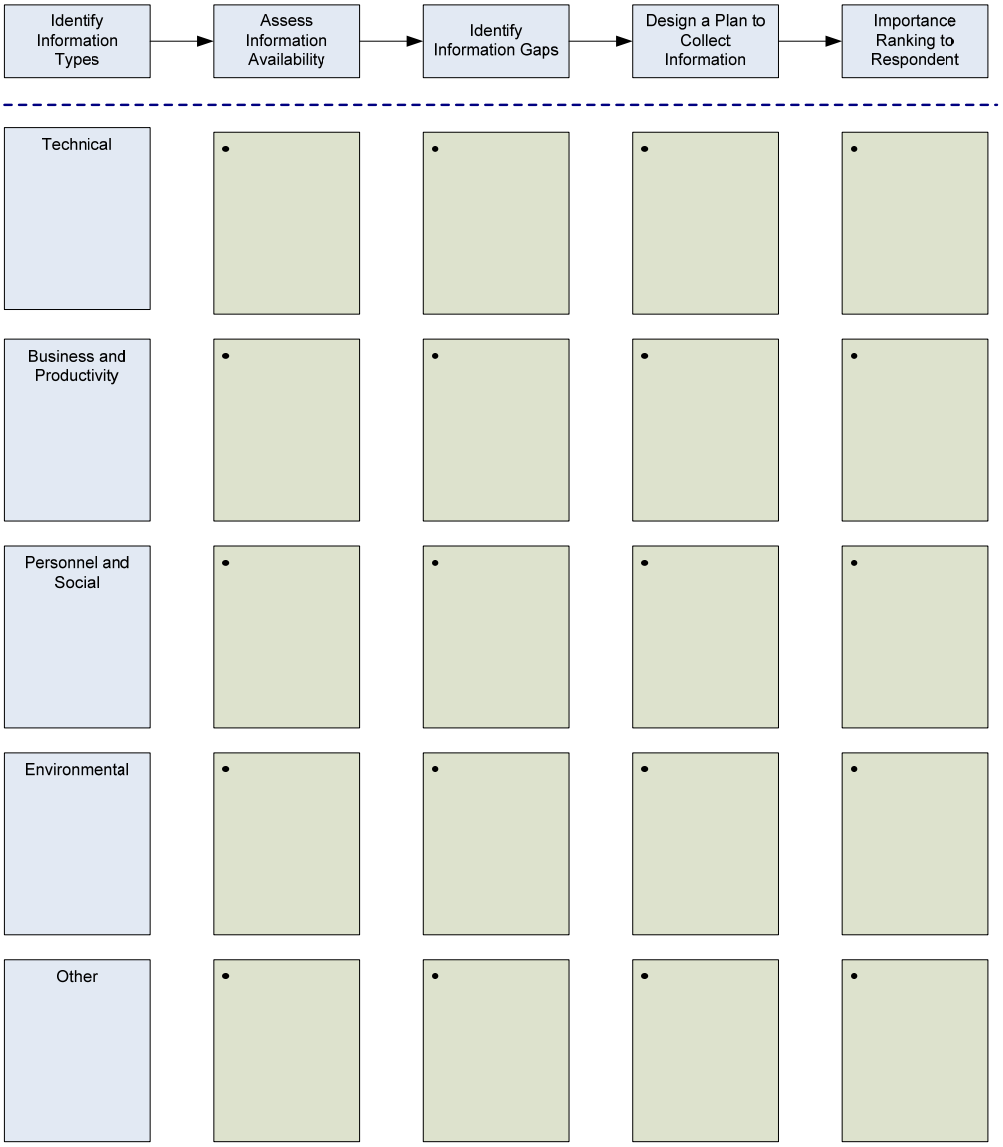
6.0 Appendix

6.1 PHASE 1 BLANK FORM

6.2 PHASE 2 BLANK FORM



6.3 PHASE 3 BLANK FORMS

phase	activity	sustainability issue	issue context	limitations	solutions	respondent priority
3.11	Strategic Planning	Social				
		Environmental				
		Economic				
3.12	Tactical Planning	Social				
		Environmental				
		Economic				

phase	activity	sustainability issue	issue context	limitations	solutions	respondent priority
3.13	Operational Planning	Social				
		Environmental				
		Economic				
3.21	Access Design	Social				
		Environmental				
		Economic				

phase	activity	sustainability issue	issue context	limitations	solutions	respondent priority
3.32	Access Construction	Social				
		Environmental				
		Economic				
3.31	Felling	Social				
		Environmental				
		Economic				

phase	activity	sustainability issue	issue context	limitations	solutions	respondent priority
3.32	Process at Stump	Social				
		Environmental				
		Economic				
3.33	Primary Transport	Social				
		Environmental				
		Economic				

phase	activity	sustainability issue	issue context	limitations	solutions	respondent priority
3.33	Log Loading	Social				
		Environmental				
		Economic				
3.33	Secondary Transport	Social				
		Environmental				
		Economic				

6.4 SAMPLE INTERVIEW QUESTIONS AND ISSUE TOPICS

The following list of sample questions provide a sample of some of the questions and types of questions used during open ended interviews for the framework implementation data collection process.

- What are the strategic reasons for engaging in forest harvesting?
- What are the broad goals that the organization would like to achieve?
- Are there social considerations or goals that are addressed?
- Describe and comment on social considerations of the operations including employment, health and safety, nutrition and food security, fuel and fodder, or other social issues.
- Are there goals and priorities on environmental stewardship in existing operations?
- What are the broad improvements that might be addressed strategically?
- What are the strategic outcomes that are desired
- What are the current conditions and access to data and information used in decision making on the forest?
- What types of information and outcomes would you like to have access to?
- What are the barriers to improving the quality and access to data?
- Describe the (Insert Phase 3 topic here – ie, timber felling) activities that occur in the operation?

- Are there safety, health, productivity (or other) issues surrounding this issue?
- What possible solutions could help improve this situation?
- What types of outcomes would be beneficial to you, the organization, and to the community?

Additional issues are listed on the following "issues sheets" that can be used to lead discussions covering each of the different phases requiring data. For each of the phases, generalized issues, that may or may not be applicable for a given site or organization, are listed as a prompt to encourage discussion and thought by both the interviewer and the interviewee. The interviewer for example may start by asking the respondent to discuss strategic planning topics. If the respondent has difficulty understanding the question or needs some prompting to start discussion, the interviewer could interject with a question about a specific issue. Additionally, these general topics can also be used to help change a topic if there has been sufficient discussion on a particular point or if the interviewee begins to discuss topics and ideas that are beyond the scope of the purpose of the interview. These issues are not designed as a list of questions that must be answered in every interview, but rather as a tool to elicit focused conversation that will provide the data required for the decision framework.

phase	activity	sustainability issue	issue context	limitations
3.11	Strategic Planning	Social	Public land access	demarcation
			Good neighbor	access rights
			Long term employment opportunities	resource security
			Forest Protection and conservation	grazing and fuel wood
			Improve lives of employees and local people	safety policies
			Population pressures	forest crops & agriculture
				planning strategies
				local opportunities for work
				salary
				benefits
			Other	Other
		Environmental	Impacts on water, air, and soils	distribution of impacts
			Deforestation and land conversion	harvest levels
			Silvicultural treatments	seasonal or other timing
			Wildlife management	silviculture prescription
			Road access	equipment size & maintenance
			Soil fertility /Site productivity	new road access
			Fire vulernablity	forest crops
				planning strategies
			Other	Other
		Economic	Markets	felling methods
			Investment costs and funding sources	felling planning
			Rotation ages	secondary products
			Output requirements	utilization
			Costs too high	timing of harvest
				silviculture prescription
				equipment size & maintenance
			Other	Other
3.12	Tactical Planning	Social	Public land access	timing of harvest
			Good neighbor	public safety
			Employment opportunities	security guards
			Contractor health and safety	grazing and fuel wood
			Salary and Benefits	safety equipment
			Access to non timber forest products	ergonomics
			Transportation infrastructure	planning strategies
				local opportunities for work
				salary
				benefits
				farmer land conversion
				theft and damage
			Other	Other
		Environmental	Under utilization of fiber	processing residue
			Adverse impacts on forest	damage to secondary products
			Adverse impact on water, air, and soils	damage to crop trees
			Damage to non crop trees and secondary species	poor operational planning
				seasonal or other timing
				silviculture prescription
				equipment size & maintenance
				site impacts
			Other	Other
		Economic	Decrease in product value	processing methods
			Operating costs too high	processing planning
			Equipment costs too high	secondary products
			Productivity not high enough	utilization
			Flow of wood to mill irregular	timing of harvest
				silviculture prescription
				equipment size & maintenance
				optimal bucking
			Other	Other
3.13	Operational Planning	Social	Public land access	timing of harvest
			Good neighbor	public safety
			Employment opportunities	security guards
			Contractor health and safety	grazing and fuel wood

phase	activity	sustainability issue	issue context	limitations
			Salary and Benefits	safety equipment
			Access to non timber forest products	ergonomics
				planning strategies
				local opportunities for work
				salary
				benefits
			Other	Other
		Environmental	Noise disturbance	transport methods
			Adverse impacts on forest	equipment mechanization
			Adverse impact on water, air, and soils	equipment size
			Damage to non crop trees and secondary species	equipment types
			Site specific conditions	damage to secondary products
				damage to crop trees
				poor operational planning
				seasonal or other timing
				silviculture prescription
			Other	Other
		Economic	Planning costs too high	data availability
			Benefits of planning uncertain	plan implementation
			Equipment and data costs too high	timing
			Efficiency of work is low	silviculture prescription
			Flow of wood to mill irregular	equipment size & maintenance
			Other	Other
3.21	Access Design	Social	Public land access	project timing
			Good neighbor	public safety
			Employment opportunities	planning strategies
			Contractor health and safety	local opportunities for work
			Salary and Benefits	salary
			Transportation infrastructure	benefits
				farmer land conversion
				theft and damage
			Other	Other
		Environmental	Land conversion	damage to adjacent trees
			Improved general access	poor operational planning
			Road standard	seasonal or other timing
			Alignment	Construction practices
			Stability	Maintenance requirements
			Compatibility with Harvesting system	Traffic capacity
			Existing transportation system	balance of cut and fill
				drainage
				transportation system upgrade
			Other	Other
		Economic	Project costs	construction methods
			Haul distances and speeds	felling planning
			Equipment costs too high	secondary products
			Productivity not high enough	utilization
			Flow of wood to mill irregular	timing of harvest
				primary vs. secondary transport
				new vs. upgrade network
				surfacing
				maintenance
			Other	Other
3.32	Access Construction	Social	Public land access	timing of harvest
			Good neighbor	public safety
			Employment opportunities	security guards
			Contractor health and safety	grazing and fuel wood
			Salary and Benefits	safety equipment
			Access to non timber forest products	ergonomics
			Transportation infrastructure	planning strategies
				local opportunities for work
				salary
				benefits
			Other	Other

phase	activity	sustainability issue	issue context	limitations
		Environmental	Site impacts on soil, water, and air	damage to adjacent trees
			Removal of land from timber production	poor operational planning
			Damage to crop trees	seasonal or other timing
			Alignment	construction practices
			Stability	maintenance requirements
			Compatibility with Harvesting system	slope stability
			Existing transportation system	balance of cut and fill
				drainage
				transportation system upgrade
				material waste disposal
			Other	Other
		Economic	Equipment and operating costs	construction methods
			Project planning	manual vs. mechanical
			Project progress	good design
			Supervision	engineering difficulties
				adherence to specifications
				unmotivated employees
				surfacing options
				maintenance
				timing
			Other	Other
3.31	Felling	Social	Public land access	timing of harvest
			Good neighbor	public safety
			Employment opportunities	security guards
			Contractor health and safety	grazing and fuel wood
			Salary and Benefits	safety equipment
				ergonomics
				planning strategies
				local opportunities for work
				salary
				benefits
			Other	Other
		Environmental	Under utilization of fiber	species utilization
			Adverse impacts on forest	felling residue
			Adverse impact on water, air, and soils	damage to secondary products
			Damage to non crop trees and secondary species	damage to crop trees
				poor operational planning
				seasonal or other timing
				silviculture prescription
				equipment size & maintenance
				site impacts
				breakage
			Other	Other
		Economic	Decrease in product value	felling methods
			Operating costs too high	breakage
			Equipment costs too high	felling planning
			Productivity not high enough	secondary products
			Flow of wood to mill irregular	utilization
				timing of harvest
				silviculture prescription
				equipment size & maintenance
			Other	Other
3.32	Process at Stump	Social	Public land access	timing of harvest
			Good neighbor	public safety
			Employment opportunities	security guards
			Contractor health and safety	grazing and fuel wood
			Salary and Benefits	safety equipment
			Access to non timber forest products	ergonomics
				planning strategies
				local opportunities for work
				salary
				benefits
			Other	Other

phase	activity	sustainability issue	issue context	limitations
		Environmental	Under utilization of fiber Adverse impacts on forest Adverse impact on water, air, and soils Damage to non crop trees and secondary species Other	processing residue damage to secondary products damage to crop trees poor operational planning seasonal or other timing silviculture prescription equipment size & maintenance site impacts Other
		Economic	Decrease in product value Operating costs too high Equipment costs too high Productivity not high enough Flow of wood to mill irregular Other	processing methods processing planning secondary products utilization timing of harvest silviculture prescription equipment size & maintenance optimal bucking Other
3.33	Primary Transport	Social	Public land access Good neighbor Employment opportunities Contractor health and safety Salary and Benefits Access to non timber forest products Other	timing of harvest public safety security guards grazing and fuel wood safety equipment ergonomics planning strategies local opportunities for work salary benefits Other
		Environmental	Noise disturbance Adverse impacts on forest Adverse impact on water, air, and soils Damage to non crop trees and secondary species Other	transport methods equipment mechanization equipment size equipment types damage to secondary products damage to crop trees poor operational planning seasonal or other timing silviculture prescription Other
		Economic	Decrease in product value Operating costs too high Equipment costs too high Productivity not high enough Flow of wood to mill irregular Other	transport methods operational planning secondary products utilization timing of harvest silviculture prescription equipment size & maintenance Other
3.41	Process @ landing	Social	Public land access Good neighbor Employment opportunities Contractor health and safety Salary and Benefits Access to non timber forest products Other	timing of harvest public safety security guards grazing and fuel wood safety equipment ergonomics planning strategies local opportunities for work salary benefits Other
		Environmental	Under utilization of fiber Adverse impacts on adjacent forest Adverse impact on water, air, and soils	processing residue damage to secondary products damage to crop trees poor operational planning seasonal or other timing

phase	activity	sustainability issue	issue context	limitations
				silviculture prescription
				equipment size & maintenance
				site impacts
			Other	Other
		Economic	Decrease in product value	processing methods
			Operating costs too high	processing planning
			Equipment costs too high	secondary products
			Productivity not high enough	utilization
			Flow of wood to mill irregular	timing of harvest
				silviculture prescription
				equipment size & maintenance
				optimal bucking
			Other	Other
3.42	Sort and Deck	Social	Public land access	timing of harvest
			Good neighbor	public safety
			Employment opportunities	security guards
			Contractor health and safety	grazing and fuel wood
			Salary and Benefits	safety equipment
			Access to non timber forest products	ergonomics
				planning strategies
				local opportunities for work
				salary
				benefits
			Other	Other
		Environmental	Adverse impacts on forest	processing residue
			Adverse impact on water, air, and soils	damage to secondary products
			Damage to non crop trees and secondary species	damage to crop trees
			Wood Decay	poor operational planning
				seasonal or other timing
				silviculture prescription
				equipment size & maintenance
				site impacts
				insects
			Other	Other
		Economic	Decrease in product value	processing methods
			Operating costs too high	processing planning
			Equipment costs too high	secondary products
			Productivity not high enough	utilization
			Flow of wood to mill irregular	timing of harvest
			Decay Loss	silviculture prescription
				equipment size & maintenance
				optimal bucking
				insects
			Other	Other
3.33	Log Loading	Social	Public land access	timing of harvest
			Good neighbor	public safety
			Employment opportunities	security guards
			Contractor health and safety	grazing and fuel wood
			Salary and Benefits	safety equipment
			Access to non timber forest products	ergonomics
				planning strategies
				local opportunities for work
				salary
				benefits
			Other	Other
		Environmental	Noise disturbance	transport methods
			Adverse impacts on forest	equipment mechanization
			Adverse impact on water, air, and soils	equipment size
			Damage to non crop trees and secondary species	equipment types
				damage to secondary products
				damage to crop trees
				poor operational planning
				seasonal or other timing

phase	activity	sustainability issue	issue context	limitations
			Other	silviculture prescription Other
		Economic	Decrease in product value Operating costs too high Equipment costs too high Productivity not high enough Flow of wood to mill irregular Other	transport methods operational planning secondary products utilization timing of harvest silviculture prescription equipment size & maintenance Other
3.33	Secondary Transport	Social	Public land access Good neighbor Employment opportunities Contractor health and safety Salary and Benefits Access to non timber forest products Other	timing of harvest public safety security guards grazing and fuel wood safety equipment ergonomics planning strategies local opportunities for work salary benefits Other
		Environmental	Noise disturbance Adverse impacts on forest Adverse impact on water, air, and soils Damage to non crop trees and secondary species Other	transport methods equipment mechanization equipment size equipment types damage to secondary products damage to crop trees poor operational planning seasonal or other timing silviculture prescription Other
		Economic	Decrease in product value Operating costs too high Equipment costs too high Productivity not high enough Flow of wood to mill irregular Other	transport methods operational planning secondary products utilization timing of harvest silviculture prescription equipment size & maintenance Other