Food and Agriculture Organization of the United Nations

A guide to multiple-use forest management planning for small and medium forest enterprises

FORESTRY WORKING PAPER

39

ISSN 2664-1062

A guide to multiple-use forest management planning for small and medium forest enterprises

FORESTRY WORKING PAPER

39

Hubertus van Hensbergen
Eco-Innovation Foundation
Stockholm

Kenichi Shono and Jonas Cedergren
Food and Agriculture Organization of the United Nations
Rome

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ROME 2023

Required citation:
van Hensbergen, H., Shono, K. & Cedergren, J. 2023. *A guide to multiple-use forest management planning for small and medium forest enterprises*. Forestry Working Paper, No. 39. Rome, FAO. https://doi.org/10.4060/cc6780en

ISSN 2664-1062 [Print]
ISSN 2664-1070 [Online]

ISBN 978-92-5-137974-5

Cover photograph: Naturally regenerated beech (*Fagus sylvatica*) forest managed for multiple purposes. ©FAO/Kenichi Shono

Contents

Boxes

Tables

Figures

Acknowledgements

This publication was developed in partnership between FAO and the Eco-Innovation Foundation. Kenichi Shono and Jonas Cedergren coordinated the work, and Hubertus van Hensbergen led the drafting of the document. Maria Ines Miranda provided materials for the Chile case study. Sheila Wertz-Kanounnikoff, Thomas Hofer and Thais Linhares-Juvenal provided overall supervision. Bianca Sipala conducted the scoping study which formed the basis of this initiative.

We thank the following persons for providing valuable inputs during the publication development process: Fady Asmar; Klas Bengtsson; Marco Boscolo; Xavier Bouan; Ben Caldwell; Magnus Grylle; Matieu Henry; Daphne Hewitt; Ying Hong; Aaron Kaplan; Rikiya Konishi; Jarkko Koskela; Isilda Nhantumbo; Cristiana Orlandi; Peter Pechacek; Cesar Sabogal; U Thiha; and Lauri Vesa.

Robin Leslie provided copyediting, and Roberto Cenciarelli undertook the design and layout.

Acronyms and abbreviations

AAC	annual allowable cut
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DBH	diameter at breast height
FAO	Food and Agriculture Organization of the United Nations
FIS	forest information system
FMU	forest management unit
FPIC	free, prior and informed consent
FSC	Forest Stewardship Council
GIS	geographical information system
HCS	high carbon stock
HCV	high conservation value
IRR	internal rate of return
IUCN	International Union for Conservation of Nature
MAI	mean annual increment
MYRLIN	Methods of Yield Regulation with Limited Information
NGO	non-governmental organization
NPV	net present value
NTFP	non-timber forest product
NWFP	non-wood forest product
PEFC	Programme for the Endorsement of Forest Certification
PES	payment for ecosystem services
RIL	reduced impact logging
SFM	sustainable forest management
SMFE	small and medium forest enterprise
SWOT	strengths, weaknesses, opportunities and threats
WRB	World Reference Base for Soil Resources

Glossary

Annual allowable cut. The volume of timber that may be harvested during a year that is specified by a sustained-yield forest plan.[1]

Annual plan of operations. A plan that sets out and schedules the operations to be carried out in a particular year.

Basal area. Single tree: The cross-sectional area of a single stem including the bark measured at breast height (1. 37 m above-ground). A stand: The cross-sectional area of all stems of a species or all stems in a stand measured at breast height and expressed per unit of land area.[1]

Clearcut system. A silvicultural system in which essentially all trees in a stand are removed, producing a fully exposed microclimate for the development of a new aged class. Regeneration can be from natural seeding, direct seeding, planted seedlings, or advance reproduction. Depending on management objectives, a clearcut may or may not have reserve trees left to attain goals other than regeneration.[1]

Compartment. A portion of a forest under one ownership, usually contiguous and composed of a variety of forest stand types, defined for purposes of locational reference and as a basis for forest management.[1]

Continuous cover forest management system. A silvicultural system in which trees are harvested singly or in small groups, continuously maintaining tree cover in an uneven-aged forest stand. Regeneration takes place within the stand by natural regeneration, planted seeds or seedlings, or coppicing from harvested trees. The system does not equate to any one silvicultural system, but it is typically based on single-tree selection.

Forest owner/rights holder. A person or legal entity having the formal or customary right to access and benefit from forest resources.

Forest management. The practical application of biological, physical, quantitative, managerial, economic, social, and policy principles to the regeneration, management, utilization and conservation of forests to meet specified goals and objectives while maintaining the productivity of the forest.[1]

Forest manager. A person or legal entity who has been delegated by the forest owner to manage the forest for the benefit of the forest owner. The forest owner and forest manager may be the same person or legal entity.

Forest management unit. An area of land managed according to a single forest management plan. An FMU may include areas of land without trees that are used for other purposes such as agriculture, conservation or infrastructure development.

Forest rights. The right to access forest resources and forestland a wide range of purposes. Forest resources may include timber and non-wood (or non-timber) forest products (NWFPs or NTFPs) as well as ecosystem services.

Forest succession. The gradual supplanting of one community of plants by another.[1]

Forest tenure. The right – statutory or customary – that determines who can use, manage, control or transfer forestland and resources such as wood or the multitude of NWFPs. Forest tenure defines for how long and under what conditions these rights are held.[2]

Growing stock. All the trees growing in a forest or in a specified part of it, usually commercial species, meeting specified standards of size, quality, and vigour, and generally expressed in terms of volume.[1]

Mean annual increment. The total increment (growth or increase in total or commercial volume) of a tree or stand up to a given age divided by that age.[1]

Risk and hazard. A hazard is an event that may occur and when it occurs has some negative consequence. Risk is the chance that an event occurs combined with the severity of the negative consequence. There is an elevated risk when a hazard with strong negative consequences has a high chance of happening.

Selection system. A silvicultural system in which only a portion of trees in a stand is removed. It regenerates and maintains a multi-aged structure by removing some trees in all size classes either singly, in small groups, or in strips. The system is also referred to as uneven-aged system, and includes group selection, group selection with reserves, and single tree selection methods.[1]

Silviculture. The art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis.[1]

Silvicultural prescription. A planned series of treatments designed to change current stand structure to one that meets management goals.[1].

Silvicultural system. A planned series of treatments for tending, harvesting, and re-establishing a stand. The system is based on the number of age classes or the regeneration method used.[1]

Species of conservation concern. Any plant and animal species whose long-term viability within a landscape country or other geographical area is a concern. These may include species listed as Vulnerable, Endangered or Critically Endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species as well as species of concern listed on relevant national lists.

Stand. A contiguous group of trees sufficiently uniform in age class distribution, composition and structure and growing on a site of sufficiently uniform quality, to be a distinguishable unit.[1] Stands may be smaller than or sometimes much larger than compartments.

[1] Helms, J.A. 1998. *The dictionary of forestry*. Bethesda, MD: Society of American Foresters.
[2] FAO. 2021. *Forest tenure*. [Cited 1 December 2022]. http://www.fao.org/forestry/tenure/en

PART I. INTRODUCTION

©FAO/Kenichi Shono

1. Concept and evolution of forest management planning

Forest management plan is "a document that translates forest policies into a coordinated programme for a forest management unit and for regulating production, environmental and social activities for a set period of time through the use of prescriptions specifying targets, actions and control arrangements" (FAO, 1998). Helms (1998) defines it as "a predetermined course of action and direction to achieve a set of results, usually specified as goals, objective and polices" with a note that it is a working document that changes in response to feedback and changing conditions, goals, and policies. Forest management plan is often seen as a prerequisite for sustainable forest management (SFM) as it translates the intent to manage forests for long-term purposes into a planned course of action.

The concept of forest management planning has evolved over centuries to an increasingly holistic one as societal expectation on the role of forests have diversified. Initially, at the time of the Industrial Revolution, forest planning was introduced to ensure adequate flow of timber for industrial needs in view of dwindling forest resources (Paletto, Sereno and Furuido, 2008). During the 1800s, yield regulation systems, combined with intensified silviculture based on monocultures or other simplified forest systems, became widely established.

From the 1950s onwards, forest management objectives have increasingly broadened to integrate environmental dimensions including a wider range of forest ecosystem services. The timber production aspect of forest management planning has now merged completely with the planning frameworks designed for conservation of non-consumptive values as the overall scope of these plans have become more holistic. For private forest owners in some countries, payment for ecosystem services (PES) comprises a valuable income stream that justifies the costs of planning and managing for these non-consumptive services.

2. Requirements for forest management planning

The objectives of forest management planning are to: 1) set out a strategic vision for the forest including the commitment to protect multiple forest values; 2) identify and describe the objectives of forest management; 3) assess the current state of the forest and forest resources; 4) identify the desired future state of the forest and values provided; and 5) describe the steps (harvesting, regeneration, etc.) to be taken to achieve the management objectives.

Forest management planning provides a fundamental basis of SFM, which can be used to meet various needs and requirements including as:

- Formal legal document specifying silvicultural activities for a forest management unit (FMU);
- Formal legal document that forms the basis of a concession or lease agreement between the government and a forest operator or manager;
- Document that is formally approved by a forest authority to permit certain forest management activities; and
- Document developed by the forest manager to guide and facilitate sustainable management of forest resources.

Consequently, forest management plans can take many forms ranging from a single map with basic information to a substantial document with comprehensive descriptions, analyses and syntheses of forest operations covering extended periods.

Forest management plans are part of a hierarchy of tools used by government authorities and private forest owners to ensure that forests are managed sustainably for the designated objectives (**Figure 1**). This guide is aimed at forest management planning at the level of an FMU, which describes site-specific operations based on the forest-level assessment of environmental, economic and social conditions. The forest management plan defines the silvicultural prescriptions and brings together all relevant considerations with the aim to provide long-term benefits through SFM (Forestry Commission Edinburgh, 2014). Operational plans guide the implementation of specific forest management operations at the compartment and stand levels according to the forest management plan, whereas the implementation plan sets out the details of each operation, for example in terms of the number of workers, exact timing, equipment to be used, etc.

Figure 1. The hierarchy of forest management planning

Source: Authors' own elaboration.

Requirement for forest management planning has increasingly become legally formalized in many parts of the world. In the European Union, most countries require forest management plans for publicly owned forests and many also require them for privately owned forests (European Commission, 2014). In many countries, forest management plans are needed to obtain a concession license to harvest timber from state-owned forests. The plans form part of the contractual obligation between the state and the concessionaire and are designed to provide information that the state requires for oversight functions.

Due to the diverse requirements of governments and forest managers in different countries and contexts, forest management plans vary in approach, emphasis and comprehensiveness. They also range widely in quality from those that are unlikely to be implementable to those that provide an excellent framework for forest management.

The duration of forest management planning also varies according to national policies, legal requirements, length of forest tenure, etc. Generally, forest management plans should have a duration of 10 years or more as shorter periods do not provide the medium-term stability that is needed to guide consistent implementation of sustainable forest management. A realistic maximum length is 20 years (FAO, 1998).

Forest management plans are also a minimum requirement under international forest certification standards such as the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC). Under these standards, forest management plans are used to demonstrate compliance with the certification requirements at the FMU level. Such forest management plans are inspected by auditors to ensure that they are appropriate to scale, intensity and risks associated with the proposed forest management activities.

Forest managers, ranging from smallholders to large corporations who are genuinely committed to responsible forest management, have been developing and implementing forest management plans for many decades. Properly formulated forest management plans confer many benefits to forest managers. The preparation of a management plan encourages careful consideration of the various forest values, including aspects that may not have seemed relevant initially. It also helps to clearly identify management objectives and address any trade-offs among the multiple objectives. Furthermore, it facilitates the planning of future activities, and provides reassurance that the forest operation is a sound business proposition in the long-term.

In addition, the process of management planning, when conducted through community engagement and participation, can serve as a valuable tool for building trust and agreeing on the sharing of benefits among the local stakeholders. Local communities can assume various roles and responsibilities in forest management, including as forest owner, forest manager, provider of auxiliary services, source of labour, and beneficiary of social support services.

3. Planning for multiple-use forest management

In recent decades, forests have been called upon to provide a wide range of products and services beyond timber. These include: water regulation; climate change mitigation; provision of timber and non-wood forest products (NWFPs); contribution to food security; biodiversity conservation; cultural and spiritual values; and support to livelihoods. The Statement of Principles on Forests, made at the Earth Summit in 1992, affirms that forests should be managed to meet the social, economic, ecological, cultural and spiritual needs of present and future generations (Sabogal *et al.*, 2013).

Globally, 749 million ha of forest (22 percent of the total forest area of the reporting countries) are managed with the primary objective of multiple use (FAO, 2022). In addition, many forest areas are managed for multiple primary and secondary objectives (e.g. managing production forest also for watershed services). Forests managed by smallholders are often used for multiple purposes, for instance providing timber, fuelwood, edible plants and wildlife for local consumption, medicinal plants and cultural values. Although we are still far from implementing a truly holistic, multiple-use approach to forest management worldwide (Sabogal *et al.*, 2013), considerable expanses of forests are indeed managed for multiple values and benefits, either formally or informally.

Multiple-use forest management can potentially increase the monetary value that communities, managers and owners obtain from the forest. However, operationalizing multiple-use forest management in a deliberate and technically informed manner remains a challenge in many places due to economic, technical and administrative constraints. As a result, timber is still the only forest commodity with readily accessible markets that is managed based on reliable technical knowledge (Sabogal *et al.*, 2013).

Nevertheless, forest management planning that recognizes the various values and benefits that people derive from forests can go a long way in ensuring not only continued productivity but also environmental, social and cultural sustainability of forest management. Therefore, adopting an integrated approach to forest management planning which considers social and environmental contexts in addition to timber production in a more formal and comprehensive manner would be an excellent starting point for promoting multiple-use forest management that enhances and optimizes the total value derived from forests.

4. Forest management planning for small and medium forest enterprises

Small and medium forest enterprises (SMFEs)[3] make significant economic contributions to the livelihoods and well-being of considerable numbers of poor people around the world. SMFEs also provide employment and contribute to forest-based economies in both developed and developing countries (Kozak, 2007). Smallholder forestry is a well-established forest management modality in many parts of the world. It is widely recognized that fostering and strengthening SMFEs can be part of an effective strategy to combat poverty and improve the livelihoods of communities living in or near forests in developing countries (Kozak, 2007).

To fulfil this potential, several barriers need to be addressed. These include: creating enabling policy environments; providing various support tools (business development, marketing, financing, technical capacity and so forth); developing equitable benefit-sharing mechanisms; ensuring resource sustainability; and overcoming management challenges (Del Gatto *et al.*, 2018; Paudel *et al.*, 2018). Furthermore, it is noted that an integrated approach is needed to remove perceived investment risk for both investors and investees.

Around the world, customary forest tenure of local communities and Indigenous Peoples is increasingly recognized. This will create a growing number of people with rights to small areas of forest who will require support in preparing forest management plans with an appropriate level of detail. Enhancing the capacity to develop and implement technically sound forest management plans can also help address many of the challenges associated with promoting SMFEs. Such plans can demonstrate legal compliance, mitigate social and environmental risks, ensure sustainability of forest resources, and support marketing and value chain development.

---

[3] There is no universally accepted definition of SMEs, and standards vary from country to country. The European Union defines medium-sized enterprises as employing less than 250 people with a turnover of less than EUR 50 million, and small enterprises as having fewer than 50 employees with a turnover of less than EUR 10 million. Spantigati and Springfors (2005) define “forest based small-scale enterprises” as “enterprises whose economic activities are undertaken mainly at the individual or household level, usually employing members of the family or close relatives and neighbours, and where salaried labour is negligible”. In this publication, we use this term to encompass community-based forest enterprises, individuals and smallholders involved in the production of forest products that meet the national thresholds of SMEs.

In situations where rural communities are working together to manage forest areas, preparing a forest management plan provides an opportunity to: empower local forest users; identify and involve local stakeholders; agree on management objectives and strategies; negotiate and agree on sharing of benefits, responsibilities and costs; and combine local knowledge with technical information (FAO, 2004a).

In many parts of the world, help in developing management plans is available to SMFEs from a variety of sources. These include: forest and agricultural extension services; commercial forestry and wood-processing companies who may be seeking outgrowers to provide them with a reliable source of timber; and environmental and social non-governmental organizations (NGOs) that understand the value of well-managed forests for supporting ecosystem services and livelihoods. Local universities and colleges that train forestry professionals could also be a source of technical support as it may be possible to engage students in supporting forest management planning as part of their field curriculum.

5. The process of forest management planning

The process of forest management planning follows a series of steps laid out in this publication as follows:

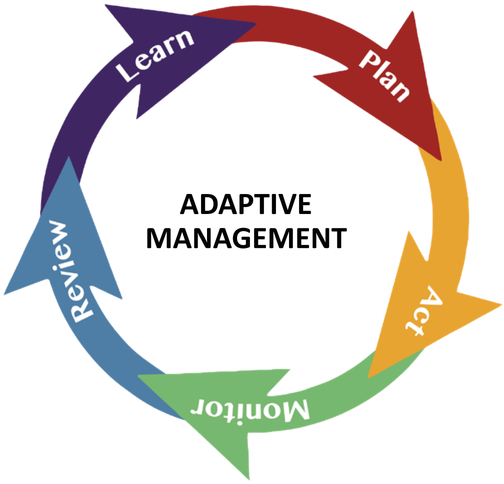
1. gathering information, including on land-use history, physical environment, natural environment and forest resources (Chapter 8), as well as on socio-economic and regulatory context (Chapter 9);
2. deciding on the appropriate format of the forest management plan (Chapter 10);
3. defining forest management objectives (Chapter 11);
4. developing a silvicultural plan (Chapter 12);
5. developing ecosystem services and biodiversity management plans (Chapter 13);
6. developing social and cultural services management plan (Chapter 14);
7. developing a business plan (Chapter 15);
8. planning for unusual events and disastes (Chapter 16); and
9. developing a monitoring system (Chapter 17).

These steps should be conducted in this sequence as much as possible. However, it should be noted that the process is reiterative as the information on which the plan is based will never be entirely complete and is subject to change.

5.1. THE MANAGEMENT CYCLE

Forest management planning is not a linear process carried out at the beginning of the forest management activity. Rather, it is a continuous adaptive learning process in which the results of forest management are evaluated and plans are adapted to meet the new reality. For example, monitoring of forest management activities may indicate the need to revise or develop an additional management objective. This in turn will necessitate additional data collection, operational planning, and identification of appropriate monitoring indicators. In this way, the forest management plan will continue to adapt and evolve to meet the changing needs and situations. **Figure 2** illustrates this cyclical process.

Figure 2. An example of adaptive management framework for natural resource management.



Source: Ashton, I. W., Baldwin, B., Bobowski, B. & McLaughlin, P. 2016. Honoring the past and celebrating the present: 100 years of research at Rocky Mountain National Park. Park Science, 32(2): 68–69.

5.2. UNDERSTANDING RISKS

All forest management activities will have some impact, and stakeholders are often concerned about the negative effects that forest operations may have on forest resources, environmental services and socio-cultural values. It is the responsibility of the forest manager to assess and minimize such risks to ensure continued flow of products and services from the forest under their management. Higher potential for more severe impacts would necessitate more detailed planning, implementation and monitoring of measures to manage such risks, while lower potential for minimal risks may only require staying vigilant of the situation.

In general, the magnitude of environmental and social risks associated with forest management increases with the area and intensity of management.[4] On the other hand, investment risks may decrease with the increase in the size of the enterprise and the forest area under management due to both economies of scale and risk averaging. However, it should be noted that most risks are context and issue specific. For example, even low-intensity harvesting of a small forest area may have high environmental and social risks if the forest management area includes critical habits for endangered species with

[4] As a reference, FSC defines small and low intensity managed forests (SLIMFs) as those with an area of less than 100 ha (or up to 1 000 ha in some countries) and rate of harvesting of less than 20 percent of the mean annual increment or annual harvest of less than 5 000 m^3 from the total production forest area (FSC, 2004).

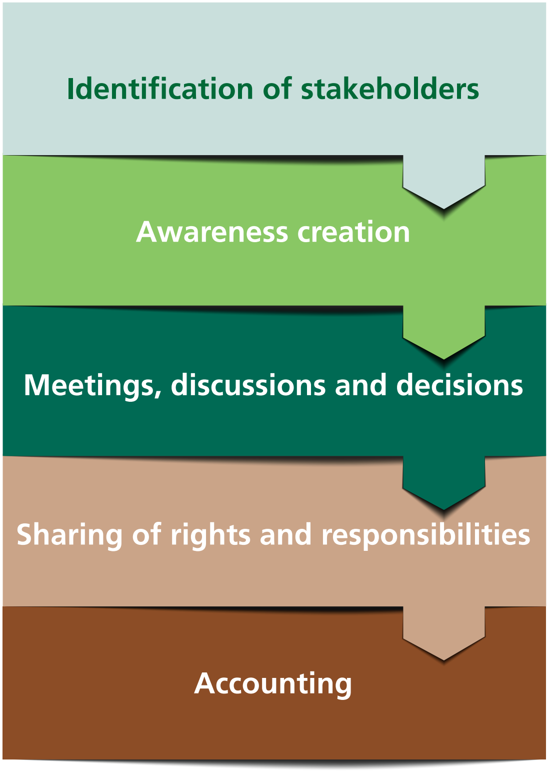
overlapping indigenous tenure claims. Thus, it is difficult to devise a general risk classification scheme that uniformly applies to the economic, social and environmental aspects of forest management.

Therefore, this guide provides two recommended levels for data collection and planning with a focus on SMFEs. The minimal requirement would likely apply to all situations while the more rigorous requirement would be recommended for aspects for which risks are perceived to be higher. These requirements are provided as general guidance only and should be adapted according to national legal requirements, availability of resources and capacity, data availability and site-specific context.

5.3. STAKEHOLDER ENGAGEMENT

The engagement of stakeholders is a critical part of the process in developing a socially acceptable forest management plan. A process for structured participation of stakeholders (**Figure 3**) starts with the identification of stakeholders, which may include local communities, forest industries and associations, local government officials, extension officers and other local forest-related organizations. This is following by creating awareness among the stakeholders on the status of forest resources, ecosystem services provided by the forest, and the planned forest management activities. The next step is informed discussions to reach decisions on the targets for multiple forest ecosystem services. Roles, rights and responsibilities of the involved stakeholders must be clearly identified. Finally, actions undertaken must be monitored to keep the stakeholders accountable for their agreed responsibilities (Baskent *et al.*, 2020).

Figure 3. A process for structured stakeholder participation



Source: Baskent, E.Z., Borges, J.G., Kašpar, J., Tahri, M. 2020. A Design for Addressing Multiple Ecosystem Services in Forest Management Planning. Forests 11(10):1108.

This process of negotiating expectations and building consensus helps deal with the complexities of multiple-use forest management. Any existing or potential conflicts over tenure and forest resource use will also be identified during this process. As well, integrating qualitative data based on perceptions and traditional knowledge of local stakeholders leads to better understanding of the real situation and improved decision-making (Baskent *et al.*, 2020). Participation should take place throughout the forest management process, from the planning, implementation to monitoring.

6. Objectives of this guide

Forest management planning has been a feature of forestry for centuries, and the structure and content of the plans have become relatively uniform around the world. Unfortunately, forest management plans are often inadequate in certain respects. Most commonly, management plans adopt broad objectives in line with national forest policies without developing locally derived objectives, which would require a detailed analysis of local needs, trends and potentials. Another frequent problem is a wish list of activities that does not have appropriate resources allocated, and are therefore unlikely to be implemented (FAO, 2004a). Furthermore, plans are often prepared by consultants for legal compliance without the commitment and engagement of the forest managers. The use of external experts can also result in customary rights holders being sidelined in the planning process and their rights not being respected. The business aspect of forestry – including business planning, processing, transporting, marketing and financial management, which are all necessary to strengthen a forest enterprise – is often ignored or described poorly. Environmental concerns may be mentioned but not translated into objectives. Even where forest management plans are prepared to a high standard, they are often not implemented due to lack of capacity or inadequate enforcement. In addition, there is little experience and support for SMFEs in preparing forest management plans.

SMFEs often cannot afford to develop plans at the same level of detail as large forest estates. However, consideration should be given to the fact that the external risks associated with management failures are generally reduced for smaller operations. Unfortunately, there is little or no guidance available for small and medium forest managers, who are often managing forest for multiple benefits with the engagement of local stakeholders, on the appropriate level of forest management planning.

This guide is intended to provide a framework for forest management planning with a focus on multiple-use and SMFEs. It leads the forest manager through the planning process in a stepwise fashion and provides advice on sources of information that are needed during the planning process. The guidance provided is general in nature as the socio-economic context and the range of products and benefits derived from forests vary widely among countries and specific locations. The frameworks presented can be adapted to national and local context in line with relevant regulatory requirements.

7. How to use this guide

This guide has three main parts.

Part I provides the background, including an introduction to the concept and evolution of forest management planning, multiple-use aspects and planning considerations for SMFEs. It also describes the general planning process.

Part II guides the readers through the processes of data collection and analysis, focusing on the use of approaches and tools that are accessible, affordable and easy to use. Data collection may need to be repeated as conditions change or when forest management objectives are revised.

Part III deals with the compilation of the forest management plan, from deciding on the format of the plan, setting forest management objective, and to developing a management plan for each forest management objective. Preparedness planning for natural disasters and accidents is also covered. Finally, guidance on developing a monitoring and evaluation system is provided.

For each step of the forest management planning process, recommended requirements are described issue by issue. The "minimum" requirements are necessary actions that all forest managers need to complete regardless of the scale of operations and the environmental context. "Good to have" requirements are additional actions that could be implemented depending on the availability of resources and capacity as well as the magnitude of risks with respect to specific issues.

A sample template of a forest management plan is provided in **Appendix 1**, which can be adapted according to the local context and requirements.

List of resources including tools, guidelines and data sources in **Appendix 2** provides further guidance on the various aspects of forest management planning.

Readers are referred to FAO's Sustainable Forest Management Toolbox (**Box 1**) for a comprehensive package of information and guidance on the various themes related to sustainable forest management.

Box 1. Sustainable Forest Management Toolbox

The implementation of SFM is an ongoing challenge worldwide, due largely to limited capacity and enabling conditions. Another hurdle is the inaccessibility (or a lack of awareness) of the considerable body of existing knowledge on, and experiences in, implementing SFM. To help overcome this latter problem, FAO has developed the SFM Toolbox.

The SFM Toolbox is a comprehensive package of tools, best practices and examples of their application. It serves as a valuable resource for a wide range of users, especially public and private forest and land managers, as well as the staff of extension services and civil society organizations, NGOs and private sector organizations with roles in promoting SFM.

The SFM Toolbox has been designed as a user-friendly web-based platform that can respond to the diverse needs of people interested in putting SFM into practice. It includes:

- modules on SFM thematic areas, which draw on the extensive technical knowledge of experts in FAO forestry practices and elsewhere. The modules comprise an overview, in-depth information, links to related tools, case studies and other throughput. These modules address a wide range of topics of relevance to forest management planning; and
- a database of SFM tools and case studies in an easy-to-access format.

The SFM Toolbox brings together a broad range of guidelines, manuals, knowledge products, case studies and other tools produced by FAO and its partners in the Collaborative Partnership on Forests, as well as by other organizations and by Member Nations. The SFM Toolbox is global in scope and covers all types of forests. It also includes tools that are specific to regions, countries and landscapes.

Source: FAO. 2023. Sustainable Forest Management (SFM) Toolbox. Rome. [Cited 1 February 2023]. http://www.fao.org/sustainable-forest-management/toolbox

PART II. GATHERING INFORMATION

©FAO/Daniel Hayduk

8. Describing the forestland

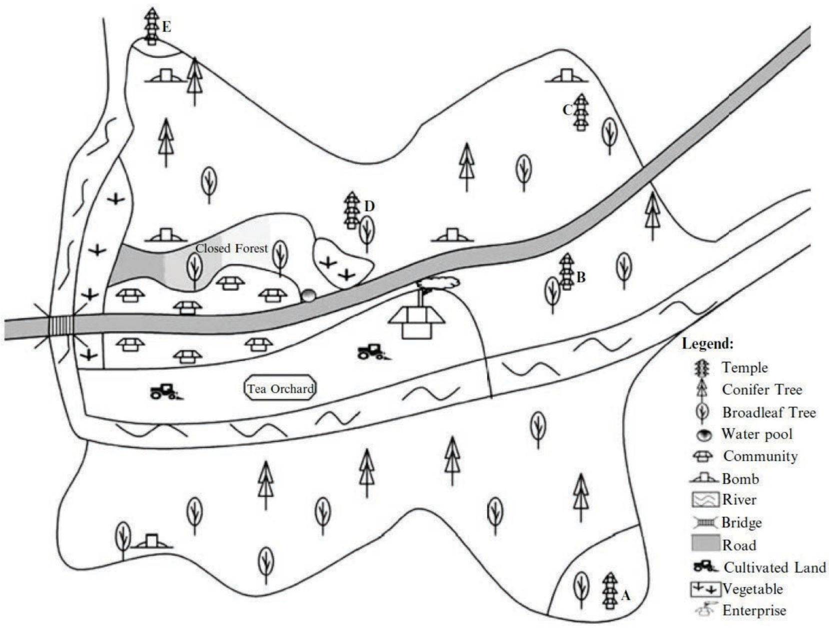
8.1. LOCATION

Documenting the location and boundaries of the FMU is the first step in describing the forestland. For small-scale operations, maps of the forest area are often attached to the title deed of the property or the lease agreement, or they may be held by the local authority or the national cadastral service. For community-managed forests, maps should be developed in a participatory manner and agreed by the community members. Where there are customary rights involved in the FMU, it is often useful to walk around the forest area with the local community members to determine the locations and boundaries of the claimed customary land.

For small and low-intensity forest operations, hand-drawn maps may be appropriate for documenting the location, boundaries and other key features of the FMU (**Figure 4**). Adequate maps can also be prepared using freely available remote sensing platforms, for example with the use of Google Earth,[5] which allows for uploading of spatial information including the FMU boundaries.

5 https://earth.google.com/web

Figure 4. Sketch of a forest management area in Dapingdi Village, Yunnan Province, China



Source: Youn, Y. C., Jinlong, L., Sakuma, D., Kim, K., Ichikawa, M. Shin, J. H. & Yuan, J. 2011. "Northeast Asia" In Traditional Forest-Related Knowledge: Sustaining Communities, Ecosystems and Biocultural Diversity, edited by Parrotta, John A. and Ronald L. Trosper, 281-313. New York, NY: Springer, 2012.

Recommended requirements:

Minimum	Good to have
• A hand-drawn map showing the FMU location. A remote sensing image of the area (e.g. from Google Earth) with the FMU boundaries overlaid could also be appropriate	• A digitized map showing the location and boundaries of the FMU. Existing maps, orthophotos or high-resolution remote sensing imagery can be used as the basis of such a map.

8.2. LAND USE AND FOREST MANAGEMENT HISTORY

History of land use in the FMU must be documented to understand the natural and anthropogenic processes that have shaped the pattern of land uses and the current condition of the forest. Productive use of the land in the past may also confer customary tenure rights.

Information on land-use history can be obtained from several sources including historical maps, old photographs, historical satellite imagery (**Figure 5**), and the collective memories of local communities which should not be overlooked.

Figure 5. Land cover and land use change over a span of 18 years near Victoria, Chile

2003 **2013** **2021**

Note: The satellite images showing forestland cleared for tree planting (2003), well-developed forest plantation (2013), and natural regeneration after harvesting of plantation trees (2021).
Source: Google Earth. [Cited 1 February 2023]. https://earth.google.com/

In addition to land use history, other factors such as natural disasters (e.g. landslides, floods, and fires) may have had significant impact that still influence the situation today. In areas with a long history of forest management, the previous silvicultural regime has likely influenced the current condition of the forest. The history of these interventions will often be held in compartment records if available. Where there are no written records, it may be possible to reconstruct forest management history by consulting local stakeholders.

Recommended requirements:

Minimum	Good to have
• Previous land uses documented. • Records of forest management in the past.	• Previous land uses documented and mapped. • Customary tenure and suitability for forest management documented based on previous land uses.

8.3. PHYSICAL ENVIRONMENT

The physical environment determines the availability of light, water and nutrients to support plant growth, which dictates the composition and structure of vegetation that establishes naturally. The physical environment also has a strong influence on forest productivity and drives decision-making on forest management, including species selection. These physical environmental factors, including climate, topography, soils and the presence of waterbodies, also influence the site's vulnerability to natural disasters. It is therefore important to develop an understanding of the physical environment, within which the FMU is located, to inform the forest management planning process.

Box 2. Open Foris - free open-source solutions for environmental monitoring

Open Foris[a] is a set of free and open-source software tools that facilitates flexible and efficient data collection, analysis and reporting. Of these, those that are particularly relevant as spatial tools for forest management planning include the Collect Earth, SEPAL, and Earth Map.

Collect Earth[b] / Collect Earth Online[c]

Collect Earth enables data collection through Google Earth and provides for augmented visual interpretation for land monitoring. Through this tool, users can analyse high and very high resolution satellite imagery for a wide variety of purposes, including: forest inventories; monitoring agricultural land and urban areas; validation of existing maps; collection of spatially explicit socio-economic data; and quantifying deforestation, reforestation and desertification. Its user friendliness make it a perfect tool for performing fast, accurate and cost-effective assessments. It is highly customizable for the specific data collection needs and methodologies.

Collect Earth Online is the next generation of web-based, crowd-sourcing technology for Earth Science analyses. It increases customization over Collect Earth desktop version and adds a variety of imagery resources and processing capabilities. This makes it suitable for a broader spectrum of applications including landscape change, land cover monitoring, and deforestation studies.

SEPAL[d]

SEPAL, which stands for "system for earth observation, data access, processing, analysis for land monitoring", allows users to query and process satellite data quickly and efficiently, tailor their products for local needs, and produce sophisticated and relevant geospatial analyses quickly. Harnessing cloud-based supercomputers and modern geospatial data infrastructures (e.g. Google Earth Engine), SEPAL enables access and processing of historical satellite data as well as newer data from Landsat and higher-resolution data from Europe's Copernicus programme.

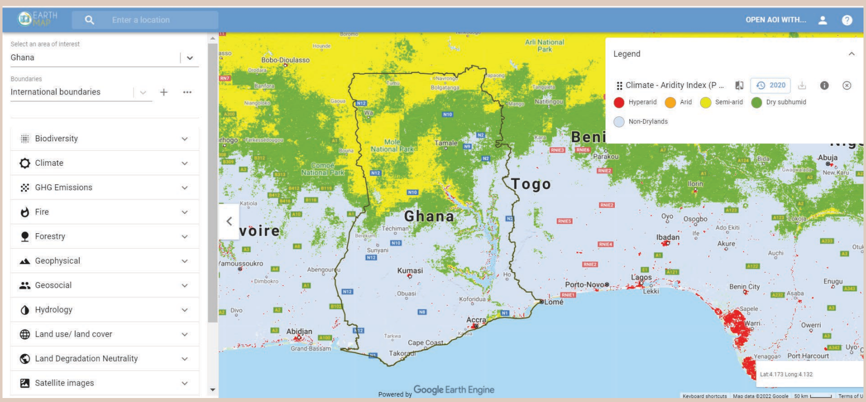
Earth Map[e]

Earth Map was created to support land monitoring in an easy, integrated and multi-temporal manner. It allows everyone to visualize, process and analyse satellite imagery and global datasets on climate, vegetation, fires, biodiversity, geosocial and other topics. Users need no prior remote sensing or geographic information system (GIS) knowledge. Its features are based on Google Earth Engine's big data capabilities, allowing users to undertake complex analysis of earth observation, environmental and climate data in a simple manner.

Earth Map's data are divided into thematic groups (climate, geosocial, vegetation, land degradation neutrality, water, satellite images, land maps, forestry, fire, geophysical, soil and biodiversity) and allow the user to visualize layers (maps) and to generate statistics to describe the areas of interest. Layers of relevance to forest management planning include:

- biodiversity;
- climate (aridity index, heat stress, precipitation and temperature);
- fire (burned area);
- forest cover and change;
- slope and elevation;
- settlements and population;
- hydrology;
- land use and land cover;
- soils;
- vegetation indices; and
- waterbodies.

Google Earth Engine gives Earth Map the capacity to run statistics on the fly on several metrics such as temperature, precipitation, burned areas, tree-covered areas, among others. These statistics can be aggregated at different time periods (yearly, monthly averages and monthly time series) and different time periods.



Notes:
[a] https://openforis.org
[b] https://openforis.org/tools/collect-earth/
[c] https://openforis.org/tools/collect-earth-online/
[d] https://openforis.org/tools/sepal/
[e] https://earthmap.org

Source: FAO. 2023. Open Foris: Free open-source solutions for environmental monitoring. Rome. [Cited 1 February 2023]. https://openforis.org/

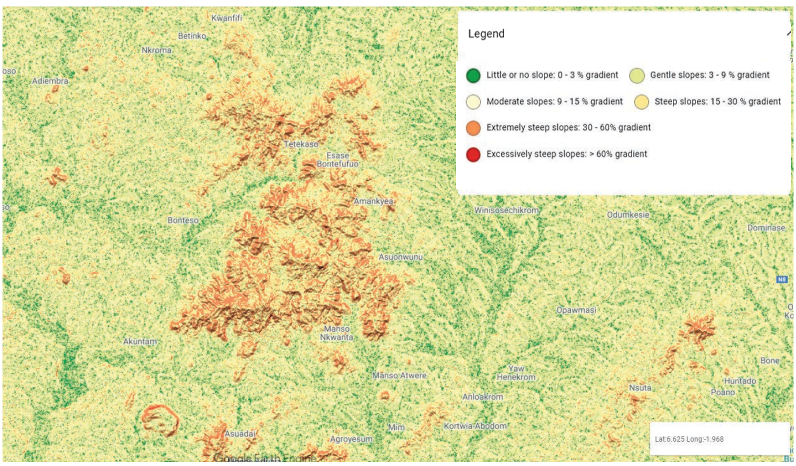
8.3.1 Topography

Topography refers to the forms and features of land surfaces in an area. It is important to consider topography, particularly the steepness of slopes, in forest management. On steep slopes, it is difficult or impossible to operate heavy equipment, and there are increased health and safety risks to workers. Slope of 45 percent (24°) is generally considered the limit for wheeled harvesters and skidders (FAO, 2004b), and areas with steeper slopes should be off limits to harvesting unless specific measures are taken to ensure operational safety and reduce soil disturbance[6]. Steep slopes are also more prone to erosion, and most landslides occur on slopes ranging from 15° to 35° (Çellek, 2020).

The Open Foris Earth Map platform (**Box 2**) allows users to view slope maps over an area of interest using the Shuttle Radar Topography Mission (SRTM)-derived elevation data (slope data layers can be found the under Geophysical tab) (**Figure 6**). These maps require field verification but provide reasonable indications of areas where forest management activities may be difficult.

Where there is sufficient capacity in GIS applications, global digital elevation model raster data (in 30-m resolution) are freely available from the European Space Agency[7] and the National Aeronautics and Space Administration[8] to facilitate slope mapping with statistics on slopes in the area of interest.

Figure 6. Slope map of an area to the southwest of Kumasi, Ghana



Source: FAO. 2023. Earth Map. Rome. [Cited 1 February 2023]. https://openforis.org/tools/earth-map/

6 Slope of 50 percent (26.6°) is the absolute limit for ground-based equipment recommended by the International Labour Organization (ILO, 1998).

7 https://spacedata.copernicus.eu/web/cscda/dataset-details?articleId=394198

8 https://asterweb.jpl.nasa.gov/gdem.asp

Recommended requirements:

Minimum	Good to have
• A hand-drawn map showing areas with slope of more than 15 percent. • Areas of landslips and active erosion indicated on a map.	• A map showing areas with slope exceeding 15, 30 and 50 percent (or other slope thresholds based on national regulations or code of practice), verified through field survey. • Contours and areas susceptible to landslips and erosion mapped.

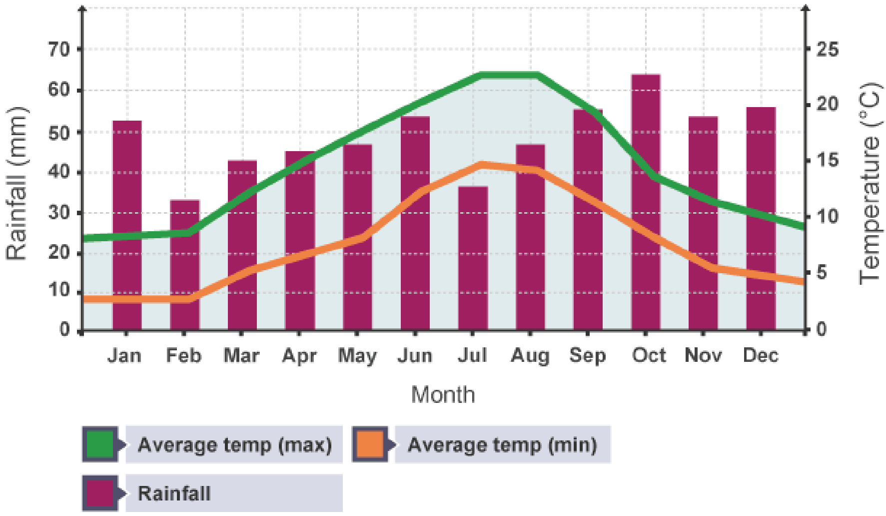
8.3.2 Climate and weather-related disasters

Climate is the average weather of an area over a longer period. Climate includes expected temperatures or rainfall in different months or days of the year. Climate also encompasses the likelihood of particular weather events, such as extreme wind speeds, temperatures, rainfall and drought, to occur at a certain place. Weather is the actual atmospheric conditions including rainfall, snowfall, solar radiation, temperature, wind speed and direction, and relative humidity experienced at a particular moment in time. Weather can change constantly over short periods. Both weather and climate are relevant considerations for forest management.

Climate data is often summarized in a climatogram showing the variation in precipitation and temperature over the course of a year (**Figure 7**). A climatogram with average monthly minimum and maximum temperatures enables the assessment of risks of frost that could kill trees or excessive heat that could affect the performance of workers. The Global Wind Atlas[9] provides wind information, including average wind speeds and interannual variations, that may also be useful for forest managers.

[9] https://globalwindatlas.info

Figure 7. Climatogram showing the average monthly rainfall and minimum and maximum temperatures



Source: Source: BBC (British Broadcasting Corporation). n.d. London. [Cited 11 January 2022]. https://bam.files.bbci.co.uk/bam/live/content/z98tvcw/large

Weather-driven natural disasters are becoming more frequent and severe due to climate change. Natural disasters can be extremely damaging, completely destroying forest stands or rendering trees unsuitable for economic uses. Disasters also pose serious threat to human lives and properties, which can affect forest operations, the local residents and markets for forest products. Many disasters have both natural and human aspects, for example wildfires ignited by humans spreading quickly under extremely dry conditions.

Common natural disasters and extreme weather events that impact forest management include:

- flooding;
- storm surge or tsunami;
- extreme winds (e.g. typhoons, storms and tornados);
- snow and hailstorms;
- extreme frost;
- wildfires;
- landslides;
- droughts;
- volcanic eruptions; and
- pests and diseases.

Information on disaster risks is often difficult to find and may be presented in forms that are difficult for a layperson to interpret. However, there is often a great deal of knowledge available in the collective memory of local communities on past events. In particular, the elderly in the community will likely remember past fires, floods, landslides and other disasters of significance.

Recommended requirements:

Minimum	Good to have
• Knowledge of past natural disasters that have affected the FMU and surrounding areas.	• Climatogram for the FMU or the surrounding area • Record of previous extreme weather events and natural disasters in and around the FMU. • Extreme weather events and natural disasters for which a preparedness and response plan is needed identified based on the frequency and impact of these events.

8.3.3 Waterbodies

Waterbodies constitute areas of surface water which can be moving (such as rivers and streams) or stationary (such as marshes, reservoirs and lakes). Some waterbodies are seasonal, only containing water during a particular season, while others are perennial, holding water throughout the year. Waterbodies serve as source of water to downstream ecosystems and communities. Health risks due to spillages of chemicals or fuels into the river is a key consideration if downstream communities obtain water for domestic use from the river. Waterbodies may also provide critical habitats and resources supporting biodiversity. As well, water is an essential resource for forest managers, providing water for nurseries and for forest fire fighting.

For the purpose of forest management planning, the location and type of waterbodies in the FMU should be documented. It is beneficial to know the extent of permanently saturated soils around a waterbody. Rivers in and around the FMU may be prone to flooding, which can have profound consequences for the forest and the infrastructure needed to maintain forest management activities. Forest managers need to be aware of the risks and benefits associated with these waterbodies for both natural ecosystems and nearby communities.

A riparian buffer zone signposted to prohibit tree harvesting and electric fishing.

Recommended requirements:

Minimum	Good to have
• A hand-drawn map showing the types and locations of waterbodies in the FMU, the direction of flow of moving water, the presence of downstream populations up to a distance of 15 km, and the extent of local floodplains.	• A digitized map containing the minimum information. • Buffer zones around waterbodies mapped and marked in the forest. • Information on downstream populations, water-dependent activities (e.g. irrigation) and habitats (wetlands and marshes) up to a distance of 25 km documented. • Risks of flooding from nearby rivers evaluated.

8.3.4 Soils and geology

Soil is a complex and dynamic living system that directly supports most above-ground vegetation, including trees. Soils differ in their ability to support vegetation depending on their depth, nutrient availability and water holding capacity. Knowledge of soils is essential to ensure successful forest management. Soil type is a key factor in determining the fertilization requirements for seedlings and is also a major determinant of site index.[10]

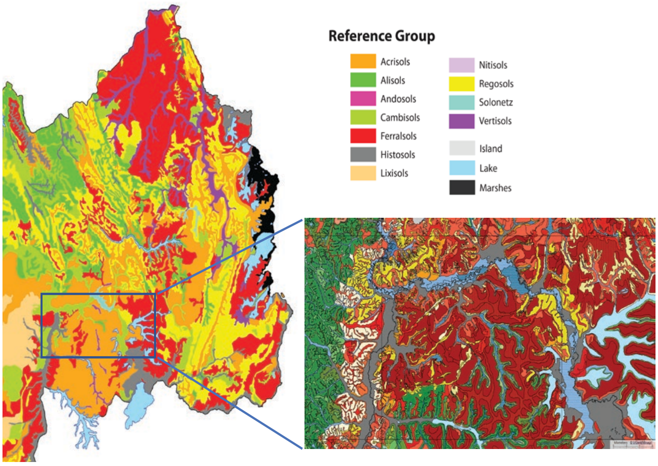
There are numerous national and international systems for describing soils for different purposes. World Reference Base for Soil Resources (WRB) is an

[10] Site index is a species-specific measure of actual or potential forest productivity or site quality, expressed in terms of the average height of trees included in a specified stand (Helms, 1998).

international soil classification system generally accepted by soil scientists, but in many countries, locally or regionally developed systems are commonly used.

Soil data is available in maps of different scales (**Figure 8**). SoilGrids[11] provides global soil information at a resolution of 250 m including an estimate of the soil type according to the WRB classification system. This information is not based on detailed fieldwork at all sites but is interpolated based on knowledge of soil-forming processes. Global soil maps of 1: 5 000 000 scale are available from FAO/UNESCO Soil Map of the World.[12]

Figure 8. Soil maps at scales of 1:250 000 and 1:25 000



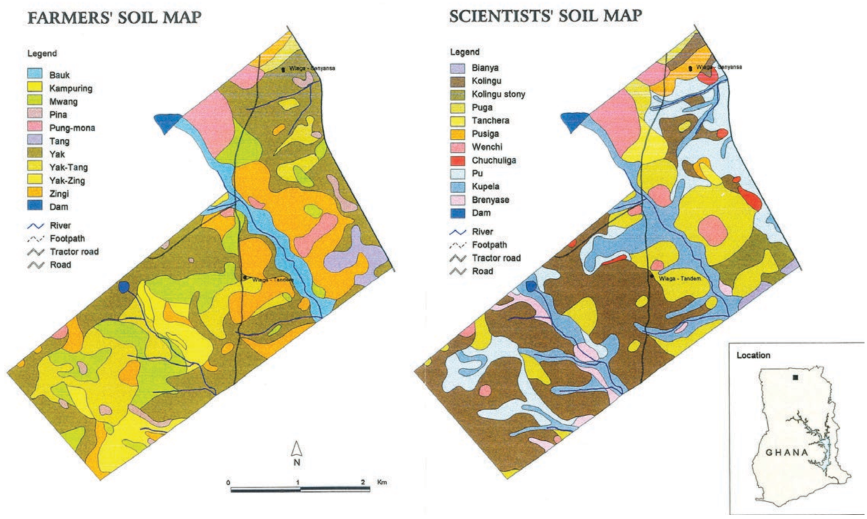
Source: Jones, A., Breuning-Madsen, H., Brossard, M., Dampha, A., Deckers, J., Dewitte, O., Gallali, T. *et al*., eds. 2013. Soil atlas of Africa. Luxembourg, European Commission, Publications Office of the European Union. 176 pp. https://esdac.jrc.ec.europa.eu/content/soil-map-soil-atlas-africa

In most countries, agricultural extension officers will have basic knowledge of soil types in the region where they work. Additionally, farmers in many parts of the world have developed their own systems of naming soils that correlate with suitability for growing different crops. Farmers are often capable of drawing useful soil maps based on their local knowledge and experience (**Figure 9**).

[11] www.isric.org/explore/soilgrids

[12] www.fao.org/soils-portal/data-hub/soil-maps-and-databases/faounesco-soil-map-of-the-world/en

Figure 9. Comparison of soil maps drawn by farmers and scientists



Source: Jones, A., Breuning-Madsen, H., Brossard, M., Dampha, A., Deckers, J., Dewitte, O., Gallali, T. *et al*., eds. 2013. Soil atlas of Africa. Luxembourg, European Commission, Publications Office of the European Union. 176 pp. https://esdac.jrc.ec.europa.eu/content/soil-map-soil-atlas-africa

Recommended requirements:

Minimum	Good to have
• Basic knowledge of the dominant soil types in the FMU and their suitability for agriculture and forestry activities.	• An indicative soil distribution map for the FMU based on available national or finer scale soil maps, updated over time based on field observation, with areas of fragile soils indicated.

8.3.5 Infrastructure and associated facilities

Infrastructure and associated facilities located in and around the FMU affect the ways in which forest management can be carried out. The condition and standard of access roads to the FMU may limit the type of vehicles that can be used to transport forest products from the FMU. The availability of accommodation close to the forest may affect the potential for ecotoursim. Connection to reliable electricity supply is a prerequisite for certain types of processing facilities, while reliable water supply is essential for various purposes. Within the forest, a network of trafficable roads is usually needed for timber harvesting as well as for rapid access in case of emergencies such as accidents or fires. Housing and other infrastructure in the forest, such as storage facilities and workshops, can also be locations of risks, for example from chemical or effluent release.

Recommended requirements:

Minimum	Good to have
• A hand-drawn map showing the locations of infrastructure in the FMU (including roads, housing, and third-party infrastructure such as railways, electricity cables, pipelines and irrigation channels).	• A digitized map showing the locations of infrastructure within the FMU, access routes to the FMU, and nearby towns and villages.

8.4. THE LIVING ENVIRONMENT

The living environment constitutes the totality of all living organisms and the interactions among them. Forest management will have impact on the living environment in and around the FMU; at the same time the living environment will dictate what types of forest activities can be conducted, how, where and when. A description of the living environment is therefore critical as it presents both opportunities and constraints for forest management.

Large organizations typically employs ecologists to describe the living environment in the FMU. This may not be feasible or practical for smaller operations. Medium-sized operations may still be able to contract specialists for limited periods during forest management planning, but small-scale owners are unlikely to have access to such expertise. However, help is often available from local NGOs and networks of people interested in nature. University and college biology departments are often searching for field projects for their students, and student labour can usually be attracted in exchange for the learning opportunity and basic provisions. In addition, there is an increasing number of freely available online resources that can be used to obtain information on the living environment, which are described in detail in the following sections.

High conservation value (HCV) approach (**Box 3**) provides a useful framework for assessing and identifying the presence of important ecological, environmental and social values present in the forested landscape.

8.4.1 Ecosystems and habitats

The term ecosystem refers to “a spatially explicit, relatively homogenous unit of the earth that includes all interacting organisms and components of the abiotic environment within its boundaries” (Helms, 1998). Habitats are defined as the place where an animal, plant, or population naturally or normally lives and develops. An aggregation of habitats having equivalent structure, function and response to disturbance, or those capable of producing similar plant communities at climax, comprise a habitat type (Helms, 1998).

Forest managers should have maps showing the locations of different ecosystems and habitat types in the FMU (see example in **Figure 10**). Typically, this would include mapping of different forest types and other habitat types

Box 3. High conservation value (HCV) approach

High conservation value (HCV) refers to a biological, ecological, social or cultural value of outstanding significance or importance at the national, regional or global scale (Stewart *et al.,* 2007). The concept was initially developed by the FSC for use in forest management certification, under which forest managers must identify and manage to maintain or enhance any HCVs that occur within the FMU (Jennings *et al.*, 2003).

The six categories of HCVs are as follows (Jennings *et al.*, 2003).

HCV 1: Areas containing globally, regionally or nationally significant concentrations of biodiversity values (e.g. endemism, endangered species, refugia).

HCV 2: Globally, regionally or nationally significant large landscape-level areas where viable populations of most, if not all, naturally occurring species exist in natural patterns of distribution and abundance.

HCV 3: Areas that are in or contain rare, threatened or endangered ecosystems.

HCV 4: Areas that provide basic ecosystem services in critical situations (e.g. watershed protection, erosion control).

HCV 5: Areas fundamental to meeting the basic needs of local communities (e.g. subsistence, health).

HCV 6: Areas critical to local communities' traditional cultural identity (areas of cultural, ecological, economic or religious significance identified in cooperation with such local communities).

With the role of forests in climate change mitigation becoming ever more important, the carbon held in forests is also a key consideration. The high carbon stock (HCS) approach aims to delink deforestation from commodity production to support the realization of "No Deforestation in High Forest Cover Landscapes". The HCS approach does not define HCS forest by an absolute carbon threshold. Instead, it uses field data on levels of biomass, vegetation structure and composition, together with remote sensing data, to create an HCS classification ranging from high-density forest to degraded former forest areas of scrub and open land. The HCS approach complements the HCV approach as some forests that provide essential carbon storage, habitat for biodiversity and forest products for local communities may not be considered as HCV (Rosoman *et al.*, 2017).

In some countries, the results of national HCV assessment are available to guide forest managers in understanding the presence of HCVs at a broad scale. To identify the presence of HCVs at the level of an FMU, an HCV assessment need to be conducted by a team of specialists. The

HCV Resource Networka is a not-for-profit organization that provides information on HCV and links to assessors. The HCV toolkit prepared by Proforest and the 'good practice guidelines for HCV assessments' (see Appendix 2) are useful tools for assessing HCVs as well as for managing and monitoring HCVs. Detailed guidance on HCS approach is available at https://highcarbonstock.org.

Notes:
Jennings, S., Nussbaum, R., Judd, N. & Evans, T. 2003. *The High Conservation Value Forest Toolkit. Oxford, Proforest.* http://www.proforest.net/fileadmin/uploads/proforest/Documents/Publications/hcvf-toolkit-part-1-finalupdated.pdf
Stewart, C., George, P., Rayden, T. & Nussbaum, R. 2008. *Good practice guidelines for High Conservation Value assessments: A practical guide for practitioners and auditors.* ProForest, Oxford

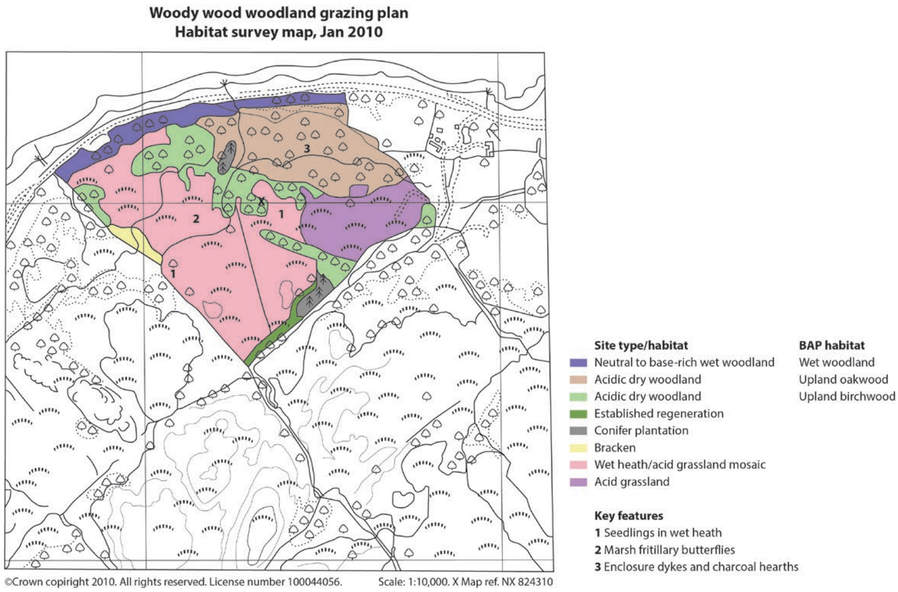
Source: Authors' own elaboration

such as grasslands and scrublands, as well as aquatic habitats. Ideally, such maps should identify different habitats at the compartment-level so that habitat-specific management activities can be implemented. Some ecosystems and associated habitats are rare and/or seriously threatened by anthropogenic activities. These areas should be protected from activities that cause further damage or decline.

The Habitat Classification Scheme[13] is useful for high-level classification of habitats. One Earth[14] also has course-scale maps of the most import ecoregions in the world and their habitats which can provide context for forest management planning.

[13] www.iucnredlist.org/resources/habitat-classification-scheme
[14] www.oneearth.org/bioregions

Figure 10. Habitat map of a small forest area in Scotland



Source: Scottish Forestry. 2010. Habitat Survey Map, Jan 2010. Edinburgh. [Cited 11 January 2022]. https://forestry.gov.scot/publications/566-habitat-survey-map-example/viewdocument/566

Recommended requirements:

Minimum	Good to have
• A hand-drawn map indicating the approximate location and extent of different natural ecosystems and habitats along with their simple colloquial descriptions.	• A digitized map indicating the location and extent of different forest types, ecosystems and habitats present in the FMU. • Description of the different ecosystems with reference to the vegetation structure and their conservation status.

8.4.2 Flora

It is important to understand the composition and structure of plant species in the forest area as they form the basis of both production (of timber and NWFPs) and biodiversity. Plants can be identified through traditional knowledge or locally available expertise including from local forestry offices, colleges, universities and NGOs. It can also be supported by mobile apps such as iNaturalist[15] and Pl@ntnet,[16] which uses citizen science to share and confirm data among a network of users.

[15] www.inaturalist.org

[16] https://plantnet.org/en

The following online resources can support the listing of both flora and fauna species of conservation concern in a defined area:

- Map of Life[17] produces a list of plant (and animal) species within 50 km of a point.
- The IUCN maintains an international database of species of conservation concern (IUCN Red List[18]) as well as a mapping platform[19] which can be used to generate a list of species likely to occur within a radius of 25 km from a point or within a defined polygon.
- Checklist of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) species[20] can be used to produce a national list of species that are at risk due to international trade.

In addition to documenting the common and the economically or ecologically valuable species, invasive alien plants that are known to be problematic in the area should be identified. Invasive species can cause considerable economic and ecological damage by inhibiting the growth of crop trees and NWFP species and altering native ecological processes.

Recommended requirements:

Minimum	Good to have
• A list of the most common plant species in the FMU developed using local knowledge (plants identified by local or common names). • Plant species of value to the forest manager and the local people identified. • Currently existing problematic invasive alien plants identified.	• A list of common plant species in the FMU developed through field survey, literature review, existing species lists and/or databases. • Plant species of economic, social and/or cultural value to the forest manager and the local people identified. • Problematic invasive alien plants, including those that show signs of expansion, identified.

8.4.3 Fauna

Fauna is a vital component of biodiversity that plays a critical role in maintaining ecological processes. In some forests, wildlife conservation is one of the main objectives of forest management either for consumptive use, ecotourism or the maintenance of cultural heritage.

Local residents are usually an excellent source of information on the presence and abundance of animal species around the forest area (both in the past and present). Forest workers in the FMU should also have records or recollections of animals they have encountered in the forest, either through direct sighting or indirect signs (footprints, nests, dens, scats, calls, etc.).

There is an increasing number of online tools available for preparing

---

17 https://mol.org

18 www.iucnredlist.org

19 www.iucnredlist.org/fr/search/map

20 https://checklist.cites.org/#/en

preliminary species list and for identifying species from photographs or sound recordings (see list of online tools listed in Section 8.4.2 which can be used for both flora and fauna species). In addition, eBird[21] collates bird species lists generated by volunteers from many parts of the world with links to the IUCN conservation status of species.

The (likely) presence of animals in and around the FMU that meet the following criteria should be documented: 1) species of special conservation value; 2) animals that provide essential ecosystem services, such as pollination of agricultural crops and control of pests and weeds; 3) animals that cause human-wildlife conflict; and 4) other species that contribute to local economies, food security and cultural preservation. Appropriate measures are needed to protect these species and their habitats as required, or to manage conflicts if any.

Finally, pests and diseases that are known to be common and problematic in the area should be noted. Damage caused by forest pests, with insects being the most common, can significantly reduce local biodiversity and alter natural forest landscapes by decimating one or more tree species. Some pests may necessitate changes in management regimes, including switching to alternative tree species in plantations. Diseases , usually caused by bacteria, viruses and fungi, can also result in large-scale damage of economic, social and environmental significance.

Recommended requirements:

Minimum	Good to have
• A list of animals that are known to occur in the FMU developed using local knowledge (identified by local or common names). • Species that are considered important for any reason by the local people identified. • Problematic pests and diseases present in and around the FMU documented.	• A list of animals that are confirmed or likely to be present in the FMU developed through field survey, literature review, existing species lists and/or databases. • Species of conservation concern with a known distribution overlapping the FMU identified. • Common pests and diseases present in and around the FMU, including those that show signs of range expansion, documented.

8.4.4 Ecosystem services

Ecosystem services, which include provisioning, regulating, supporting and cultural services, generate a wide range benefits for human society, underpinning many production systems (**Table 1**). This section is principally concerned with regulating services as most other aspects are covered elsewhere in greater detail.

[21] https://ebird.org/home

Table 1. Ecosystem services belonging to four categories

Provisioning services	Regulating services	Cultural services	Supporting services
Products obtained from ecosystems	Benefits obtained from regulation of ecosystem processes	Non-material benefits obtained from ecosystems	Services necessary to produce all other ecosystem services
Food	Climate regulation	Spiritual and religious	Soil formation
Fresh water	Disease regulation	Recreation and ecotourism	Nutrient cycling
Fuelwood	Water regulation	Aesthetic	Primary production
Fibre	Water purification	Inspirational	
Biochemicals	Pollination	Educational	
Genetic resources		Sense of place	
		Cultural heritage	

Source: Millennium Ecosystem Assessment. 2003. *Ecosystems and human well-being: a framework for assessment.* USA, Island Press. http://pdf.wri.org/ecosystems_human_wellbeing.pdf

Quantifying intangible ecosystem services is often complex and time-consuming, requiring expertise that may not be readily available locally. HCV approach provides a useful framework for assessing ecosystem services, but implementing a full HCV assessment may not be feasible or practical for SMFEs given the financial constraints and the limited area extent of the FMU. In these cases, consultations with local communities provide an effective approach to identifying the most important ecosystem services that benefit the local populations either directly or indirectly. It should be noted, however, that local communities often have difficulty in identifying such ecosystem services without prior awareness raising and effective moderation (Wangchuk *et al.*, 2019).

There are some freely available online resources to support this task, including the Ecosystem Services Identification & Inventory Tool[22] and Spurring INnovations for forest eCosystem sERvices in Europe (SINCERE),[23] which provide links to a range of tools for different circumstances. Some of these tools enable the comparison of ecosystem services provided under different land-use allocations and management scenarios.

Recommended requirements:

Minimum	Good to have
• Ecosystem services that provide important benefits to local communities identified through consultations.	• An HCV assessment conducted to identify critical ecosystem services provided by the forest in the FMU. • An assessment of the impact of forest management on ecosystem services provisioning.

22 www.esiitool.com

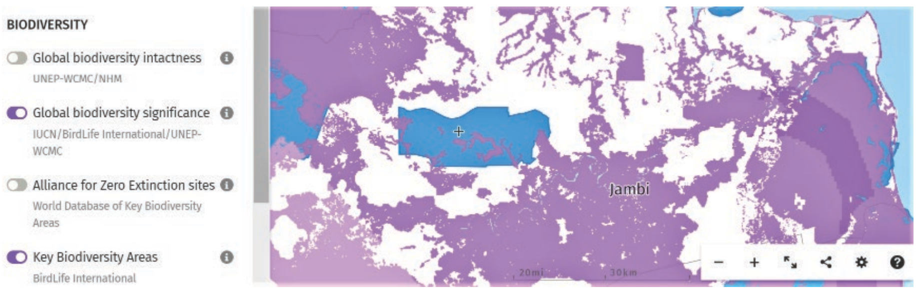
23 https://sincereforests.eu/resources/toolkit/assessing-and-valuing-ecosystem-services

8.4.5 Biodiversity

Forests, including those managed primarily for production, play a critical role in the conservation of biodiversity (Harrison *et al.*, 2022). It is therefore important to understand the presence and status of key biodiversity resources that are present in the FMU to ensure that forest management activities do not threaten these species, habitats and resources. Sections 8.4.2 and 8.4.3 deal with identifying flora and fauna, which comprise key components of biodiversity. This section presents some useful online tools that can support the identification of critical areas for biodiversity conservation at the landscape level.

- Global Forest Watch24 provides maps that can be overlaid with various biodiversity indicators including threatened ecosystems (**Figure 11**). In the below figure, areas of global biodiversity significance (from IUCN/BirdLife International/UNEP-WCMC) are shown in purple and Key Biodiversity Areas (from Birdlife International) in blue

Figure 11. A Global Forest Watch map showing priority areas for biodiversity conservation in Jambi Province, Sumatra, Indonesia

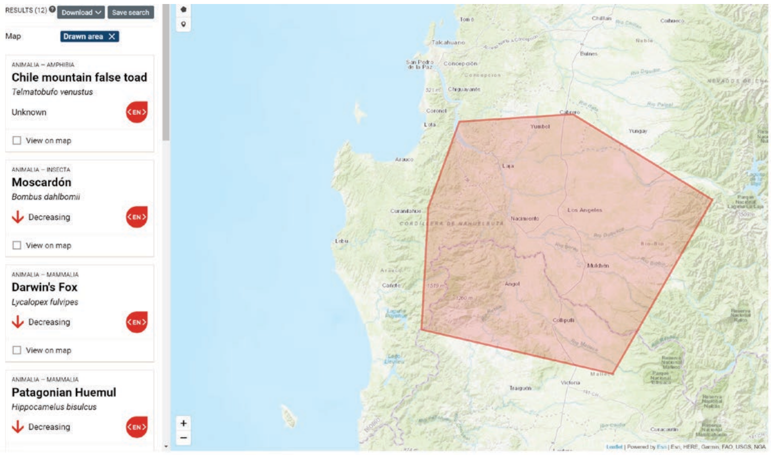


Source: Global Forest Watch. 2022. Washington, D.C. [Cited 11 January 2022]. www.globalforestwatch.org

- Nature Map Explorer[25] provides a set of integrated global maps on biodiversity and ecosystems services at a course scale that can provide context for the FMU.
- IUCN's Red List mapping platform[26] can be used to identify species of conservation concern likely to occur within 25 km around a point or within a defined area of at least 2 000 km² (**Figure 12**).

24 www.globalforestwatch.org
25 https://explorer.naturemap.earth/map
26 www.iucnredlist.org/fr/search/map

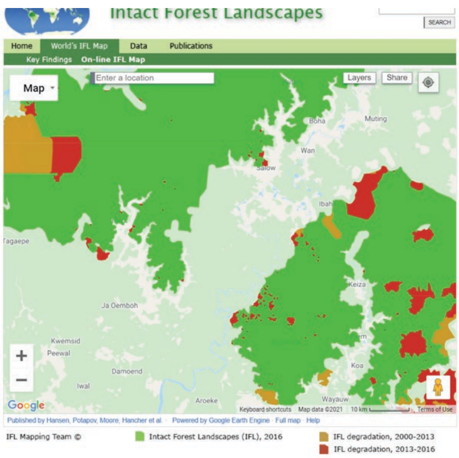
Figure 12. A map showing species of conservation concern that are likely to occur in an area in Chile



Source: IUCN. 2023. The IUCN Red List of Threatened Species Version 2022-2. Gland. [Cited 11 January 2023]. https://www.iucnredlist.org

- Intact Forest Landscapes (IFL) interactive mapping platform[27] can be used to determine if the FMU forms part of an intact forest landscape,[28] **Figure 13** shows the extent of intact forest landscapes in bright green and areas of degradation in red and orange.

Figure 13. Intact forest landscapes in an area in Papua New Guinea



Source: The IFL Mapping Team. 2021. Intact Forest Landscapes. [Cited 11 January 2023]. https://intactforests.org/index.html

27 www.intactforests.org/world.webmap.html

28 Intact forest landscape is defined as "an unbroken expanse of natural ecosystems within the zone of current forest extent, showing no signs of significant human activity and large enough that all native biodiversity, including viable populations of wide-ranging species, could be maintained" (www.intactforests.org)

Recommended requirements:

Minimum	Good to have
• Any conservation status attached to the FMU determined in consultation with local government forestry officers. • The presence of critical areas for biodiversity conservation in and around the FMU identified by consulting global databases.	• The presence of critical areas for biodiversity conservation in and around the FMU identified through an HCV assessment.

8.5. FOREST RESOURCES

This section deals with the assessment of forest resources of economic, social and cultural values.

8.5.1 Timber

Timber resources typically comprise the most commercially valuable commodity from the forest and form the backbone of most forest enterprises. Timber can be harvested and regrown, either through natural regeneration or planting, for future harvest. The economic viability of forest enterprises is dependent on income from the timber (and NWFP) harvest covering all costs of forest management.

Forest inventory and growing stock

The volume of commercial timber available for harvesting, or the growing stock, must be determined through a forest inventory.[29] This involves measuring trees to determine how much timber of different species and dimensions is present. Traditionally, this has been done through ground-based surveys, but there is now an increasing use of remote sensing data either from satellite or aircraft-borne instruments.

Forest inventory is a specialized field in forestry. There are many different approaches and methods to forest inventory, and the choice will be determined by many factors including the forest type (e.g. monoculture forest plantation vs. diverse natural forest) and the types and accuracy of information required for decision-making. The method used should be the least-cost method that provides the required information. In most cases, sampling approach is taken as it is not practical nor beneficial to measure all trees in the forest.

By convention, measurement of a tree diameter is carried out at breast height (1.37 m) usually using a tape measure. It is possible to use diameter tapes that are calibrated to measure the diameter of a cylindrical object, but a standard tape measure can also be used, in which case the circumference is divided by π (3.142) to derive the diameter. The diameter is a commercially

[29] Forest inventory can compass not only commercial timber species but also all other aspects of the physical and living environment discussed in this chapter.

important measure because timber processing plants often have a minimum diameter that they can use, and legal restrictions often set thresholds on minimum or maximum felling diameter.

In the absence of specialized forest inventory instruments, a simple tree-measuring kit can be prepared using the DIY Tree Measuring Kit (Natural Resources Wales, 2022).[30] This kit includes callipers for tree diameter, a hypsometer for tree height and stem height and a relascope for determining the basal area surrounding a point. There is also an increasing number of mobile phone apps available[31] and the use of drones[32] to estimate tree dimensions and growing stock.

It is common to describe stocking of a site in terms of the basal area, which refers to the area of the stems measured at breast height per unit area of ground. The basal area ranges between 5 m^2 / ha and 40 m^2/ ha for most forest types. The basal area increases as the trees increase in diameter but decreases when trees die or are removed by harvesting. The basal area is often used as reference in silvicultural planning. For example, a stand may be classed as ready for thinning when it reaches a basal area of 25 m^2/ ha. Basal area can also be combined with usable stem length to estimate commercial timber volume.

To estimate the volume or biomass of a tree, species-specific relationships between the tree diameter, volume and biomass need to be known. This relationship is expressed as an allometric equation, which estimates volume and biomass using parameters such as tree diameter, height, and wood density. An international web platform, GlobAllometree,[33] is a useful resource that provides free access to a global database of tree allometric equations. A simple way of estimating merchantable volume of a tree is to multiply the basal area by tree height and form factor (Volume = BA x H x FF).[34]

Large companies usually employ experts to design and implement forest inventory to estimate growing stock at the required accuracy. Smaller enterprises may not have the resources or the capacity to do this, in which case they must use other practical and appropriate methods. Caldwell *et al.* (2021)[35] describes how groups of smallholders can organize forest inventories to enable better planning of forest businesses through improved knowledge of their resources and market opportunities. The document also provides step-by-step guidance on measuring trees in the forest and using the data to estimate timber volume.

---

30 https://cdn.naturalresources.wales/media/688310/template-diy-tree-measuring-kit.pdf
31 For example, www.arboreal.se/en/arboreal-forest and www.moti.ch
32 https://deepforestry.com
33 www.globallometree.org
34 If species-specific form factor is not available, 0.7 can be used as a general default value.
35 www.fao.org/3/cb4905en/cb4905en.pdf

Recommended requirements:

Minimum	Good to have
• A list of commercially valuable trees available in the FMU. • Basal area and volume of commercial trees estimated for representative areas of the FMU.	• Basal area and volume of commercial trees estimated for each stand in the FMU based on forest inventory data and appropriate form factors or allometric equations.

Forest growth

The rate at which trees grow determines the volume of timber that can be harvested sustainably. Tree growth rates are extremely variable between individuals, species, sites and habitats, and therefore requires repeated measurements of a sufficient sample size of trees under different growing conditions to estimate at a required level of accuracy.

Tree growth rate can be determined in several ways. In natural forests managed for timber production, there are often permanent sample plots in which the same trees are measured every few years to determine long-term growth rates. In even-aged stands where the timing of a stand replacement event (e.g. clearcut followed by replanting, fire, or storm blowdown) is known, the growth rate of the stand can easily be determined by dividing the diameter by the age of the stand.

Where tree growth is seasonal (due to cold winters or seasonal drought), growth rings can be used to determine historical growth rates. The growth rate of individual trees reflects the effects of past silvicultural activities and growing conditions. The tree in **Figure 14** has a circumference of 41. 5 cm with 11 growth rings. Thus, the annual growth rate of the tree is 41. $5/11\pi$ = 1.2 cm. It is likely that the tree benefited from a thinning operation around year 5 or 6, which accelerated its growth. Weather conditions in year 10 may have been unfavourable as the growth ring suddenly becomes much narrower. If it is not desirable or permissible to fell a tree, an increment borer can be used to obtain a tree core sample. Black Rock Forest (2020) provides a video on the use of an increment borer.[36]

[36] www.youtube.com/watch?v=sKfK2nqb5XM

Figure 14. Cross-section of a tree trunk showing clear growth rings

Wider rings represent years with favourable growth conditions (e.g. wetter years, after thinning). Light coloured bands are spring-summer/wet season growth, while the narrow dark coloured bands represent autumn-winter/dry season growth. Fire scars may also be visible if the tree was scarred by fires in the past.

For the common plantation species and intensively managed natural forests in temperate and boreal regions, extensive research has been conducted to develop growth rate estimates under different management scenarios. However, such data are usually not available for natural tropical forests, where tree species are diverse and do not develop annual growth rings. In these cases, growth rates of the main commercial timber species may be obtained from local forestry officers or from the experience of other forest managers in the area.

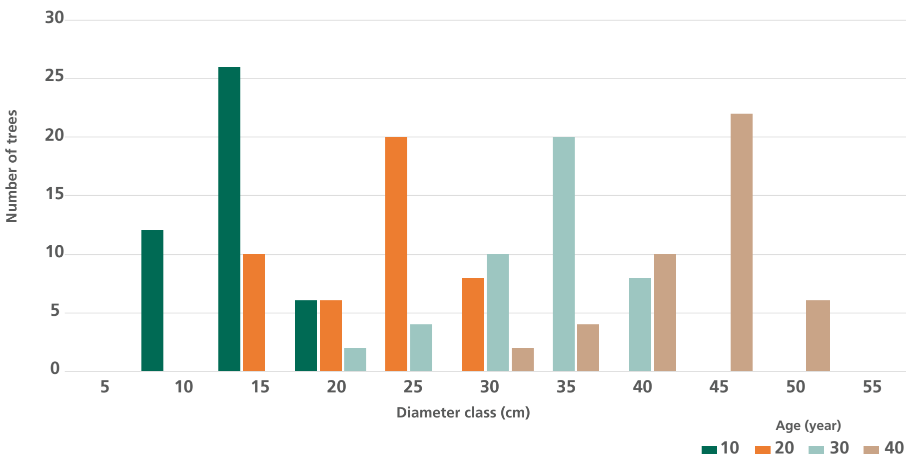
Recommended requirements:

Minimum	Good to have
• Growth rates of tree species to be harvested obtained from local extension officers or other forest managers in the area.	• Growth rates of the main commercial timber species in the FMU estimated from historical growth rates, repeated measurement of permanent sample plots, experience of other forest managers in the area, or information from the local forestry offices.

8.5.2 Growth and yield modelling

The estimated growth rates of the main commercial timber species can be combined with forest inventory data to estimate the timber assortments that will be available in the future (**Figure 15**). For some species and forest types, these models have been summarized as yield tables for different silvicultural systems (Matthews *et al.*, 2016). The choice of silvicultural system and the site-specific growing conditions (availability of light, water, and nutrients) are usually the most critical factors in determining growth and yield. The difference in the height trees of the same age, expressed as site index, indicates forest productivity.

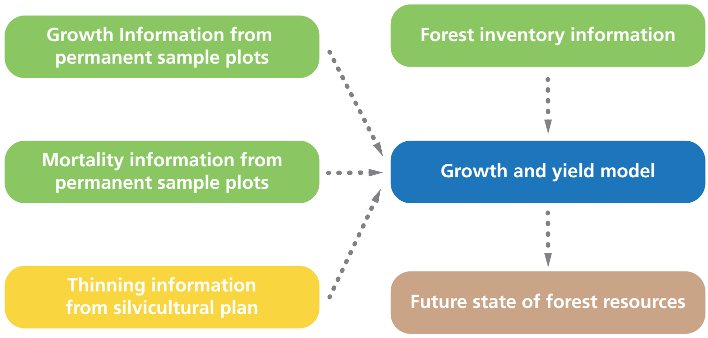
Figure 15. Hypothetical diameter distribution of a dryland forest measured at age 10 and modelled to 40 years



Growth and yield models based permanent sample plot data are well developed for plantation species and intensively managed natural forests in developed countries (**Figure 16**). However, there is little information available for the more complex tropical forests. In tropical forests, the MYRLIN system can be used to estimate future yields[37] and this has been recently updated with improved parameter estimates for a wider range of moist forest types (Alder, 2020).

[37] https://bio-met.co.uk/myrlin/original

Figure 16. Structure of a typical growth and yield model for a forest



Notes: Green boxes represent inputs from inventories and sample plots; orange box represent inputs from forest management practices; blue box represents the model and calculations; and the brown box represents the outcome of forest management, which will include both the future state of forest resources and available products.

With knowledge on the estimated volume of individual trees or stands up to a specified point in time, the mean annual increment (MAI) can be calculated. MAI is the average annual growth of a tree or a stand of trees, usually expressed as volume per unit area (e.g. m^3/year).

Recommended requirements:

Minimum	Good to have
• Future stand volume estimated up to the end of the current forest management period by combining the current growing stock and the growth rate.	• Stand-level growth and yield modelled up to the end of the current forest management period. • Mean annual increment of the forest stands estimated.

8.5.3 Non-wood forest products

The terms non-wood forest products (NWFPs) and non-timber forest products (NTFPs) are often used interchangeably, although there is a difference in that NTFPs include fuelwood and small woods while NWFPs exclude all woody raw materials. In this publication, we use the term NWFPs, which consist of goods of biological origin other than wood, derived from forests, other wooded land and trees outside forests. These include bamboo, rattan, palms, vines, resin, honey, fungi, edible plant parts, medicinal plants and animals.

Many NWFPs play a crucial role in local livelihoods and strengthening resilience by providing resources for subsistence as well as income generation. Certain NWFPs also constitute valuable commodities in national and international markets. Some forest managers may also harvest NWFPs commercially. In some cases, for example in South Africa with the *Boletus edulis* mushrooms, NWFPs generate more income than timber in some years.

A local community member preparing nets to catch fish in a river in a forest area.

© FAO/Brent Stirton-Getty Images for FAO, CIFOR, CIRAD, WCS

It is essential to consider NWFPs in forest management decision-making as certain forest management activities can influence the availability of NWFPs. The most practical way to obtain information on the use of various NWFPs is to consult the local people (noting that men and women may have different relationships with NWFPs). A visit to the local market may also reveal information on the types and value of NWFPs that are on sale. In addition, there are online resources available for specific NWFP species in certain countries or regions (e.g. online database of the Non-Timber Forest Products-Exchange Programme[38] which contains information on various NWFPs commonly harvested in Southeast Asia).

Recommended requirements:

Minimum	Good to have
• A list of NWFPs used by the forest manager (including forest workers) and local communities compiled through consultations. • General understanding of how, when and where local people collect NWFPs.	• Information on the use of NWFPs by local communities (including species, quantities, seasons and locations). • NWFP species of conservation concern identified. • Field inventory of NWFPs that are used commercially by the forest manager.

[38] https://ntfp.org/information-resources

8.6. SOCIAL AND CULTURAL FEATURES

In addition to ecological, environmental and economic benefits, forest also provide resources of social, cultural, religious, historical, recreational and scenic values, which may be of relevance at the local and wider scales (**Table 2**). Knowledge on the local use and perception of the forest is vital in accounting for the needs of local populations in forest management planning.

Table 2. Socially and culturally important sites and resources that may be found in a forest

Site and resources fundamental for meeting basic needs	Hunting and trapping grounds, NWFPs, fuelwood, plants and animals that serve as sources of food, building materials, fodder and grazing areas for livestock, water resources.
Site and resources of cultural importance	Traditional meeting places, archaeological sites, culturally significant trees, plant or animal resources used in traditional ceremonies.
Religious sites and resources	Sacred trees and forests, places of worship, shrines.
Historical sites	Battle sites, ancient buildings.
Sites and resources of recreational and spiritual importance	Picnic sites, forest trails, camping grounds, viewpoints, fishing sites, sites for watching birds or animals.

It is critical that these social and cultural resources are identified with the engagement of local communities, including representatives from minority, vulnerable and marginalized groups. Local communities should also validate and agree to the results and decisions made. Forest management activities, if poorly planned and without the involvement of local stakeholders, frequently lead to conflict with local populations.

Some of these resources may be accessed free of charge for those who have traditionally used them, or they may be used to generate income. It is not unusual to charge for the use of a picnic site or for overnight camping as such activities will require management. Non-consumptive uses may also provide significant local employment in a range of roles including facilities maintenance, access control, guiding and interpretation, and catering.

One method of collecting this type of information is rapid rural appraisal, which uses a fairly quick but efficient team-based approach. This can generate useful information to help guide the process of community engagement.

Recommended requirements:

Minimum	Good to have
• Resources of social and cultural significance in the FMU identified and mapped in consultation with local communities	• Assessment of risks to social and cultural resources posed by forest management activities. • Awareness of opportunities to generate income and diversify forest employment through social and cultural resources.

A large tree considered sacred by villagers.

©Aulia Erlangga/CIFOR

9. Describing the social, economic and regulatory environment

9.1. IDENTIFYING LOCAL STAKEHOLDERS

Engagement of local communities and considering their needs should be at the heart of forest management process. In some cases, local communities own the forest or the right to manage the forest for their benefit, and carry out the management themselves. Even in these cases, ensuring equitable sharing of benefits and engaging other community members who are not part of the forest management group will still be important.

Local communities can also provide support services for forest operations, including labour and technical services. As well, local residents can also alert the forest manager in case of timber theft, other illegal activities and fires. Therefore, maintaining a good relationship with local stakeholders is critical regardless of whether the forest manager is part of the local community or a non-local actor.

Where forest management rights are allocated to the forest manger by government authorities, local communities may have overlapping customary rights to the forests of the FMU, including the right to harvest NWFPs and timber. If the local population include Indigenous Peoples,[39] a process of free, prior and informed consent (FPIC) should be followed (see **Appendix 2** for further guidance). Even for community-managed forests, it is necessary to understand and consider issues such as equity, social exclusion, asymmetric power relations, elite capture of benefits and gender to ensure effective forest management and equitable distribution of benefits (Gilmour, 2016).

[39] In accordance with international consensus, FAO abides by the following criteria when considering Indigenous Peoples: 1) priority in time, with respect to occupation and use of a specific territory; 2) the voluntary perpetuation of cultural distinctiveness, which may include aspects of language, social organization, religion, and spiritual values, modes of production, laws, and institutions; 3) self-identification, as well as recognition by other groups, or by State authorities, as a distinct collectivity; and 4) an experience of subjugation, marginalization, dispossession, exclusion or discrimination, whether or not these conditions persist.

A community elder explaining the location of sacred forests

©Violet Atieno-CIFOR

Recommended requirements:

Minimum	Good to have
• Key local stakeholders to the FMU identified with brief descriptions of their relationship to the forest. • The identity and location of neighbours who own or manage lands adjacent to the FMU.	• Mapping of local stakeholders, including communities, government authorities, extension workers, civil society organizations, forest product traders, forest enterprises, industry associations, etc.

9.2. DESCRIBING LOCAL POPULATIONS

Describing local populations is a complex task that involves collecting basic demographic information as well as understanding their relationship with the forest. Demographics refers to the structure and distribution of individuals in a population. Demographic information relevant to forest management planning include the size, location, age structure and gender composition of the population. Data on employment and educational attainment levels may also be relevant. These demographic data provide information on the availability of forest workers both now and in the future, as well as the local demand for forest products including fuelwood.

Demographic information of nearby villages and population centres should be available from regional or local authorities. In the event that such data are not available, it may be necessary to carry out surveys to collect data on the basic demographic parameters.

Recommended requirements:

Minimum	Good to have
• Basic demographic information of local villages and towns.	• Assessment of how the demographics of local villages and towns may affect the FMU in terms of availability of labour, forest management expertise and other services.

9.3. LOCAL BUSINESSES AND MARKETS

Local businesses can provide critical services for forest management and offers marketplaces for the sale of timber, NWFPs as well as ecosystem services (**Table 3**).

Table 3. Types of services and markets provided by local businesses and organizations

Products	Services	Markets
Timber	• Forest management advisers • Forestry contractors including for harvesting • Vehicle and equipment sales, repair and maintenance • Forestry training	• Sawmills • Furniture makers • Charcoal producers • House builders • Farmers • Biomass users
Non-wood forest products	• Agricultural advisers • Value chain development	• Local residents • Vendors in local market • NWFP collectors and processors • Traditional healers
Non-consumptive use	• Ecotourism guides • Tourism organization	• Ecotourists • Youth organizations and schools • Hotels and tourism operators

Local businesses may be both competitors and supporters of the forest management enterprise for different objectives. Small forest owners often cooperate when cost savings can be realized (e.g. in sharing a harvesting contractor) while at the same time competing to sell their products. Large companies may provide technical and operational support for small forest owners in exchange for preferential access to the forest products.

Recommended requirements:

Minimum	Good to have
• Local timber buyers and producers' cooperatives identified.	• Local buyers and market opportunities for forest products identified. • The local availability of forestry support services documented.

9.4. REGIONAL BUSINESSES AND MARKETS

Regional businesses and markets offer opportunities for the sale of a wider range of forest products, including different dimensions and species of timber, by-products such as sawdust and wood chips for biomass, and various NWFPs. These opportunities enable forest revenue diversification, enhancing resilience in view of inherent risks of biological production and market fluctuations. In most cases, even for products that are ultimately exported, agents servicing these markets are regionally based.

As well, a more varied range of forestry-related services are typically available at a higher level of competence in regional markets. These services may relate to forest health, training, management advisory, forest engineering and planning support. In many countries, there are national and/or regional associations of forest managers that can provide advice regarding regional support services and markets. Such support may be critical to the success of a forest management enterprise.

Recommended requirements:

Minimum	Good to have
• Awareness of regional markets and buyers of forest products, as well as product demand and prices in these markets.	• Regional buyers and market opportunities for various forest products identified and documented. • Availability of forestry-related support services at the regional level documented.

9.5. UNDERSTANDING PRODUCT REQUIREMENTS AND OPPORTUNITIES FOR VALUE ADDITION

Often, small forest owners sell their forest products at the offered price without exploring ways to maximize the potential value of their products. As a result, logs with higher potential value may be sold for low-value uses such as wood chip production. In these situations, simply sorting logs into categories based on species and dimensions may allow the forest managers to capture more value as it may be possible to sell some of the timber for high-value uses. An even better approach would be for the forest manager and the sawmills to understand the exact requirements in terms of dimensions and wood properties from the final product manufacturer. This would allow for

Sawmill in Ghana producing legal timber for domestic and international markets.

more efficient use of timber and wood residues, as well as enhanced value generation.

Improved understanding of product requirements may also influence the silvicultural system to enable production of timber of the right species, properties and dimensions for the market. A wide range of products can be produced from timber of various dimensions and species, including the currently underutilized species. Small pieces of timber may be used to make utensils, tool handles and chopping boards. Larger dimensions can be used for construction or furniture making. The largest pieces of timber may be used for beams or marine piles. Nowadays, it is also possible to create large wood panels by glue-laminating or cross-laminating smaller pieces of wood.

Smalls-scale producers are often at a considerable disadvantage in the marketplace because of the small volume of products they sell in relation to buyer requirements. This can lead to low prices or poor terms of sale dictated by traders who seek to maximize their margins. Forming forest producer cooperatives and establishing direct relations with the wood processors may provide small-scale forest producers with more bargaining power.

To optimize sales price, the forest manager must learn as much as possible about the market requirements. This can be achieved by speaking to timber processors to determine their requirements and what they are prepared to pay for timber that meets their specifications.

Recommended requirements:

Minimum	Good to have
• Understanding of the market requirements for forest products in terms of species and dimensions.	• Prices of different forest products and the required specifications in terms of species, dimensions and quality documented. • Understanding of the end uses of timber locally and regionally.

9.6. FOREST RIGHTS AND TENURE

Forest tenure is the right, statutory or customary, that determines who can use, manage, control, or transfer forest lands and resources such as wood or the multitude of NWFPs. Forest tenure may be assigned according to government laws (statutory law) or by long-held traditions of communities (customary law). Most aspects of forest rights are linked to landownership, but forest resources and the land are dealt with separately in some countries. In most cases, the owner of forest rights can assign the rights to another party through a contractual agreement. To practise forest management, the forest manager must be able to demonstrate the possession of relevant rights.

In some countries, particularly those with long traditions of customary tenure, there can be difficulties in verifying tenure rights. Participatory mapping approach can be a practical approach to map the current and historical land use, as well as areas under customary management and resource use (Brown *et al.*, 2013). FAO has developed the SOLA Suite,[40] a set of free, open-source tools aimed at improving tenure governance by increasing transparency, reducing the cost for recording, and managing existing tenure rights in customary or informal tenure systems.

Recommended requirements:

Minimum	Good to have
• Documented evidence of forest tenure for the entire area of the FMU. • Any overlaps and conflicts in tenure (e.g. hunting grounds, customary land occupation) documented on a map.	• The way in which customary rights are exercised documented in consultation with concerned stakeholders.

[40] www.fao.org/tenure/sola-suite/en

9.7. LAWS AND REGULATIONS

The laws and regulations applicable to forest management vary enormously among countries and sometimes even within countries, for example between forest plantations and natural forests. Laws that relate directly to forestry include those that deal with land and tree ownership, taxes or royalties for harvesting trees, fees for obtaining permits, rules related to transport of forest products, environmental provisions, and changes of land use. Forestry laws may also prescribe or forbid certain silvicultural practices or systems. Forestry laws cover a range of aspects and may take many forms ranging from precise instructions to general requirements (Table 4).

Table 4. Aspects typically addressed in forestry laws and regulations

Forest management planning	• Requirements for forest management planning (the content, planning process, intervals for updating, public consultation, and qualifications required for developing it)
Environmental and social impacts	• Requirements for environmental and social impact assessment • Enforcement environmental and social performance standards • Requirements on buffer zones around waterbodies • Restriction of certain activities on steep slopes • Designation of set aside areas for environmental protection • Requirements (or prohibition) on the use of fire • Protection of biodiversity (species, habitats and ecosystems) • Restrictions on the use of chemical pesticides and fertilizers
Consultation and participation	• Requirements to engage, consult and reach agreements with local communities • Specifying levels of compensation to local communities for timber harvested from community lands • Specifying social contributions such as roads, schools, clinics, etc. • Requirements to allow local community access to forest resources
Timber harvesting and transport	• Minimum felling diameters and rotation periods • Felling licences • Forest road specifications including requirements for road closure • Transport permits • Record keeping of harvest volumes • Verification of harvests by regulatory authorities
Silviculture	• Specifying species permitted for harvesting • Restrictions on the use of certain species (e.g. non-naïve species, genetically modified trees) • Requirements for reforestation, rehabilitation and enrichment planting • Restrictions or prohibitions on certain types of silvicultural activities (e.g. clearfelling)
Forest taxes and allocation of rights	• Stumpages • Concession fees and rents • Rules for competitive bidding • Rules for allocation of concessions • Rules for allocation of communal forest rights

Labour laws cover the relationship between an employer and the employee, including the process of employment, disciplinary procedures, employee dismissals, and compensation requirements when terminating employment. Labour laws usually define the difference between short-term and long-term employment and set time limits for repeated short-term employment. These laws also cover social security payments, insurance for workers, minimum wages, health and safety requirements, as well as workers' rights to organize.

Business laws govern the dealings between persons and businesses and include the regulation of commercial entities as well as commercial transactions. These laws usually place different requirements on business entities depending on the size and forms of ownership.

There will likely be many other laws that forest managers need to comply with in different countries. These could include laws related to mineral rights, biodiversity conservation, environmental protection, compliance with various international conventions, Indigenous Peoples' rights, human rights, etc.

Information on laws relevant to forestry is generally available from national forest authorities, local forestry officers, forestry extension agents, forest-related NGOs or local government representatives. In some countries, information on all laws is available online. As legal language can be difficult to understand, it may be useful to seek advice from knowledgeable sources, such as lawyers, local government agents and NGOs. Forest faculties in some universities also offer extension services. In addition, national or local forest owners' associations can be valuable sources of information. Other potential sources of information and advice on legal requirements include labour unions and local chambers of commerce.

Recommended requirements:

Minimum	Good to have
• Awareness of national and local forestry laws pertaining to forest operations in the FMU. • Understanding of relevant permit requirements and how to obtain them.	• Local and national laws relevant to the forest operations, including forestry laws, business laws, labour laws and environmental laws, documented.


PART III. DOCUMENTING THE FOREST MANAGEMENT PLAN
©FAO/Kenichi Shono

Based on the quantitative and qualitative information gathered and analysed in Part II, the forest management plan needs to be compiled and documented in a suitable format with the appropriate level of detail in view of the legal requirements and the scale and complexity of forest management (Chapter 10).

Objective setting is a critical process whereby the objectives of forest management are identified for multiple uses considering the economic, environmental and social pillars of sustainable forest management (Chapter 11). Relevant and realistic forest management objectives should be developed as appropriate for the environmental, geopolitical and sociocultural context in which the forest management activity will take place.

For each identified objective, there should be a plan to guide the implementation of activities towards its achievement. Planning related to the production of timber and NWFPs is covered in the silvicultural plan (Chapter 12). If objectives related to ecosystem services, biodiversity, social and cultural aspects are identified, management plans need to be developed to address them (Chapter 13 and Chapter 14). The business plan is another key component of a forest management plan that is often overlooked (Chapter 15). Finally, there should be preparedness plans in place for extreme weather events, natural disasters and accidents to enable appropriate response actions (Chapter 16).

As noted previously, forest management planning is an adaptive process in which the results of forest management are evaluated and plans are revised as needed. Therefore, each forest management objective needs to be monitored through appropriate indicators that provide feedback to the forest manager to ensure effective implementation of planned actions. The final part of the forest management plan will be the monitoring and evaluation plan that describes the monitoring protocols and feedback system (Chapter 17).

10. Forest management plan format

In **Appendix 1**, a sample format of a forest management plan is provided, which can be adapted depending on the forest management objectives, relevant legal requirements, and the environmental, socioeconomic and cultural context.

Traditionally, forest management plans have been produced as physical documents, parts of which have been replaced in some cases by digital files and spatial information stored in GIS databases. For very small operations, a few maps may be sufficient to store most of the required planning information. The map in **Figure 17** was drawn for a small forest estate of Eucalyptus plantation at the time of planting, which will need to be redrawn in six years when the stand is harvested and replanted. It contains most of the required information for forest management planning given the scale and context of this FMU (listed in **Table 5**). In **Box 5**, requirements for forest management plan documentation for small-scale forest operations in Chile is provided as an example of a simple, map-based forest management plan.

Figure 17. Map of a small forest estate in Patagonia, Chile

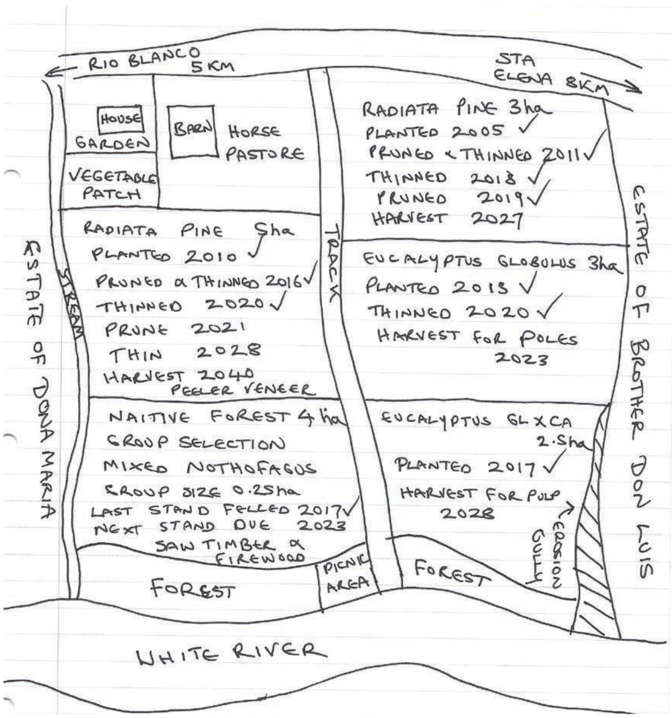


Table 5. Key information contained in the hand-drawn map presented in Figure 15

Social information	• Location and identity of neighbours • Location and distance to the nearest villages • Location of a picnic site used by local people • Location of housing and subsistence crop growing area • Location of pasture for livestock
Environmental information	• Location of natural forest riparian buffer • Location of environmentally sensitive areas • Location of watercourses
Forest management information	• Location and area of compartments • Forest management objectives of each compartment • Date of planting of each compartment • Schedule of silvicultural activities for each compartment • List of silvicultural activities that have been carried out

Many larger forest operations make use of computer software-based forest information system (FIS) that provides up-to-date site specific information about the forest area to support effective decision-making and guide field operations. FIS typically integrate spatial GIS data with growth models, market information and financial models.

Developing and maintaining such information systems may not be feasible for small and medium forest owners. Fortunately, there is an increasing number of forest consultancy organizations that can provide such services in a cost-efficient manner. In addition, there are freely accessible forest information tools that can be used to store and present forest management planning information. For example, myForest[41] is used by about 8 000 small forest owners in the United Kingdom to prepare legally-compliant forest management plans (Sylva Foundation, 2022). FAO's Open Foris Arena (**Box 4**) may also present a viable solution for SMFEs to store, analyse and manage forest inventory data including socio-economic, biodiversity and other parameters of interest.

[41] https://myforest.sylva.org.uk

Box 4. Open Foris Arena for collecting, storing, managing and analysing forest inventory data

Arena[a] is a newest addition to the open-source Open Foris[b] suite developed by FAO. It offers a platform for storing, managing and analysing of data collected in a forest inventory. Arena provides methods for customization of inventory data structure, multicycle data management and data checks in a multilingual environment. Arena also offers access to map repositories and high resolution satellite imageries, such as NICFI Planet Labs[c] images, and it offers methods to update data directly from the map user-interface. The data in Arena's secure server is hosted by the Amazon Web Services, and it can be processed using R scripts within RStudio.

Arena Mobile is a fast, intuitive and flexible data collection tool for field-based surveys. This app allows the completion of complex data structures, such as biophysical, socio-economic or biodiversity surveys that are designed on the Open Foris Arena platform. It works both on Android and iPhone devices.

Arena Mobile's main features include:

- off-line data collection;
- on-the-fly validation to improve data quality;
- handling of large lists of species or other attributes;
- geo-location through an embedded Global Positioning System (GPS);
- photo and video recording;
- integration with Arena for data management, analysis and export to commonly used formats; and
- can calculate attributes for data quality control in the field.

Notes:

[a] https://openforis.org/tools/arena

[b] https://openforis.org

[c] www.planet.com/nicfi

Source: FAO. 2023. Open Foris Arena. Rome. [Cited 1 February 2023]. https://openforis.org/tools/arena/

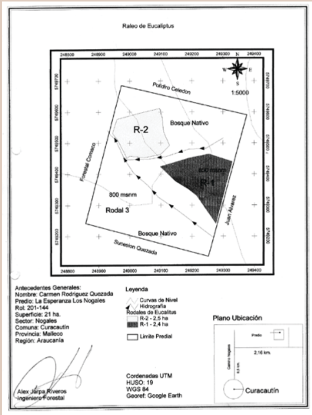
Recommended requirements:

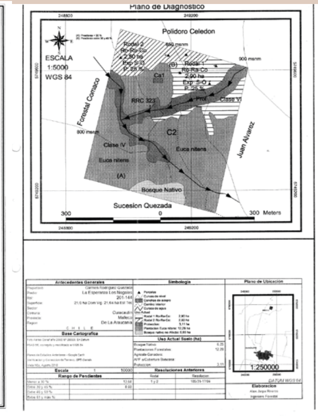
Minimum	Good to have
• Hand-drawn map(s) and accompanying documents that demonstrate legal compliance and forest tenure. • Documents providing silvicultural guidance and responses to specific social and environmental issues.	• Forest management plan in the form of a more substantive document (~100 pages) supported by some information (e.g. spatial data and financial projections) as electronic files in appropriate format.

Box 5. Forest management planning for small-scale forest management in Chile

Since 2000, the focus of forest policy in Chile has shifted from timber production to restoration and conservation of native forests as well as support to smallholder forest owners. Forest management plans are mentioned under a variety of forest laws (Morales, 2002). The framework for forest law is distinct for plantations of exotic species and management of native forests. Management planning is closely linked to the payment of state subsidies for forest management. Management plans require approval by the National Forest Corporation (CONAF), and for areas exceeding 200 ha, they must be drawn up by a forest engineer or someone of equivalent qualifications. CONAF is also responsible for ensuring that management plans are followed. All large forestry companies currently operating in Chile hold FSC and national forest management standard (CERTFOR or El Sistema Chileno de Certificación de Manejo Forestal Sustentable, which is endorsed by PEFC) certifications. Many smallholders of forest plantations are also certified under group schemes therefore conforming to group certification management planning standards.

It is required to consider environmental and social considerations in forest management planning with an emphasis on protection of high conservation values (HCVs). The duration of management plans is set at a maximum of ten years. For small forest owners, forest management plans are presented for each forest management activity and are supported by an overview plan of the FMU. This means that historic record of each intervention is available, but there is little information on the long-term silvicultural planning. Key challenges associated with this system of forest management planning include the absence of information on the condition of the forest (as forest inventory is not required) and the lack of long-term objectives for forest management.





The above left document is a management plan presented to obtain permission to conduct thinning of a Eucalyptus plantation of 21 ha (left). An overview plan on the right shows the location of different stands, watercourses and associated riparian protection areas.

Notes: Morales, E. 2002. Changing ownership and management of state forest plantations: Chile. IIED. https://pubs.iied.org/sites/default/files/pdfs/migrate/G00303.pdf

Source: Authors' own elaboration

11. Setting management objectives

Most forest managers will have some ideas on what forest products they wish to derive from their forests from the outset. The process of examining these ideas in depth and exploring alternatives often leads to better solutions that optimize the combination of forest products and services. All categories of objectives covered in this chapter should be considered and assessed for their relevance and applicability, including environmental services and benefits to local stakeholders and the wider society. Even in a community-managed forest, different individuals and groups within the community may have distinct needs, which necessitates balancing and negotiating competing objectives. The objectives for the forest should be considered with a long-term vision and include all values to be maintained for future generations.

When considering potential management objectives, it should be noted that there may be issues of interest and relevance for which forest management at the level of the FMU will have little or no influence. Defining objectives for such aspects serves little purpose. For example, setting an objective to maintain populations of wide-ranging fauna may not be meaningful as their population dynamics will be determined by conditions outside the control of the forest manager.

To develop objectives that are realistic and practical in guiding sustainable forest management, a useful guide is to ensure that they are SMART (specific, measurable, achievable, and time-bound).

Specific: The objective is well-defined, precise and unambiguous.

Measurable: Progress towards the achievement of the objective can be measured through quantitative or qualitative observations.

Achievable: The objective is attainable within the period covered by the management plan.

Relevant: The objective is relevant with regards to the overall goals of forest management.

Time-bound: The objective has a clearly defined timeline within the duration of the management plan.

Progress towards the achievement of set objectives needs to be monitored through observations and measurements (described in Chapter 17). The setting of objectives and monitoring form an iterative process in which the objectives are refined to include only those that are relevant and realistic, and for which there are feasible monitoring methods available.

11.1. SITUATION ANALYSIS

Situation analysis developed from the information gathered previously will allow for identification of opportunities and constraints for forest management. For example, there may be areas where timber production cannot be practised due to the presence of HCVs, for environmental protection or operational safety. There may also be areas that are unsuitable for forest production due to soil and moisture constraints. On the other hand, there could be opportunities for forest management related to product markets, land suitability, social context, etc. These aspects should be considered in forest management planning and objective setting so that the most appropriate management objectives and options can be identified.

A common approach to a situation analysis is a strengths, weaknesses, opportunities, and threats (SWOT) analysis (**Table 6**).

Table 6. SWOT analysis for a hypothetical teak plantation

Strengths	Weaknesses
• Sites are excellent for growing teak. • Natural forest areas have a good mixture of species for biodiversity conservation. • There is good rapport between the local people and the landowners. • Local knowledge and experience with teak silviculture exist from successful previous rotations. • Windstorms are rare. • Business partners are well known and respected in the country. • Achieving forest certification will be relatively easy. • The existing area has good water supply and adequate road access. There is a suitable location for nursery establishment.	• Large buyers may not be attracted given the low levels of expected production. • Long-term investment of at least 20 years is needed. • There is a significant capital requirement for plantation establishment and timber processing. • Road infrastructure for timber transport is in poor condition.
Opportunities	**Threats**
• There is a good export market for teak. • International teak supply is less than the current demand. • Local competition is limited. • There is high potential for value addition through local timber processing • Establishment costs can be reduced through the use of agroforestry involving local farmers. • Certified teak attracts high premium due to its scarcity in the market. • There are opportunities for recreational use of the natural forest area. • There are opportunities for production of NWFPs (including turmeric, edible lilies, indigo) in the teak stands. • The plantation can serve as a buffer and wildlife corridor connecting nearby protected areas, providing biodiversity benefits at the landscape level.	• There is risk of fire in young stands. • Criminal activities in the area pose a security threat. • There is a risk of timber theft when the stand matures. • Heavy rains causing erosion is common.

11.2. OBJECTIVES FOR FOREST PRODUCTION

Both short- and long-term horizons must be considered in planning for forest production. Forest management activities carried out today should be directed at producing the desired mix of forest products during the current management cycle as well as achieving the long-term vision with regards to species composition and structure of the forest.

11.2.1 Tree crops

Objectives for the tree crop need to be specified both in terms of the final tree crop and the pathway (including regeneration, thinning and other silvicultural treatments) to get there. For forest plantations, this is relatively straightforward as the regeneration methods, optimal crop tree density, thinning regimes and growth response to silvicultural treatments are well established. Defining the final tree crop for natural forests is more complex as the forest's response to silvicultural interventions can be unpredictable. For some natural forests with a long history of management, such as European beech or oak forests, silvicultural systems are well understood. However, such knowledge is scarce for more diverse tropical forests. In such cases where the forest dynamics are less understood, the general pattern of succession need to be inferred from observation and experience. In such cases, a sensible approach is that of adaptive management in which different management approaches are tested in smaller areas.

Objectives for timber production are usually stated in terms of the species, size distribution and the volume of timber to be harvested during the period covered by the forest management plan (**Table 7**). In addition, form is an important consideration as straight trees have larger usable volume and attain higher prices. Silvicultural practices, such as removing crooked trees and thinning, can facilitate the growth of straight trees with clear boles, thereby increasing the forest value.

Table 7. Forest production objectives for two diverse types of forest

Boreal pine forest of 100 ha	Miombo woodland of 100 ha in Mozambique
Annual yield of 250 m^3 of pulp logs, 300 m^3 of sawlogs, and 100 tonnes biomass	Annual yield of 500 small agricultural poles, 200 large building poles, 150 m^3 of sawlogs, and 100 tonnes biomass
Long-term vision for the forest	**Long-term vision for the forest**
Forest will be regenerated through natural seeding. An average of 1 ha/year will be harvested. Stands will be clearfelled at the age of 80 to 120 years depending on site conditions. Forest stocking and structure will remain similar in the long-term, although deciduous hardwoods may become more abundant due to climate change and natural succession.	Forest will be regenerated from root suckers and coppice stumps after clearfelling. Some rare high-value species that have been reduced by previous harvesting will be planted. 1 ha will be clearfelled each year. The future forest will have trees of better stem form and timber properties, and more abundance of high-value timber species.

If the mean annual increment has been estimated, this can be used to calculate the annual allowable cut (AAC) by making allowance for estimated damage and mortality to the residual stand from timber harvesting. AAC refers to the volume of timber that can be harvested on a sustainable basis in a defined forest area in a given year. In the absence of suitable growth models or the capacity to estimate sustainable yields based on available data, a simple rule of retaining at least one (preferably two) future crop trees for every tree harvested can be followed. The growth of future crop trees can be accelerated by removing competing trees nearby. However, this will entail costs that will need to be evaluated against the value of additional timber growth (Gräfe *et al.*, 2021).

Timber is usually divided into categories according to species, dimensions, wood quality and the intended end use, with some categories fetching higher prices than others (**Table 8**). Depending on the end use, there may be preference for certain wood properties such as more even growth rings and trees that are grown slowly.

Table 8. Categorization of Scots pine (Pinus sylvestris) timber assortments by dimensions

Type of timber assortment	Middle diameter (cm)	Small-end diameter (cm)	Length (m)	Price/m³ (EUR)
Sawmill wood (large thickness class)	≥ 35	≥ 14	2.5	65.0
Sawmill wood (medium thickness class	25-34	≥ 14	2.5	56.9
Sawmill wood (small thickness class)	≤ 24	≥ 14	2.5	48.8
Pulpwood	-	≥ 5	2.5	38.1
Energy wood (stem residuals)	-	-	-	13.6

Source: Węgiel, A., Bembenek, M., Łacka, A. & Mederski, P. S. 2018. Relationship between stand density and value of timber assortments: a case study for Scots pine stands in north-western Poland. *New Zealand Journal of Forest Science,* 48: 12.

In addition to the scheduled rotational harvest, there will often be low-level continuous harvest of timber for various purposes, including the collection of fallen deadwood as fuelwood and the cutting of small trees for poles and manufacture of furniture and tools. These uses may have a meaningful impact on the forest income as well as the future state of the forest, and should therefore be considered in the planning and objective setting.

Recommended requirements:

Minimum	Good to have
• The expected appearance and structure of the forest in the long-term described in general terms as an objective. • The expected yields of different timber assortments during the current forest management period included in the objective.	• The expected future structure and species composition of the forest at the end of the forest management period or at 20 years, whichever is longer, described as an objective. • Annual allowable cut and expected yields of different timber assortments for the current forest management period or 20 years, whichever is longer, documented as an objective.

11.2.2 Non-wood forest products

For any NWFP species identified as being locally important for subsistence, trade or as cultural tradition, objectives for their sustainable use should be included in the forest management plan. In some cases, there may be a risk of overharvesting valuable products such as edible fungi, fruits, rattans, orchids, and certain wildlife. In such cases, regulation of harvest and measures to ensure regeneration may need to be included as objectives. If NWFPs are used only sporadically or at low levels, objectives may simply relate to allowing access to the resource when necessary.

Setting objectives for NWFPs is not easy because these species can be extremely variable in their distribution and availability, both spatially and temporally, depending on interplay of environmental factors many of which are outside the control of forest managers.

In addition, there are likely to be trade-offs between the production of NWFPs and timber. As such, management practices designed to maximize timber production may need to be modified to accommodate NWFP production. Collection of some NWFPs, such as pine resins, may directly affect the quality of timber as resin tapping can damage the cambium resulting in timber defects (Miina *et al.*, 2020). Where wild animals constitute an important NWFP, maintaining their habitat quality may be a relevant consideration. Forest management can also affect food availability for domestic animals that feed in the forest on fallen fruit or grasses in silvopastoral systems. Some NWFP species may have specific habitat or microclimate requirements for successful regeneration, in which case it may be necessary to set objectives to maintain such conditions.

Recommended requirements:

Minimum	Good to have
• Objectives developed to ensure future availability of any NWFPs valued by local communities.	• Objectives developed to maintain viable populations of NWFPs harvested by the forest manager and local communities.

11.3. OBJECTIVES FOR ECOSYSTEM SERVICES

In addition to provisioning services in the form of forest products, forests provide a range of regulating and supporting services. These include services that are important at local levels (such as for mitigation of local floods and shallow landslides) as well as those that have implications at larger scales including water and climate regulation. They also include non-consumptive resources such as landscape aesthetics and recreational opportunities.

HCV assessment results (**Box 3**) provide a useful basis for developing environmental objectives. FSC has recently developed 'Guidance for Demonstrating Ecosystem Services Impacts' (FSC, 2018), which includes examples of SMART objectives for ecosystem services and provides verifiers that can be used to demonstrate achievement.

There is a growing market for regulating ecosystem services, particularly for water regulation and carbon storage. However, due to economies of scale as well as technical and administrative requirements involved in developing viable PES projects, markets for PES may not be readily and easily accessible to SMFEs. Secure tenure and the involvement of project developers who can provide essential technical support and reduce transaction costs are often necessary in setting up successful PES projects (Peters-Stanley and Gonzalez, 2014). Nonetheless, there are some government-facilitated PES schemes, such as tax breaks and payments for watershed conservation, that even smallholders can take advantage of in some countries. Thus, it would be in the interest of even small forest owners to be aware of the current and future opportunities in this regard.

Recommended requirements:

Minimum	Good to have
• Objectives developed for key ecosystem services of known concern to local communities.	• Objectives developed for ecosystem services that are considered important at the local and landscape levels, including any identified HCVs.

11.4. OBJECTIVES FOR BIODIVERSITY

With the continuing loss of biodiversity being a key global issue and considering that forests harbour most of the earth's terrestrial biodiversity, maintaining and enhancing biodiversity values in managed forests is a major

Community members collecting bamboo shoots in forest.

concern for forest management (Harrison *et al.*, 2022). Biodiversity, which includes diversity within and among species and ecosystems, forms the basis of ecosystem services, and thus must be protected and sustainably managed.

Biodiversity conservation may comprise one of the objectives of forest management, depending on: the scale of forest management; the presence of critical habitats and species of conservation concern in the FMU; landscape context; and the interactions between biodiversity and the local people.

It should be noted that biodiversity is particularly complex and costly to monitor, and it is often difficult to link observed changes in biodiversity to management actions (Harrison *et al.*, 2022). For example, monitoring the population of a certain fauna may not provide any actionable feedback to the forest manager as the population size naturally fluctuates and is affected by factors outside the control of the forest manager. Thus, in most cases, biodiversity objectives relate to actions or conditions that are known to have impact on biodiversity rather than the biodiversity itself. For instance, an objective could be to protect small-scale critical habitats or conserve key biodiversity resources (nest sites, feeding grounds, deadwood, old trees, etc.) rather than to conserve or enhance populations of certain fauna or flora species.

An HCV assessment would include the identification of areas that should be prioritised for biodiversity conservation and appropriate management actions.

Recommended requirements:

Minimum	Good to have
• Objectives for biodiversity developed to protect any critical habitats, species of conservation concern and/or globally important areas for biodiversity identified in the FMU. Objectives should be described in simple terms and allow for inexpensive monitoring using local knowledge where possible.	• Objectives for biodiversity developed based on HCV assessment results. Objectives should allow for periodic monitoring that provides actionable feedback.

11.5. OBJECTIVES FOR THE PEOPLE

Social and cultural objectives relate to forest resources, sites, objects and artefacts in the FMU that may be affected by forest management activities, which are of social or cultural significance to local stakeholders (including forest workers, their families, and members of the local community). Even in the case of community-managed forests or individual ownership of a forestland by a local community member, it is important to consider social and cultural impacts of forest management on all local stakeholders, including marginalized groups of people and those not directly involved in the forest management or the sharing of economic benefits.

Forests managed by Forest User Groups in Mongolia providing ecosystem services including water regulation, biodiversity support and landscape aesthetics.

Objectives for the people encompass those related to employment, including the number of people employed by the FMU, terms and conditions of their employment, the composition of employees, occupational training, and health and safety of forest workers and nearby residents. It is also common for forest lease agreements to include provisions for social services and facilities for local communities.

In many societies, forest work has been segregated by gender, often on the basis of unjustified arguments such as safety risks or requirement for physical strength. Also, in many countries, men tend to be involved in harvesting of forest products of higher value for shorter times requiring less travel distances (Nzunda, 2022).

Objectives relating to gender equity may be needed where gender inequality is an issue. These objectives could be in terms of gender composition of employees as well as removal of barriers to employment of women (e.g. through the provision of segregated bathing and sleeping facilities in forest camps).

Under community-based forestry,[42] local people are intimately involved in forest management activities that are practised on land under communal tenure and requires collective action. Under such forms of forestry, social and cultural objectives usually comprise key aims of forest management.

[42] FAO originally adopted to the term "community forestry" to refer to "any situation which intimately involves local people in a forestry activity". The term "social forestry" emerged concurrently, which has no clear definition but is used interchangeably with community forestry by some. "Participatory forestry" is also used as a generic term to denote the participation of stakeholders in forest management decision-making. FAO uses the term "community-based forestry" as an umbrella description and includes both collaborative regimes (forestry practised on land that has some form of communal tenure and requires collective action) and smallholder forestry (forestry practised by smallholders on land that is privately owned) (Gilmour, 2016).

©CIFOR/Axel Fassio

Mapping workshop to develop a forest management plan in Ghana.

The targeted benefits for local communities may include income generation from timber and NWFP production, fuelwood supply, fodder and shade for livestock, health benefits, recreational, cultural and religious use, food supply, and water regulation, among many others. Equitable sharing of benefits and responsibilities is a critical aspect, which should be considered in the objective setting process.

If the FMU provides resources of social and cultural value that are important in the local context, objectives should be developed to ensure their maintenance. It should be noted that some cultural services can be directly monetized in some places, for example through access fees for recreational use of forest and income from associated services (e.g. fees for car parking, provision of accommodation, catering and sanitary services).

Recommended requirements:

Minimum	Good to have
• Objectives developed for: 1) protection of forest resources and sites that are socially or culturally important to local stakeholders and that may be affected by forest management activities; 2) health and safety of forest workers; 3) social contributions as required by law or forest lease agreements; and 4) social and cultural aspects considered important by community members (including those members that are not directly involved in forest management).	• Objectives developed for social and cultural values identified through the HCV assessment (i.e. HCV 5: community needs; and HCV 6: cultural values).

12. Silvicultural plan

Silvicultural plan is a key component of the forest management plan, which identifies the silvicultural system and activities to be implemented in each compartment of the FMU. It comprises a planned set of silvicultural interventions designed to achieve the desired stand characteristics and to meet the identified production objectives. The silvicultural plan also forms the basis of operational planning. There are often country-specific or forest type-specific silvicultural guidelines available that may be helpful in designing silvicultural regimes to optimize forest production.

12.1. DEFINING FOREST COMPARTMENTS AND STANDS

The FMU is normally divided into compartments, which is defined as "a portion of a forest under one ownership, usually contiguous and composed of a variety of forest stand types, defined for purposes of locational reference and as a basis for forest management" (Helms, 1998). In smaller forest holdings, it is possible for the FMU to consist of only one compartment. Every compartment is managed under a specific silvicultural system, but it may be composed of stands that are at different stages of forest development. Forest stand is "a contiguous group of trees sufficiently uniform in age class distribution, composition and structure and growing on a site of sufficiently uniform quality, to be a distinguishable unit" (Helms, 1998). Based on the forest inventory data or field observation, the forest manager must define forest compartments and stands within the FMU, for which silvicultural interventions are defined and scheduled.

Recommended requirements:

Minimum	Good to have
• A hand-drawn map showing the compartments in the FMU, along with a brief general description of each compartment.	• A digitized map showing the location of all compartments and stands in the FMU, along with a description of each stand (e.g. area, species, and management history).

12.2. IDENTIFYING THE SILVICULTURAL SYSTEM

Silvicultural system is defined as "a planned series of treatments for tending, harvesting, and re-establishing a stand" (Helms, 1998). The silvicultural system is usually defined at the level of the compartment. Silvicultural systems are categorized by the number of age classes or the regeneration method (**Table 9**). There are many variants within these broad categories of silvicultural systems, and different terms may be used in various types of forests across the world.

Table 9. Broad categorization of silvicultural systems

Clearcut system	The cutting of essentially all trees producing a fully exposed microclimate for the development of a new age class. Regeneration can be from natural seeding, direct seeding, planted seedlings or advance regeneration (Helms, 1998).
Group selection	Trees are removed and new age classes are established in small groups. (Helms, 1998).
Seed tree system	The cutting of all trees except for a small number of widely dispersed trees retained for seed production and to produce a new age class in fully exposed microenvironment (Helms, 1998).
Shelterwood system	The cutting of most trees, leaving those needed to reproduce sufficient shade to produce a new age class in a moderated microenvironment (Helms, 1998).
Selection system	Individual trees of all size classes are removed more or less uniformly throughout the stand, to promote growth of remaining trees and to provide space for regeneration (Helms, 1998). This can also be referred to as continuous cover forestry.

A patch of forest under clearcut harvesting.

Based on the selected silvicultural system, various silvicultural interventions will be implemented to direct forest stand development to meet the production objectives of forest management. The types and timing of silvicultural activities required may vary among compartments and stands due to differences in species composition, site index, and the intended product. For example, pruning is not likely to be done if the wood is intended for chipping as there is no need to produce knot-free stems. The most common silvicultural activities are described in **Table 10**. As some of the interventions are costly, it is important to evaluate the costs and benefits of each intervention.

Table 10. The most common silvicultural activities

Site preparation	Hand or mechanized manipulation of a site that is designed to enhance the regeneration success (Helms, 1998). Treatments may include bedding, burning, chemical spraying, chopping, disking, drainage, raking and scarifying designed to modify the soil, litter or vegetation.
Planting or direct seeding	The planting of seedlings (usually grown in a nursery) or the sowing of seeds. Fertilizer may be applied to increase growth rate or overcome nutrient deficiency in the soil (Helms, 1998).
Enrichment planting	Interplanting to improve the percentage of desirable species or genotypes or to increase biodiversity (Helms, 1998). Enrichment planting is often used to increase the density of commercial timber species that have been removed by harvesting. This can be done through generalized planting throughout an area, in strips or in canopy gaps created by harvesting of individual trees.
Weed control	A release treatment in stands not past the sapling stage that eliminates or suppresses undesirable vegetation (Helms, 1998).
Coppice singling or reduction	Reduction of the number of shoots arising from a single stump, eventually leaving one well-growing stem of good form.
Pruning	The removal, close to the branch collar or flush with the stem, of side branches (live or dead) and multiple leaders from a standing tree. Pruning is normally done on plantation trees to improve the tree or its timber, or on urban or rural trees, to improve their aesthetics or health (Helms, 1998).
Thinning	The removal of trees to reduce stand density primarily to improve growth, enhance forest health, or recover potential mortality (Helms, 1998). Often, more trees are planted or allowed to develop initially than will be present in the mature stand; this helps to produce tall straight trees without side branches. Stands are then thinned to reduce competition and remove the less desirable individuals (with defects or of lower commercial value).
Liberation	A treatment made in a stand not past the sapling stage to free the favoured trees from competition with older, overtopping trees (Helms, 1998). Liberation is usually applied under individual selection systems to enhance the growth of future crop trees. Creepers may also be cut as part of liberation treatment.

Recommended requirements:

Minimum	Good to have
• Silvicultural system selected for each compartment and described based on traditional or common knowledge.	• Silvicultural system for each compartment described based on scientific evidence and expert knowledge.

12.3. SCHEDULING OF SILVICULTURAL OPERATIONS

The scheduling of forest management activities that will be carried out to implement the specified silvicultural system will vary among compartments and stands due to differences in the management objective, stage of forest succession or stand age, species composition, site growing conditions, etc.

Natural disturbances can also affect the scheduling of silvicultural activities. For example, a prolonged drought may slow tree growth and consequently delay thinning and final harvest. On the other hand, a severe storm that blows down many trees may bring forward the timing of final harvest in a clearfelling system or require salvage harvesting followed by interventions to assist forest recovery.

The annual plan of operations specifies the set of silvicultural activities that need to be implemented in each compartment each year (**Table 11**).

Table 11. Planning of silvicultural activities in a year under a group selection system

Compartment no.	Activity
1	Final felling of three stands established in 1950.
	Scarification of soil in the felled area to encourage natural regeneration.
4	Pre-commercial thinning of the stand established in 2010.
5	Weed control in the stand established in 2019.
9	Pruning of trees in stands established in 2005.
	Weed control in stands established in 2019.
11	Felling of fire-damaged trees replanting with a mixture of suitable species.
19	Sanitary cleaning of exotic species from the set-aside area.

It is necessary to understand what silvicultural activities will be required each year as the costs associated with these activities must be covered by investment and income generated from the forest. Usually, some flexibility can be accommodated in the scheduling of silvicultural activities depending on the availability of labour and financing without significantly affecting long-term production.

Forest stands at different silvicultural stages.

©CIFOR/Axel Fassio

Recommended requirements:

Minimum	Good to have
• Schedule of planned silvicultural activities documented up to at least the next revision of the forest management plan.	• Schedule of planned silvicultural activities up to the end of the current forest management period together with compartment records describing the previous silvicultural activities carried out.

12.4. HARVEST PLANNING

Harvest planning involves the selection of methods for tree felling, bucking, transportation of felled trees to landing, and loading of logs onto final transport. There are many options for how these activities can be conducted and numerous ways in which the different methods can be combined (**Table 12**).

Table 12. Various ways in which timber can be felled, cut to length, moved to forest landing and loaded for transport

Tree-felling methods	Bucking[43] methods	Transport from stump to landing	Loading onto final transport
• Axe • Manual sawing • Power sawing • Harvester head • Feller-buncher • Harvester felling	• Manual sawing • Power sawing • Harvester cross-cutting	• Manual carrying • Cable hauling with mobile equipment (tractor, bulldozer or skidder) • Cable hauling along the ground with stationary equipment • Aerial cable hauling • Forwarder • Helicopter carrying	• Manual loading • Loading with an excavator • Loading with a grapple head (on agricultural tractor, dedicated machine or a truck) • Bunching grapple for multiple logs

43 Bucking refers to sawing of felled trees into shorter lengths (Helms, 1998)

Community members manually carrying timber to forest log landing.

©CIFOR/Fiston Wasanga

The details of harvesting are planned shortly before the work is carried out. This is because there may be changes in field conditions, methods and available equipment, which cannot be predicted at the time of forest management planning. However, the forest management plan should describe the general harvesting plan including expected methods to be used from felling to transport to ensure efficient, safe and environmentally-friendly harvesting operations. Harvest planning should consider seasonal and weather-related restrictions on harvesting, methods for harvesting on steep slopes, management of waste material, prevention of damage to the residual stand, and worker health and safety.

Tree felling is one of the most dangerous of all forest management activities. Hazards associated with felling a tree affects not only the person doing the felling but also other harvesting crew in the vicinity. Harvesting can also cause damage to other trees around the harvest tree, which may be struck by the falling tree or be pulled down due to lianas. There are also injury risks associated with the use of heavy machinery. If the harvesting involves dragging logs with cables, there are risks of breakage or slippage of cables or of their anchoring points as well.

The level of hazard varies according to the site conditions, with work on steep slopes being particularly dangerous. Many countries have regulations or industry codes of practice with regards to harvesting on slopes, including slope thresholds for certain types of forest management activities and machineries.

Primary processing of a log in the forest.

Forestry machineries themselves will also have designed operating limits set by manufacturers including gradients for moving across and up or down slopes (Lundbäck *et al.*, 2021; ILO, 1998).

To reduce these hazards, it is vital that safe harvesting methods and thresholds are defined and followed, and that the harvesting process is planned in sufficient detail. Occupational health and safety training and provision of proper personal protective equipment are also critical aspects in reducing hazard risks.

Smallholding forest owners often sell their timber standing, in which case the buyer is responsible for planning and carrying out the harvest. Even in such cases, it is necessary to ensure that harvest planning is done to avoid unnecessary damage to the forest.

Harvesting and transport are costly activities, and different harvesting methods have vastly different capital and operational costs associated with them. Harvesting is likely to have at least a short-term impact on the cash flow of the forest enterprise although revenues from the sale of harvested timber normally arrive shortly after harvest. This is another reason harvest planning is critical as the expected costs of harvesting need to be integrated into the business plan (described in Chapter 15).

Recommended requirements:

Minimum	Good to have
• Expected harvesting methods described (including tree felling, bucking, transport from stump to landing, and loading on the final means of transport). • Harvesting costs roughly estimated. • Necessary measures to ensure worker safety during harvesting identified and included in the harvesting plan.	• Harvesting activities scheduled and costed for the current forest management period. • Required training, supervision and personal protective equipment to ensure worker safety during harvesting identified and included in the harvesting plan.

12.5. NON-WOOD FOREST PRODUCTS PLANNING

NWFPs are extremely diverse and vary widely in the types, species and parts of plants and animals utilized among the different countries and localities. For certain NWFP species, there is some knowledge on how forest management practices can influence their yields and regeneration. For example, production of some berries in boreal forests may be significantly increased under a more open canopy and by having longer forest rotations (Miina *et al.*, 2010). *Lactarius deliciosus* (commonly known as saffron milk cap or red pine mushroom) on the other hand are more productive in younger stands of *Pinus pinaster* in Spain (Taye *et al.*, 2016).

In many parts of the world, however, the management of NWFPs tends to be rather unregulated. Little is known about their sustainability, volume of harvest, economic value and contributions to local livelihoods. For this reason, realizing a multiple-use approach that optimizes the management of timber and NWFPs within the same FMU remain a challenge particularly in developing countries (Blaser, Frizzo and Norgrove, 2021). In these cases, it is necessary to adopt adaptive management approaches to determine what management interventions may help sustain NWFP yields and to establish sustainable harvesting levels and practices. In **Box 6**, general considerations for sustainable harvesting of the main categories of NWFPs are presented.

Recommended requirements:

Minimum	Good to have
• The types and quantities of NWFPs collected in the FMU monitored in collaboration with local communities where appropriate. • Periodic consultations with local NWFP collectors conducted to understand the trends in the availability of NWFPs in the forest.	• The availability of intensively utilized NWFPs monitored through surveys in the forest. • Best practices for harvesting and management of NWFPs identified and included in the silvicultural plan. • Actions to ensure the achievement of both timber production and NWFP objectives identified in case there are significant interactions between these objectives.

12.6. ASSOCIATED FOREST MANAGEMENT ACTIVITIES

There may be other forest management activities that support, but are not directly part of, silvicultural operations and harvesting. These activities may include: maintaining buildings, roads, buildings and other infrastructure; procuring materials, machineries and equipment; and establishing and operating a tree seedling nursery. Plans for these activities and procurement can be included in the silvicultural plan or comprise a standalone section of the forest management plan.

Recommended requirements:

Minimum	Good to have
• Key production-related forest management activities that are not described in other sections of the forest management plan briefly described and roughly costed.	• Key activities identified in the minimum requirement also scheduled.

Box 6. Considerations in sustainable harvesting of different categories of NWFPs

Leaves

- How to reduce damage to reproductive structures, growing points, branches, bark and trunks.

Exudates

- How to avoid girdling the tree or over-damaging stemwood.
- If making incisions or holes in the tree, setting standards on the minimum and maximum height on the tree where incisions/holes are made, as well as the size, length, depth and pattern of the incisions/holes.

Bark

- How to avoid girdling the tree or over-damaging the cambium (the thin inner layer from which new bark is produced).
- Setting standards on the minimum and maximum height on the tree where the bark is removed, the depth of the cut, the percentage of the total girth removed, the equipment used, and treatment of the wound after the cut.

Roots

- Deciding on which part of the root, rhizome, culm or bulb to remove (e.g. lateral rather than taproot), and how to remove it without causing unnecessary damage to the plant.
- Stems/apical buds
- How to reduce damage to the root base or to immature stems and shoots.

Fruits

- How to reduce damage to reproductive structures, growing points, branches, bark and trunks.
- How to avoid harvesting of unripe fruit.

Fungi

- How to minimize trampling of soil or disturbance of the leaf litter layer, which may damage the underground mycelial colony.

Honey

- How to avoid harvesting immature honey, killing the larvae or flaming the hives.

Source: Stockdale, M. 2005. Steps to sustainable and community-based NTFP management - a manual written with special reference to South and Southeast Asia. Quezon City, the Philippines, NTFP Exchange Programme for South and Southeast Asia. https://ntfp.org

13. Ecosystem services and biodiversity management plans

If objectives for ecosystem services and biodiversity are determined as relevant for the FMU, it is necessary to develop a plan to ensure the achievement of these objectives. These plans should complement the silvicultural plan and be integrated into the overall forest management plan including the business plan. It is likely that there will be trade-offs among the objectives for forest production and ecosystem services. These trade-offs must be managed to optimize the balance of forest products and services based on the identified objectives of forest management.

If an HCV assessment has been undertaken, the assessment report will have identified and mapped all HCVs present in the FMU accompanied by HCV management and monitoring plans. This may replace the need for specific management planning for ecosystem services.

13.1. ECOSYSTEM SERVICES PLANNING

Forests provide a range of regulating ecosystem services (as described in Sections 8.4.4), and planning should be in place to maintain ecosystem services for which objectives have been developed under Section 11.3. It is not possible within the scope of this guide to provide specific guidance on planning for the wide range of ecosystem services. In this section, we provide some general guidance on planning for water regulation service as it is often the most recognized and easily understood forest ecosystem service of concern to neighbouring communities.

Forests impact water supplies through two main processes. First, trees consume water through evapotranspiration, which fall back to the ground in the form of precipitation. Second, trees increase the rate at which water enters the soil (Restiani, Malmer and Van Hensbergen, 2014). Through these processes, forests can attenuate peak flows, recharge ground aquifer, and mitigate water-related disasters such as floods and landslides.

The quality of water in streams is dependent on erosion occurring in upstream catchments and the amount of sediments that reach the streams. Thus, the ability of vegetation to stabilize slopes, reduce the amount of runoff and to slow runoff to enable suspended material to be deposited or filtered contributes to maintaining water quality. In well-managed forests, the amount of erosion in forest stands is typically low, but erosion from forest roads can be high. As roads are the most significant source of sediments in a managed forest, forest roads must be appropriately designed, built and maintained (and closed when no longer needed) to minimize the severity and duration of impact on water quality. Proper design of stream crossings is also critical.

The management of water quality within the FMU should focus on three key principles (FAO, IUFRO and USDA, 2021):

1. Minimize soil compaction, which reduces water infiltration. This may require reducing or eliminating the use of heavy equipment, limiting forest operations to periods when the soil is less prone to compaction, and developing road networks to reduce off-road activities of heavy machines.
2. Minimize soil erosion due to surface waterflows. This may require avoiding timber harvesting on steep slopes; reducing the size of patch cut area, and constructing and maintaining roads using best practices (e.g. construction of proper stream crossings, use of culverts and side drains, etc.).
3. Maintain appropriate natural vegetation buffers along streams and other water bodies. This is to ensure continuous tree canopy and litter cover, which reduces erosion, traps sediments, and minimizes water temperature fluctuations. As a rule of thumb, the width of the buffer zone on each side should be at least equal to the width of the stream.

A poorly constructed stream crossing in a logging concession resulting in significant erosion

Often, there are national regulations in place regarding protection of rivers, wetlands and other waterbodies with specifications of buffer zones and management prescriptions.

Recommended requirements:

Minimum	Good to have
• Management prescriptions specified for objectives related to water quality and other ecosystem services. • Plans in place to ensure compliance with regulations related to environmental protection.	• HCV management plan providing the basis for ecosystem services management.

13.2. BIODIVERSITY PLANNING

Setting aside areas of natural forest representing each type of ecosystem present in the FMU plays a key role in maintaining overall biodiversity. In many countries, there are national regulations that require setting aside a certain portion of the FMU (e.g. 15 percent) for conservation purposes, including for biodiversity. In some cases, this may also entail enlarging and

Native forest vegetation maintained for biodiversity conservation and other ecosystem services within a forest plantation.

©Zig Koch/Klabin

restoring natural areas through planting or natural regeneration. Reducing habitat fragmentation and ensuring connectivity between natural areas in the FMU and the wider landscape will facilitate species movement and help maintain populations and their genetic diversity.

Forests at different successional stages support different assemblage of animals and plants, and maintaining this successional mixture, either naturally or through silvicultural activities, benefits biodiversity (Harris, 1984). Forest management practices such as selective logging, thinning, prescribed burning, mowing and coppicing can increase the heterogeneity of tree communities, thereby helping to enhance the diversity and abundance of pollinators (Krishnan *et al.*, 2020).

Planted forests, especially monoculture plantations of exotic tree species, usually support lower levels of biodiversity composed of a limited variety of generalist species. Maintaining patches of natural forests in these planted forests can improve their biodiversity value. Natural forest set-asides and buffer zones within forest plantations also serve key functions in mitigating wildfire as natural forests burn less easily than plantations, thus helping to slow or prevent the spread of fire if appropriately designed. Such areas of natural vegetation can also contribute to pest management by hosting natural predators of forest plantation species.

Other measures to mitigate the impact of forest management activities on biodiversity include: 1) protecting key biodiversity resources such as rare

An old tree providing microhabitats and structures for a wide range of plants and insects.

plants, nest sites, large trees, hollow trees, dead wood, fruit trees and seed sources; 2) sustainably managing timber and NWFP species; 3) mitigating the impact of forest harvesting through reduced impact logging; 4) avoiding disturbance to species during critical times in their life cycle; 5) controlling invasive species; and 6) protecting forests from illegal and unauthorized activities (Harrison *et al.*, 2022).

Recommended requirements:

Minimum	Good to have
• Simple and practical measures to prevent negative impacts on biodiversity identified according to the biodiversity objective.	• Appropriate measures identified to prevent negative impacts on species of conservation concern, critical habitats and the overall biodiversity in the FMU and the surrounding landscape according to the biodiversity objective and the HCV management plan.

14. Social and cultural services plan

If social and cultural objectives have been developed, a plan of measures to achieve these objectives must be included in the forest management plan. These measures should aim to maintain and minimize the impact of forest operations on these areas and objects in cooperation with the local communities. Effective engagement and communications with the local communities form the basis of successfully managing social relations.

Social management activities may be as simple as allowing access to the forest or involve more complex processes (such as setting up a grievance mechanism). Potential social and cultural management measures include:

- continuous communications with the local communities (via print media, digital communications, village meetings, etc.);
- including areas of social and cultural importance in conservation set-asides;

A forest of cultural and religious importance.

©Unsplash/Jeremy Bezanger

- restoration of degraded and previously damaged areas;
- reducing the environmental impact of forest harvesting;
- appropriate infrastructure planning to avoid damaging areas and resources of social and cultural value;
- scheduling of operations (e.g. to minimize disturbance to lifecycles of critical NWFPs);
- allowing public or selective access to the forest for various purposes;
- controlling illegal activities (e.g. encroachment, poaching, and unauthorized harvesting);
- agreeing with the local communities on sustainable hunting and fishing methods;
- developing consensus on customary tenure claims and setting rules on resource use;
- establishing a grievance mechanism; and
- supporting community development and alternative livelihoods in cooperation with local government and NGOs.

In addition to social and cultural resources directly used by communities, recreational services of forests are becoming increasingly recognized across the world. They may include both intensive (e.g. forest playgrounds, campsites) and extensive (e.g. walking, hiking, horse riding, and mountain biking) forms of forest recreation and ecotourism. Management planning for high intensity

Recreational use of forest at Kakum National Park, Ghana

forest recreation includes identifying the locations and defining technical specifications of access roads, parking areas, play equipment, footpaths, sanitary facilities and catering. Plans may also address security, fire prevention, nature education and interpretation (Douglass, 1982). Even for extensive use areas, it is likely that management actions, such as providing parking facilities, maintaining footpaths and properly constructing river crossings to prevent environmental damage, will need to be specified.

It should be noted that social and cultural management activities may require financial contingencies. On the other hand, recreational use presents opportunities to generate income. These financial implications must be included in the business plan.

Recommended requirements:

Minimum	Good to have
• Simple measures to achieve social and cultural objectives identified. At a minimum, these should include making neighbours and local communities aware of the forest manager's intentions in relation to forest management.	• A plan of actions to address social and cultural objectives identified. These should include continuous social engagement with local communities and the protection of critical social and cultural resources. • Documented process in place and records maintained on communications with local stakeholders. • A process in place to negotiate and agree on any verified or claimed customary tenures within the FMU.

15. The business plan

Forest management activities, with their associated social and environmental benefits, will only be maintained if the income from the forest meets the cost of forest management. Thus, a forest management plan must include a viable business plan, which presents the business concept and its aims, and describes how they will be reached in a systematic way. Boscolo, Lehtonen and Pra (2021) break down the process of developing a bankable business plan into the following ten modules:

1) evidenced business idea;
2) committed and competent management and organization;
3) market outlook;
4) scalable production assets;
5) assessment of market participants and marketing strategy;
6) applied technologies and logistics;
7) assessment of business environment and legal issues;
8) financial analysis;
9) compliance with environment, social and governance criteria; and
10) risk assessment.

It is beyond the scope of this guide to cover the process of business planning in detail. Readers are referred to an FAO learning guide[44] (Boscolo, Lehtonen and Pra, 2021) and an associated e-learning course,[45] which have been developed to assist smallholders, producer organizations and enterprises in preparing bankable business plans. In this section, we provide general guidance on some of the key elements of a business plan, including: business organization; products and markets; estimation of cost and income; and cash flow analysis.

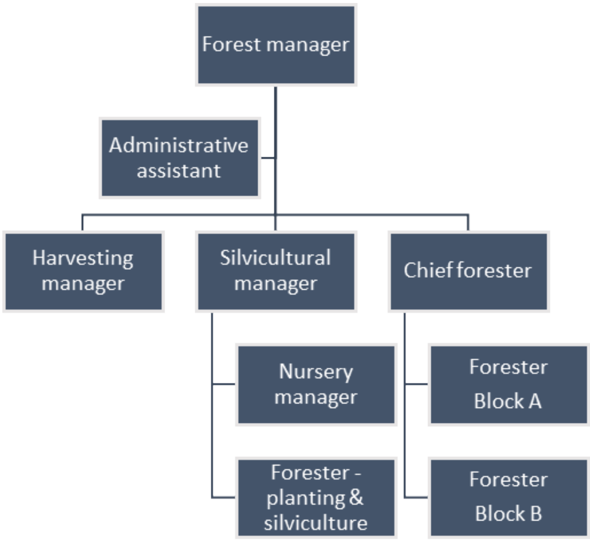
15.1. BUSINESS ORGANIZATION

A central aim of a business plan is to demonstrate the organizational sustainability of the planned business (Boscolo, Lehtonen and Pra, 2021). To do so, a business plan must include information on the organizational structure with defined roles, responsibilities and the required skills and expertise of those who will be involved in running the forest business. This can be shown in an organogram (**Figure 18**) which visually presents the structure, positions and hierarchy of the organization together with a description of responsibilities for each identified position. It is important to ensure that as many of the community members are employed by the enterprise as possible (unless in the case of a community-based operation run by the community members themselves).

---

44 www.fao.org/3/cb4520en/cb4520en.pdf
45 https://elearning.fao.org/course/view.php?id=931

Figure 18. A sample organogram for a medium-sized forest operation



Source: Authors' own elaboration.

Recommended requirements:

Minimum	Good to have
• A simple organogram of the forest business, including the roles and responsibilities of key positions in the organization.	• Organogram including the roles, responsibilities and the required skills of all positions in the organization. • Employment related targets in relation to social objectives included in the business plan (e.g. composition of employees, occupational training, worker health and safety).

15.2. PRODUCTS AND MARKETS

Market assessment plays a critical role in ensuring continued success of the forest enterprise as it defines the desired product volume, quality and characteristics. It also identifies market channels and point of sales, as well as labelling and packaging requirements. The market also defines the existing and potential scale of the business and consequently the scale of the investment (Boscolo, Lehtonen and Pra, 2021).

Once the desired mixture of products is determined, silvicultural regime can be developed to produce these products at the required timing. Various products can be produced from similar forest stands depending on the silvicultural regime. For example, a forest stand intended for pulpwood production will be managed on a short rotation without pruning. On the other hand, the silvicultural regime aimed at producing larger diameter timber for sawlogs or veneer logs will have longer rotation period with successive thinning operations to optimize timber quality.

The identification of products and markets, as well as subsequent financial analysis, also apply to NWFPs and ecosystem services that the forest manager may be interested in marketing.

Recommended requirements:

Minimum	Good to have
• Markets for the main forest products identified and described. • Market requirements in terms of timber volume and properties (species, dimensions and quality) identified and considered in silvicultural planning.	• Markets for all relevant forest products and services identified and described, including their market channels. • Market requirements for all relevant forest products and services considered in silvicultural planning.

15.3. ESTIMATING COSTS

Forest management entails a wide range of costs, including those associated with labour and materials required for silvicultural activities, infrastructure maintenance, disaster preparedness, management supervision, planning and monitoring, and regulatory compliance. There may also be costs associated with social responsibility programmes and environmental protection.

There are fixed and variable costs in running a business. Fixed costs are those that do not change based on production output. In forestry, fixed costs

Recently thinned community forest in Mongolia. Harvested poles were used as fuelwood and to produce handicrafts

©FAO/Kenichi Shono

may include land rent, salaries of permanent staff and the costs of maintaining infrastructure. Variable costs, on the other hand, change according to the scale of production or operations (e.g. costs of raw materials, consumables, labour, transport and energy), and are normally expressed as cost per unit of production. In many countries, forest research organizations and forest owners' associations provide estimates on the variable costs of forest operations. For SMFEs, the labour costs may constitute time investment by the forest owner and family, which are reclaimed as income from the profits of the operation.

Recommended requirements:

Minimum	Good to have
• Major fixed and variable costs of forest management estimated for the duration of the forest management plan.	• Annual accounting and scheduling of fixed and variable costs (including social and environmental management costs) developed covering the duration of the forest management plan.

15.4. ESTIMATING REVENUES

The income of the FMU may come from a variety of sources, with timber commonly being the main source of revenues. In many cases, a variety of NWFPs are also harvested and their value may occasionally exceed the timber value, for example when high-value fungi are in abundance. In addition, there may be PES and recreational access fees that contribute to the income stream.

For planning purposes, annual revenues should be estimated based on the expected yields of timber assortment and/or NWFPs using product prices gathered through market analysis (Section 9.4). Products are sold at different points of the value chain. For example, trees can be sold standing, at the farm gate, collection yard or at processing facilities. In estimating revenues, it is therefore essential to specify the price to be paid given the product type, species, quality and dimensions, as well as how and where the product will be sold.

Recommended requirements:

Minimum	Good to have
• The expected revenues from the sale of major forest products estimated for the duration of the forest management plan using planned volume of products to be sold and their average selling price. • The timing of sales of these forest products planned.	• The expected revenues from the sale of all major forest products estimated annually for the duration of the forest management plan.

15.5. CASH FLOW ANALYSIS

A key component of the business plan is an estimate of cash flows[46] with clearly evidenced underlying assumptions such as product prices, volumes, costs and risks.

As forest management is a long-term activity, profit may not be realized every year or during the early years of the management period. Some forests require many years of investment before they become profitable. However, the eventual financial return must cover the costs of investment and return a profit.[47] For those periods when the costs exceed the income, it is necessary to have sufficient financial resources to cover the deficit. The cumulative financial position at a given point in time determines the amount of finance that is required to continue running the forest enterprise.

The overall profitability of the forest investment is usually calculated as the internal rate of return (IRR), while the net present value (NPV) represents the value of all future cash flows generated through the investment. These calculations can be handled using a spreadsheet (**Table 13**) but require understanding and knowledge of basic financial analysis. FAO's RuralInvest software may present a viable solution for running a cash flow analysis (**Box 7**).

Table 13. A portion of a spreadsheet showing NPV and IRR for a forest stand managed on a 40-year rotation

(USD)	Total	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6~
Cost	14 667	2 037	250	170	517	970	…
Income	48 400	0	0	0	0	0	…
Cash flow		-2 037	-2 287	-2 457	-2 973	-3 943	…
Annual income		-2 037	-250	-170	-517	-970	
NPV		8 160	10 442	11 005	11 505	12 367	
IRR	6%						

Notes: The cash flow position at the end of each year is indicated. During the 40-year rotation, the worst cash flow position occurs at year 18, and the cash flow does not turn positive until after the second commercial thinning in the 29th year. This evaluation uses nominal values and does not consider potential increases in labour costs or timber value. Discount rate is set at 3 percent.

[46] Cash flow refers to the net amount of cash and cash equivalents being transferred in and out of a business.

[47] In some cases, forests are managed for non-financial benefits including ecosystem services that are not monetized directly. In such cases, investment in forest management may result in net financial losses which are compensated by societal values for which the forests are managed.

In the absence of a cash flow analysis, the profitability of forest management can be estimated with simple calculations of the expected costs and incomes over the rotation period (**Table 14**). This approach is probably adequate for small forest owners who are not seeking investment or financing.

Box 7. FAO RuralInvest software for financial calculations

RuralInvest is a free toolkit designed to support field technicians in their work with entrepreneurs by allowing the systematization and development of bankable and sustainable business proposals.

The toolkit comprises user-friendly software, an e-learning course, tailored face-to-face training, user manuals and a worldwide community of users. Through a participatory and bottom-up approach, RuralInvest methodology brings together local communities, rural entrepreneurs, government field technicians, project staff and financing institutions to identify, prepare, evaluate and finance small and medium sustainable rural investment projects.

Source: FAO. 2023. RuralInvest: Fostering Access to Finance for Small-scale Entrepreneurs. Rome. [Cited 1 February 2023]. https://www.fao.org/in-action/ruralinvest/en/

Table 14. Simple cost and income analysis for a 1-ha forest stand over a 40-year rotation period

Cost item	USD
Labour	12 667
Establishment	267
Tending	4 000
Protection	1 600
Pruning	400
Thinning	800
Brashing & roading	5 600
Equipment and materials	800
Equipment cost	250
Seedling cost	300
Fertilizer	250
Management overhead	1 200
Total costs	14 667
Income from timber sales	48 400
Profit margin over 40 years	33 733

Notes: Labour costs account for most of the overall cost. 'Tending' includes work on the site such as weed control as well as off-site work such as maintenance of fences and firebreaks. The evaluation is based on nominal prices.

Forest restoration is currently receiving strong international and government attention due to the importance of forests as a response to climate change and for biodiversity conservation. There are often subsidies available for non-government entities, including communities and private forest owners, that may cover all or part of the initial costs involved in restoration. If such subsidies are available, they should be accounted in the cash flow analysis in the year in which they will be received.

Minimum	Good to have
• Simple cost and income analysis conducted to demonstrate that the income exceeds the costs at the end of the forest management period.	• An analysis of profitability and cash flow by year for the duration of the management plan developed. • Sources of financing identified for any required investment.

16. Abnormal events and disasters

There will always be chances of unexpected events occurring, from accidents to extreme weather events. It is simply not possible to build in complete resilience to all hazards. Therefore, being prepared for disasters is a crucial aspect of forest management planning. This includes planning for four types of actions: prevention/mitigation; preparedness; response; and recovery (**Table 15**).

Table 15. Examples of prevention, preparedness, response and recovery actions to hazardous events

Prevention	Preparedness	Response	Recovery
• Safety training for forest workers • Reducing worker exposure to hazards • Monitoring of weather conditions • Prescribed burning to reduce fuel load	• Training on emergency response • Maintaining access roads • Knowing how to contact local civil authorities • Ensuring that all equipment needed for response is working properly	• Withdrawing unneeded personnel from the forest • Evacuating injured people • Summoning help from civil authorities • Activating response actions	• Repairing affected infrastructure • Restoring damaged forests • Salvage harvesting of timber • Revision of the forest management plan considering the losses

16.1. EXTREME WEATHER EVENTS

Extreme weather events include storms, heavy precipitation (rain, snow, and hail), heat waves and cold waves. These conditions can trigger natural disasters such as floods, droughts and landslides. Extreme weather and associated disasters may also weaken trees, making them susceptible to pest and disease outbreaks.

The design of the FMU in terms of silvicultural regime, planting design and the choice of species can be of relevance in mitigating the impacts of extreme weather events. For example, the pattern of harvesting and thinning, both in natural forests and plantations, can be arranged so that stands are not destabilized and that susceptible stands are protected by intact forests surrounding them.

Storms, floods and fires can cause severe and extensive damage to forests, resulting in loss of large volumes of timber. In some case, damaged or fallen trees can be salvaged for commercial use as part of recovery action. Contingency plans for these disasters should be in place well before they occur as such recovery actions must be completed within weeks or at the most a few months following the event.

Recommended requirements:

Minimum	Good to have
• Required actions to prepare for, respond to and recover from the most likely natural disasters identified. • A process in place to revise the forest management plan when a disaster causes severe damage to the forest, infrastructure or humans that may prevent forest management objectives from being achieved according to the existing plan.	• A preparedness, response and recovery action plan for natural disasters with higher frequency and more severe impacts developed (and reflected in silvicultural and business plans accordingly).

Damaged coconut plantation to be salvage harvested.

© FAO/Sasha Guyetsky

16.2. FIRES

Catastrophic forest fires are becoming a frequent and extremely damaging disaster in many parts of the world. Severe fires can completely destroy forests, and even moderate fires may damage trees resulting in loss of economic value. Fires also threaten lives and property in and around the FMU affecting the forest business in many ways. Smoke from fires can have adverse health impacts even on people living at a distance from the FMU, causing respiratory illnesses that could even lead to death. On the other hand, fires are a part of the natural disturbance regime necessary to ensure forest regeneration in certain forest types. Thus, forest fire management should aim to minimize losses while allowing fire to play its natural ecological role where appropriate.

Forest fire risks can be significantly reduced through an integrated approach to fire management which includes five key elements as follows: 1) review (monitoring and analysis); 2) risk reduction (prevention); 3) readiness (preparedness); 4) response (suppression); and 5) recovery. Forest managers have important roles to play in all these elements.

Fire management planning spans the overall forest management and operational planning. The forest management plan should address forest design aspects that affect fire risks such as the layout of compartments, areas of natural vegetation in planted forests, and firebreaks. Silvicultural aspects such as tree spacing, pruning, fuel reduction by litter or weed removal or by

Forest fire caused by human activity

©FAO/Luis Tato

prescribed burning also need to be considered. Fire control infrastructure such as roads and water supplies must be identified and installed, and firefighting equipment made available. There are also regular activities such as preparing and maintaining firebreaks that should be included in the annual plan of operations.

Recommended requirements (if there is a known fire risk in the area):

Minimum	Good to have
• Necessary fire mitigation measures (e.g. firebreaks and an early warning system) identified and put in place. • Awareness of how to summon help in fire control when needed.	• Fire mitigation measures identified and integrated in the silvicultural plan (e.g. stand design, fuel reduction, and firebreak establishment and maintenance). • Fire preparedness and response plans developed, regularly reviewed and updated. • Fire control crews trained and equipped prior to each fire season.

16.3. PESTS AND DISEASES

Insect pests, diseases and other biotic agents can adversely affect tree growth and the yield of timber and NWFPs. Therefore, measures to protect forests from pests and diseases are an integral part of sustainable forest management (FAO, 2009). These measures may include silvicultural prescriptions aimed at either reducing the incidence of the pest and disease or at producing environmental conditions that make it difficult for them to survive, reproduce and travel. The ability of trees to defend against pest and disease becomes weakened when they are unhealthy. Thus, silvicultural interventions to keep trees health may help to ward off pests and diseases. While more information is available on pests and diseases affecting commercially planted trees in industrialized countries, little is known of pests associated with trees harvested from natural tropical forests.

Recommended requirements:

Minimum	Good to have
• Common pests and diseases in and around the FMU identified • Necessary measures identified and implemented to prevent or control outbreaks if these species show signs of becoming problematic.	• Silvicultural interventions designed to minimize risks of pest and disease outbreaks. • Operational monitoring in place to enable early detection of pests and diseases.

16.4. ACCIDENTS AND THEIR PREVENTION

Forestry work is among the most dangerous occupations due to the use of heavy machinery and sharp cutting tools in a natural environment that is highly variable both in time and space. For example, soil conditions will change depending on the weather, and soil properties will vary from one place to another in the forest.

While some forest hazards are associated with the nature of the location, others occur due to the nature of the work. The first type of hazard can be mitigated to a certain extent during forest management planning by identifying and excluding areas that are too dangerous for forest management activities (e.g. steep slopes or slopes with soils prone to movement). Limits can also be placed on weather and field conditions that are considered safe for forest operations. The second type of hazard can be mitigated through the provision of proper personal protective equipment, training on safe operational practices, and adequate supervision to ensure compliance with standard operating procedures.

The first principle of safety is to ensure that every job is done in a correct and safe manner every time. This requires that all workers are fully trained and sufficiently skilled to carry out the work properly. When accidents do occur, it is necessary to ensure that victims can be stabilized and quickly transported from the site to medical facilities. This requires an adequate road network and means of communication.

Advice on safety issues is often available from local disaster response agencies such as fire brigades and the police. In addition, in many countries, forest industry associations or agricultural cooperatives can provide support.

Finally, there are also accident risks to people not directly involved in forest management, including those who enter the forest for collection of NWFPs or for recreation. Activities such as timber transport on public roads can also pose significant risks to other road users.

Recommended requirements:

Minimum	Good to have
• Areas and conditions that are too dangerous for certain forest management activities (e.g. harvesting) specified in the forest management plan and relevant maps. • Routes for transport of accident victims from the forest to a safe place identified. • Means of communication made available to ensure appropriate response in the event of accidents.	• A system for emergency response described. • Safety risks to third parties identified and considered in forest management planning.

16.5. LEARNING FROM INCIDENTS AND TAKING CORRECTIVE ACTIONS

Any accidents that do occur should be recorded, reported and investigated so that lessons learned can be used to prevent their occurrence in the future. This should be a part of the monitoring and feedback system (Chapter 17). A typical format for such hazard reporting includes:

1) identified hazard or a problem;
2) required corrective action;
3) name of supervisor responsible for the corrective action;
4) date by which the corrective action is to be completed;
5) signature of supervisor responsible for taking correction action; and
6) signature of supervisor confirming that corrective action has been completed.

Recommended requirements:

Minimum	Good to have
• Provision made in the forest management plan for recording and reporting incidents and hazards. • Incident reports evaluated periodically and appropriate actions taken to prevent future accidents.	• Responsible person(s) for reviewing incident reports and taking corrective actions identified. • Operational practices amended to prevent future occurrences based on evaluation of incident reports.

17. Monitoring and evaluation

Monitoring of forest management can be time-consuming and expensive, and is often considered the most difficult part of the management cycle. The purpose of monitoring is to track progress towards the achievement of forest management objectives. Therefore, monitoring must be explicitly linked to objectives, and the monitoring results should provide feedback that enables adaptive management. Some monitoring activities may be part of legal or contractual requirement, in which case the monitoring parameters may not directly correspond to forest management objectives.

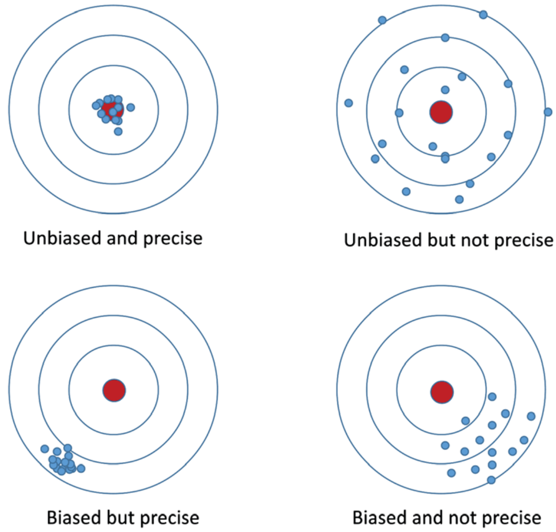
If it is found that feasible monitoring methods do not exist for certain forest management objectives, it may be necessary to adjust or reformulate these objectives to enable monitoring (**Table 16**).

Table 16. Examples of alternate objectives capable of being monitored

Original objective	To reduce soil erosion from harvesting activities in FMU over a ten-year period	To increase biodiversity in the forest over a ten-year period
Problem	Soil erosion can be measured by monitoring sediment load in streams. However, stream sediment load is highly variable depending on rainfall and it can also be affected by activities upstream of the FMU. Designing a monitoring programme, as well as sample collection and analysis, require expertise that may not be readily available.	Biodiversity includes genetic, species, and ecosystem diversity. It is not possible to monitor all aspects of biodiversity. Even if the monitoring focuses on key indicator species, population trends may fluctuate naturally or be impacted by factors outside the control of forest manager.
Revised objective	To ensure proper implementation of reduced impact logging (RIL) practices through training, supervision and monitoring.	To increase the area of natural habitat managed for biodiversity twofold in ten years
Rationale	Research results show that RIL practices significantly reduce soil disturbance from road construction and skidding. The implementation of RIL is under the control of the forest manager and can be monitored effectively.	Natural habitats support greater biodiversity than intensively managed forest stands. Forest area managed for biodiversity can be recorded and monitored easily.

Monitoring normally involves repeated measurements to detect if meaningful changes have taken place. Two basic concepts of statistics must be understood to design robust monitoring programmes. These are bias and precision (**Figure 19**).

Figure 19. Illustration of bias and precision



Adapted from: White, G. C., Anderson, D. R., Burnham, K. P. & Otis, D. L. 1982. *Capture – recapture and removal methods for sampling closed populations.* United States. www.osti.gov/biblio/6729610

Tree diameter measurements may be imprecise, for example because the measuring tape is not always perpendicular to the stem or due to errors in reading the tape. In another instance, the measurements could be biased because the surveyor is consistently measuring the diameter 10 cm below breast height. If these problems are compounded, the measurements will be both imprecise and biased.

When we measure certain parameters for monitoring, we need to do so in a way that minimizes bias and maximizes precision. To increase precision of our estimate, we can increase the number of times we take the measurement. To decrease bias, we need to consider factors that might influence the result in a systematic way. In the example above, the surveyor could be provided with a stick to indicate the exact height at which the diameter measurement should be taken. Estimates of monitoring parameters should be accurate enough to detect real changes as appropriate for the scale, intensity and purposes of forest management.

17.1. DEFINING WHAT AND HOW TO MONITOR

Defining parameters to monitor and how to measure them is an iterative process as these will continue to evolve as circumstances change and more suitable monitoring methods become available. Parameters can be measured through either quantitative or qualitative indicators (**Table 17**).

Table 17. Examples of quantitative and qualitative indicators

Quantitative	Qualitative
• Tree growth • Volume of harvested timber or NWFPs • Area of natural vegetation or set-asides • Sediment load in a stream • Number of visitors to the forest • Number of employees • Number of work-related injuries	• Feelings towards the forest • Beauty of the landscape • Community well-being • Community perception • Cultural values

Key factors to consider in identifying good indicators include the following:

- Relevant: Is the indicator closely related to the intended objectives and activities?
- Affordable: How expensive is it to collect and analyse the data?
- Technically feasible: Does date collection and analysis require specialized knowledge and expertise? Is such technical competence locally available?
- Accessible: Does this indicator rely on access to information that is held by other entities?
- Understandable: is the indicator easy to understand and interpret for the forest manager and key stakeholders?
- Practical: Are practical methods available to collect data of sufficient accuracy.

Once the indicators are selected, it will be necessary to define data collection methods and responsibilities (i.e. who will collect the data, how, where, when, and how often). The intensity and frequency of observations should be minimized to reduce monitoring costs while ensuring detection of changes at the required accuracy. Many ecological processes take place slowly, hence frequent observations may not be needed for these parameters. For example, for trees in dry forests that grow very slowly, it may be sufficient to measure them every few years when accumulated change will be easier to detect.

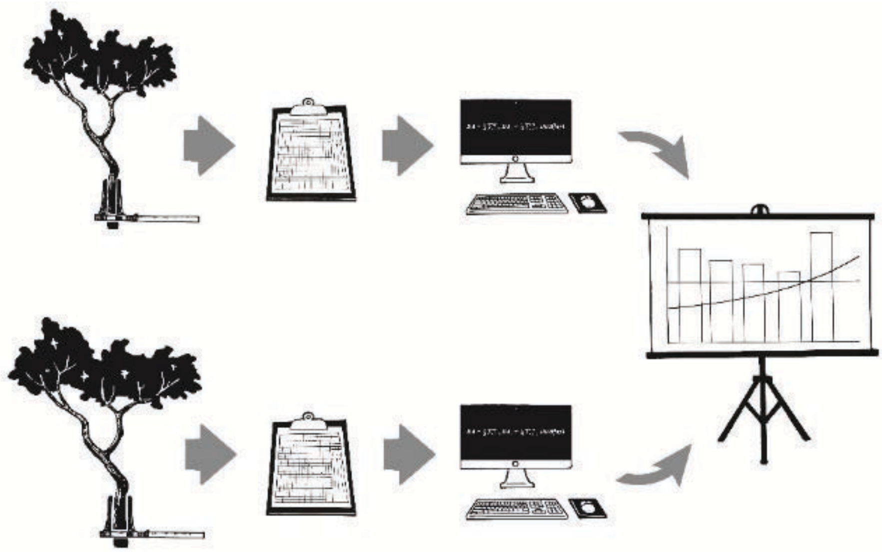
Recommended requirements:

Minimum	Good to have
• Simple monitoring indicators identified for all forest management objectives with defined data collection methods and frequency.	• Robust monitoring indicators identified for all forest management objectives with defined data collection protocols and responsible persons assigned.

17.2. ANALYSING AND PRESENTING MONITORING RESULTS

Monitoring information must be analysed and provided in a suitable format to support forest management decision-making, which requires a multistep process (**Figure 20**).

Figure 20. A multistep process of turning data into usable information



Source: Authors' own elaboration

First, measurements taken in the field are recorded in a data form. The recorded data are then entered into a computer software for analysis. In some cases, field data can be recorded directly on a tablet computer, field laptop or a smartphone, which can be transferred electronically to analysis software.

It is also important to check the field measurements to ensure data reliability as equipment failures, calibration errors or mistakes in copying data can result in erroneous monitoring results. The results of data analyses are then presented in suitable formats (e.g. maps, graphs and tables) that enable detection of changes over time in the variables of interest (**Table 18**).

Table 18. Growth monitoring data of teak stands

Compartment number	Mean annual increment (MAI) (m^3/ha/year)	Target MAI (m^3/ha/year)	Difference (m^3/ha/year)
SJ1	7.2	7	0.2
SJ2	7.8	7	0.8
SJ3	6.6	7	-0.4
SJ7	8.3	7	1.3
SE4	8.8	8	0.8
SE8	7.8	8	-0.2
SE12	8.3	8	0.3
QP1	10.4	9.5	0.9
QP2	8.7	9.5	-0.8
QP3	9	9.5	-0.5

Notes: In this example, observed MAIs of teak trees up to age ten for different compartments are shown. Red numbers in the difference column highlight compartments that are underperforming.

Recommended requirements:

Minimum	Good to have
• The way in which monitoring information will be analysed and presented in an easy-to-understand format described.	• Standard procedures described for analysing and presenting monitoring information to support forest management decision-making.

17.3. ADAPTIVE MANAGEMENT

If the monitoring results reveal that one or more of the forest management objectives are not being achieved, it will be necessary to modify or improve the associated forest management practices so that the objectives can be attained. If the objectives are unrealistic or are no longer in line with the current realities, then the objectives themselves need to be revised.

The monitoring results should be reviewed at least annually and considered in revising the forest management plan at predetermined intervals (often at five-year intervals). However, corrective actions should be taken in response to any major failures with significant consequences as soon as they are detected.

Recommended requirements:

Minimum	Good to have
• A process in place to detect and respond to any significant failures to achieve forest management objectives.	• A plan for periodic review of monitoring information (at least annually) in place.

18. Conclusion

This guide outlines the processes involved in developing a forest management plan for multiple use with a focus on SMFEs. In view of the multiple values and benefits provided by forests at local and landscape levels, a holistic approach to forest management planning that seeks to optimize the balance of social, economic and environmental outcomes is needed.

Sound forest management planning helps to ensure the economic viability of the forest enterprise and sustainability of forest resources along with other tangible and intangible benefits. Even where forest production is the primary objective of forest management, considering the multiple values provided by forests in the planning process can lead to more integrated forest management resulting in better outcomes for all stakeholders.

In forest management planning for multiple use, SMFEs often face challenges related to availability of financial resources, knowledge and capacity, and technical support. This guide sets out the process for assessing the various benefits provided by forests in forest management planning, including those services that are not readily marketable but that may be critical to the well-being of local stakeholders and the global community. This holistic planning process may also help forest managers to diversify and add value to their products, improve business profitability, enhance relations with local stakeholders and increase the flow of environmental and social benefits.

The importance of the participatory approach to forest management planning with the meaningful engagement of multiple stakeholders is underscored in this guide as a prerequisite to SFM. It is also critical that local communities, including marginalized groups, are capacitated and empowered to participate in forest management not only under community-based forest management modalities but also in forests managed by other actors.

Efforts to promote SFM need to be supported through an enabling environment. However, forest management is ultimately implemented by forest managers who are working on the ground to make sustainable use of forest resources. Thus, small and medium forest owners have a critical role to play in achieving SFM, and forest management planning is a vital tool that can assist forest managers in this regard.

References

Alder, D. 2020. *Updating the MYRLIN models for growth projection in mixed tropical forest.* Report prepared for the Food and Agriculture Organization of the United Nations, Rome. www.bio-met.co.uk/pdf/FAO-Myrlin-Feb-2020-Report.pdf

Alder, D., Baker, N., Wright, H.L. 2002. MYRLIN: Methods of Yield Regulation with Limited Information. University of Oxford, Oxford Forestry Institute. www.myrlin.org

Baskent, E.Z., Borges, J.G., Kašpar, J., Tahri, M. 2020. A Design for Addressing Multiple Ecosystem Services in Forest Management Planning. *Forests* 11(10):1108. https://doi.org/10.3390/f11101108

Black Rock Forest. 2020. *Dendrochronology. How to use an increment borer* [video]. Cited 7 February 2022.. www.youtube.com/watch?v=sKfK2nqb5XM

Blaser, J., Frizzo, J. & Norgrove, L. 2021. *Not only timber: the potential for managing non-timber forest products in tropical production forests—a comprehensive literature review*. ITTO Technical Series No. 50. International Tropical Timber Organization (ITTO), Yokohama, Japan, and Precious Forests Foundation, Zürich, Switzerland.

Boscolo, M., Lehtonen, P. and Pra, A. 2021. *Developing bankable business plans – A learning guide for forest producers and their organizations.* Forestry Working Paper No. 24. Rome, FAO. https://doi.org/10.4060/cb4520en

Brown, E., Dudley, N., Lindhe, A., Muhtaman, D.R., Stewart, C. & Synnott, T., eds. 2013. *Common guidance for the identification of High Conservation Values.* HCV Resource Network.

Calama, R., Tomé, M., Sánchez-González, M., Miina, J., Spanos, K. & Palahí, M. 2010. Modelling non-wood forest products in Europe: a review. *Forest Systems,* 19(4): 69–85. DOI:10.5424/fs/201019S-9324

Caldwell, B., Gichuru, T., Boscolo, M., Vesa, L., Zapata, J., Grouwels, S., Bull, L. & Campbell, J. 2021. *Taking stock: what we grow together counts. A practical guide for family farmers and their associations to develop a planted forest inventory.* Forestry Working Paper, 23. Rome, FAO. DOI.org/10.4060/cb4905en

Çellek, S. 2020. Effect of the Slope Angle and Its Classification on Landslide. *Natural Hazards Earth Systems Sciences Discussions.* https://doi.org/10.5194/nhess-2020-87

Del Gatto F., Mbairamadji J., Richards M. & Reeb D. 2018. *Small-scale forest enterprises in Latin America: unlocking their potential for sustainable livelihoods.* Forestry Working Paper No. 10. Rome, FAO. 86 pp. Licence: CC BY-NC-SA 3. 0 IGO.

Douglass, R.W. 1982. *Forest recreation.* 3rd Edition. Elsevier. www.elsevier.com/books/forest-recreation/douglass/978-0-08-028804-8

European Commission. 2014. *Forest management plans or equivalent instruments. Summary of Member States' replies to the DG ENV questionnaire.* Cited 7 February 2022. https://ec.europa. eu/environment/forests/pdf/fmp_table.pdf

FAO, IUFRO and USDA. 2021. *A guide to forest-water management*. FAO Forestry Paper No. 185. Rome. https://doi.org/10.4060/cb6473en

FAO. 2020. *Tenure security for better forestry* (updated October 2021). www.fao.org/forestry/tenure/en/

FAO. 2020. *Global Forest Resources Assessment 2020 – Key findings.* Rome, FAO. www.fao.org/3/CA8753EN/CA8753EN.pdf

FAO. 2009. *Global review of forest pests and diseases*. FAO Forestry Paper 156. Rome, FAO.

FAO. 2004a. *Simpler Forest Management Plans for Participatory Forestry*. Rome, FAO.

FAO. 2004b. *Regional Code of Practice for Reduced-Impact Forest Harvesting in Tropical Moist Forests of West and Central Africa*. Rome, FAO

FAO. 1998. *Guidelines for the management of tropical forests. 1. The production of wood.* FAO Forestry Paper 135. Rome, FAO. www.fao.org/3/w8212e/w8212e00.htm

Forestry Commission, Edinburgh. 2014. *Design techniques for forest management planning*. Cited 7 February 2022. www.gov.uk/government/publications/design-techniques-for-forest-management-planning-practice-guide

FSC (Forest Stewardship Council). 2018. *FSC-GUI-30-006 Guidance for Demonstrating Ecosystem Services Impacts Guidance Document (GUI) V(1-1).* https://fsc.org/en/document-centre/documents/resource/336

FSC (Forest Stewardship Council). 2004. *FSC-STD-01-003 SLIMF Eligibility Criteria***.** https://connect.fsc.org/document-centre/documents/resource/205

Gilmour, D. 2016. *Forty years of community-based forestry: A review of its extent and effectiveness*. Rome, FAO.

Gräfe, S., Köhl, M., Eckelmann, C.M., Bremner, Q., Oatham, M., Pacheco, R., Playfair, M. & Shono, K. 2021. *Sustainable management of logged tropical forests in the Caribbean to ensure long-term productivity*. Forestry Working Paper No. 27. Rome, FAO. https://doi.org/10.4060/cb5484en

Harris, L.D. 1984. *The fragmented forest: Island biogeography theory and the preservation of biotic diversity*. Chicago, University of Chicago Press.

Harrison, R.D., Shono, K., Gitz, V., Meybeck, A., Hofer, T. & Wertz-Kanounnikoff, S. 2022. *Mainstreaming biodiversity in forestry.* FAO Forestry Paper, No. 188. Rome, FAO and Bogor, Indonesia, CIFOR. https://doi.org/10.4060/cc2229en

Helms, J.A. 1998. The dictionary of forestry. Bethesda, MD: Society of American Foresters.

ILO (International Labour Office). 1998. *Safety and health in forestry work.* Geneva, International Labour Office. ISBN 92-2-110826-0 ILO. www.ilo.org/wcmsp5/groups/public/@ed_protect/@protrav/@safework/documents/normativeinstrument/wcms_107793.pdf

Kozak, R.A. 2007. *Small and medium forest enterprises: instruments of change in the developing world*. Washington, DC, USA: Rights and Resources Initiative.

Krishnan, S., Wiederkehr Guerra, G., Bertrand, D., Wertz-Kanounnikoff, S. & Kettle, C.J. 2020. *The pollination services of forests – A review of forest and landscape interventions to enhance their cross-sectoral benefits*. Forestry Working Paper No. 15. Rome, FAO & Bioversity International. https://doi.org/10.4060/ca9433en

Lundbäck, M., Persson, H., Häggström, C. & Nordfjell, T. 2021. Global analysis of the slope of forest land. *Forestry: An International Journal of Forest Research,* 94(1): 54–69. DOI.org/10. 1093/forestry/cpaa021

Matthews, R.W., Jenkins, T.A.R., Mackie, E.D. & Dick, E.C. 2016. *Forest yield: A handbook on forest growth and yield tables for British Forestry.* 92pp. https://www.forestresearch.gov.uk/publications/forest-yield-a-handbook-on-forest-growth-and-yield-tables-for-british-forestry

Miina, J., Kurttila, M., Calama, R., de-Miguel, S. & Pukkala, T. 2020. Modelling non-timber forest products for forest management planning in Europe. *Current Forestry Reports,* 6, 309–322.

Miina, J., Pukkala, T., Hotanen, J.P. & Salo, K. 2010. Optimizing the joint production of timber and bilberries. *Forest Ecology and Management,* 259: 2065–71. DOI:10.1016/j.foreco.2010.02.017

Millennium Ecosystem Assessment. 2003. *Ecosystems and human well-being: a framework for assessment.* http://pdf.wri.org/ecosystems_human_wellbeing.pdf

Natural Resources, Wales. *DIY Tree Measuring Kit.* Cited 12 January 2022. https://cdn.naturalresources.wales/media/688310/template-diy-tree-measuring-kit.pdf

Nzunda, E. 2022. *Assessment of forest planning and management in different forest types in selected African countries*. AFF Working Paper. African Forest Forum, Nairobi.

Paletto, A., Sereno C. & Furuido, H. 2008. Historical evolution of forest management in Europe and in Japan. *Bull. Tokyo Univ. For.,* 119: 25–44. www.researchgate.net/publication/29779770_Historical_evolution_of_forest_management_in_Europe_and_in_Japan

Paudel N.S., Adhikary A., Mbairamadji J. & Nguyen, T. Q. 2018. *Small-scale forest enterprise development in Nepal: overview, issues and challenges.* Rome, FAO. 84 pp. Licence: CC BY-NC-SA 3.0 IGO.

Peters-Stanley, M. & Gonzalez, G. 2014. Sharing the stage: state of the voluntary carbon markets 2014. Forest Trends' Ecosystem Marketplace.

Restiani, P., Malmer, A. & Van Hensbergen, H.J. 2014. Forest, water, and carbon storage: creating synergies and balancing trade-offs in view of climate change. In: A. Jagerskog, T. J. Clausen, T. Holmgren & K. Lexen, eds. *Energy and water: The vital link for a sustainable future*. Stockholm, SIWI.

Rosoman, G., Sheun, S.S., Opal, C., Anderson, P., & Trapshah, R., editors. 2017. *The HCS Approach Toolkit.* Singapore: HCS Approach Steering Group.

Shono, K. & Jonsson, Ö. 2022. Global progress towards sustainable forest management: bright spots and challenges. *International Forestry Review* 24(1): 85-97. doi.org/10.1505/146554822835224856

Taye, Z.M., Martínez-Peña, F., Bonet, J.A., Martínez de Aragón, J. & de-Miguel, S. 2016. Meteorological conditions and site characteristics driving edible mushroom production in Pinus pinaster forests of Central Spain. *Fungal Ecology,* 23: 30–41. DOI:10.1016/j.funeco.2016.05.008

Spantigati, P. & Springfors, A. 2005. Microfinance and forest-based small-scale enterprises. Forestry Paper 146, Rome, FAO.

Sylva Foundation. 2022. *MyForest.* Long Wittenham, Oxfordshire, UK. Cited 7 February 2022. https://myforest.sylva.org.uk

Wangchuk, J., Choden, K., Sears, R.R. & Baral, H. 2019. *Ecosystem Services from Forest Management Units in Eastern and Central Bhutan*. Working Paper 248. Bogor, Indonesia: CIFOR.

Wright, H.L. & Alder, D. (editors) 2000. Proceedings of a workshop on Humid and semi-humid tropical forest yield regulation with minimal data. University of Oxford, Department of Plant Sciences, Oxford Forestry Institute. OFI Occasional Papers 52.

Appendix 1. Sample forest management plan framework

A sample content and framework for a forest management plan is provided below as reference. This generic format can be adapted based on the local context including prevailing legal requirements related to forest management planning.

1. Describing the forestland

1.1. Location

1.2. Land-use and forest management history

1.3. Physical description

1.3.1. Topography
1.3.2. Climate and weather
1.3.3. Waterbodies
1.3.4. Soils and geology
1.3.5. Infrastructure and associated services

1.4. The living environment

1.4.1. Ecosystems and habitats
1.4.2. Flora
1.4.3. Fauna
1.4.4. Biodiversity
1.4.5. Ecosystem services

1.5. Forest resources

1.5.1. Growing stock
1.5.2. Forest growth
1.5.3. Non-wood forest products
1.5.4. Social, cultural and aesthetic features

1.6. Social and cultural features

2. Describing the social, economic and regulatory environment

2.1. Local communities and populations

2.1.1. Demographics
2.1.2. Local use and perception of forest

2.2. Regional populations

2.3. Local businesses and markets

2.4. Regional businesses and markets

2.5. Product requirements

2.6. Forest rights and tenure

2.7. Laws and regulations

3. Management objectives

3.1. Situation analysis

3.2. Objectives for forest products

3.2.1. Tree crops
3.2.2. Non-wood forest products

3.3. Objectives for ecosystem services

3.4. Objectives for biodiversity

3.5. Objectives for the people

4. Silvicultural plan

4.1. Silvicultural system and prescriptions

4.2. Forest management compartments and stands

4.3. Schedule of silvicultural operations

4.4. Harvest planning

4.5. Non-wood forest products planning

4.6. Associated forest management activities

5. Ecosystem services and biodiversity management plan

5.1. Ecosystem services planning

5.2. Biodiversity planning

6. Social and cultural services plan

6.1. Social and cultural services planning

7. Business plan

7.1. Business organization

7.2. Products and markets

7.3. Costs of forest management

7.4. Revenues from forest management

7.5. Cash flow analysis

8. Preparedness plan for abnormal events and disasters

8.1. Extreme weather events

8.2. Forest fires

8.3. Pests and diseases

8.4. Accidents and their prevention

8.5. Learning from incidents and taking corrective actions

9. Monitoring and evaluation

9.1. Monitoring criteria and indicators

9.2. Analysis of monitoring results

9.3. Adaptive management

Appendix 2. Further reading, tools and data sources

Land cover	
Earth Map	https://earthmap.org
Collect Earth / Collect Earth Online	https://openforis.org/tools/collect-earth/ https://openforis.org/tools/collect-earth-online/
Google Earth	www.google.com/earth
Global Forest Watch	www.globalforestwatch.org
Open Foris	https://openforis.org
SEPAL	https://openforis.org/tools/sepal/
Geophysical parameters and climate	
Assessing slope of the land	https://rb.gy/6eusy9
FAO/UNESCO Soil Map of the World	www.fao.org/soils-portal/data-hub/soil-maps-and-databases/faounesco-soil-map-of-the-world/en
Global Wind Atlas	https://globalwindatlas.info
SoilGridsTM	www.isric.org/explore/soilgrids
Habitats and biodiversity	
Data Basin	https://databasin.org
Earth Map	https://earthmap.org
Global Forest Watch	www.globalforestwatch.org
A good practice guide for identifying HCVs across different ecosystems and production systems	www.hcvnetwork.org/library/common-guidance-for-the-identification-of-hcv-english-indonesian-french-portuguese
Good practice guidelines for High Conservation Value assessments: A practical guide for practitioners and auditors	www.proforest. net/fileadmin/uploads/proforest/Documents/Publications/hcv-20good-20practice_final.pdf
Habitats Classification Scheme	www.iucnredlist.org/resources/habitat-classification-scheme
The High Conservation Value Forest Toolkit	www.proforest. net/fileadmin/uploads/proforest/Documents/Publications/hcvf-toolkit-part-1-final-updated.pdf

Intact Forest Landscapes	https://intactforests.org/world webmap.html
One Earth	www.oneearth.org
Nature Map Explorer	https://explorer.naturemap.earth/map
Flora and fauna	
Checklist of CITES species	https://checklist.cites.org/#/en
eBird	https://ebird.org/home
iNaturalist	www.inaturalist.org
IUCN Red List of Threatened Species	www.iucnredlist.org
Map of Life	https://mol.org
Pl@ntnet	https://plantnet.org/en
Forest inventory	
6 principles of a robust forest information system	https://medium.com/openforests/6-principles-that-help-to-design-a-robust-forest-information-system-2fb3177dbe22
Dendrochronology: How to use an increment borer	www.youtube.com/watch?v=sKfK2nqb5XM
DIY Tree Measuring Kit	https://cdn.naturalresources. wales/media/688310/template-diy-tree-measuring-kit.pdf
GlobAllomeTree	www.globallometree.org
Methods of Yield Regulation with Limited Information (MYRLIN)	https://bio-met.co.uk/myrlin/original
Open Foris Arena	https://openforis.org/tools/arena/
SFM Toolbox module 'Forest Inventory'	www.fao.org/sustainable-forest-management/toolbox/modules/forest-inventory/basic-knowledge/en
Taking stock: What we grow together counts. A practical guide for family farmers and their associations to develop a planted forest inventory	www.fao.org/3/cb4905en/cb4905en.pdf
Non-wood forest products	
ASEAN Guidelines for Sustainable Harvest and Resource Management Protocols for Selected Non-Timber Forest Products (NTFPs)	https://ntfp.org/wp-content/uploads/2021/11/20.-ASEAN-NTFP-Guidelines-Final.pdf
Guide for small and medium enterprises in the sustainable non-timber forest product trade in Central Africa	www.fao.org/3/am804e/am804e.pdf

Non-Timber Forest Products-Exchange Programme (NTFP-EP) Product Database	https://ntfp.org/information-resources
Not only timber: the potential for managing non-timber forest products in tropical production forests—a comprehensive literature review	www.itto.int/direct/topics/topics_pdf_download/topics_id=6727&no=1&disp=inline
NTFP Sustainable Harvesting and Resource Management Protocols for Rattan	https://ntfp.org/wp-content/uploads/2021/10/ASEAN-NTFP-Protocols_Rattan_Final101321.pdf
NTFP Sustainable Harvesting and Resource Management Protocols for Fruits	https://ntfp.org/wp-content/uploads/2021/10/ASEAN-NTFP-Protocols_Fruits_Final101321.pdf
Rainforest Alliance Technical Report: Cooperative Non-Timber Forest Product Management in Western Amazonia	www.rainforest-alliance.org/business/commodity/non-timber-forest-products
SFM toolbox module 'Management of Non-Wood Forest Products'	www.fao.org/sustainable-forest-management/toolbox/modules/management-of-non-wood-forest-products/basic-knowledge/en
Steps to Sustainable and Community-based NTFP Management	https://rb.gy/xjag0u
FPIC and Indigenous Peoples' rights	
FAO e-learning course: 'Free, Prior and Informed Consent (FPIC) - An Indigenous Peoples' right and a good practice for local communities'	https://elearning.fao.org/course/view.php?id=500
FAO website on Indigenous Peoples	www.fao.org/indigenous-peoples/our-pillars/fpic/en
Social dimensions	
FAO SFM Toolbox module 'Collaborative Conflict Management'	www.fao.org/sustainable-forest-management/toolbox/modules/collaborative-conflict-management/basic-knowledge/en
FAO SFM Toolbox module 'Forest Law Enforcement'	www.fao.org/sustainable-forest-management/toolbox/modules/forest-law-enforcement/basic-knowledge/en
FAO SFM Toolbox module 'Forest Tenure'	www.fao.org/sustainable-forest-management/toolbox/modules/forest-tenure/basic-knowledge/en
FAO SFM Toolbox module 'Gender in Forestry'	www.fao.org/sustainable-forest-management/toolbox/modules/gender-in-forestry/basic-knowledge/en
FAO SFM Toolbox module 'Participatory Approaches and Tools for SFM'	www.fao.org/sustainable-forest management/toolbox/modules/participatory-approaches-and-tools-for-sfm/basic-knowledge/en
Forty years of community-based forestry	www.fao.org/publications/card/en/c/b7c18106-c19d-412f-bd77-a35a2aee00b5

How to use Rapid rural Appraisal (RRA) to develop case studies	www.treesforlife.info/fao/Docs/P/tr-e01.5.pdf
SOLA and Open Tenure - free, open-source solutions to protect and strengthen tenure rights	www.fao.org/tenure/sola-suite/en
Ecosystem services	
ESII Tool	www.esiitool.com
FSC Guidance for Demonstrating Ecosystem Services Impacts	https://fsc.org/en/document-centre/documents/resource/336
SFM Toolbox module 'Forests and water'	www.fao.org/sustainable-forest-management/toolbox/modules/forest-and-water/basic-knowledge/en
SFM Toolbox module 'Watershed Management'	www.fao.org/sustainable-forest-management/toolbox/modules/watershed-management/basic-knowledge/en
Spurring INnovations for forest eCosystem sERvices in Europe (SINCERE) toolkit	https://sincereforests.eu/resources/toolkit/assessing-and-valuing-ecosystem-services
Silviculture and harvesting	
FAO SFM Toolbox module 'Management of planted forests'	www.fao.org/sustainable-forest-management/toolbox/modules/management-of-planted-forests/basic-knowledge/en
FAO SFM Toolbox module 'Silviculture in natural forests'	www.fao.org/sustainable-forest-management/toolbox/modules/silviculture-in-natural-forests/basic-knowledge/en
FAO SFM Toolbox module 'Wood harvesting'	www.fao.org/sustainable-forest-management/toolbox/modules/wood-harvesting/basic-knowledge/en
Business development and financing	
Community-based tree and forest product enterprises: Market analysis and development	www.fao.org/3/i2394e/i2394e.pdf
Developing bankable business plans. A learning guide for forest producers and their organizations	www.fao.org/3/cb4520en/cb4520en.pdf
FAO e-learning course 'Developing bankable business plans for sustainable forest-based enterprise'	https://elearning.fao.org/course/view.php?id=931
FAO e-learning course 'Sustainable financing of forest and landscape restoration'	https://elearning.fao.org/course/view.php?id=675

FAO SFM Toolbox module 'Development of forest-based enterprises'	www.fao.org/sustainable-forest-management/toolbox/modules/development-of-forest-based-enterprises/basic-knowledge/en
Forest business incubation: Towards sustainable forest and farm producer organization (FFPO) businesses that ensure climate resilient landscapes	www.fao.org/3/I8754EN/i8754en.pdf
Local financing mechanisms for forest and landscape restoration	www.fao.org/documents/card/en/c/cb3760en
RuralInvest	www.fao.org/in-action/rural-invest/toolkit/en
Monitoring	
FAO SFM Toolbox module 'Forest management monitoring'	www.fao.org/sustainable-forest-management/toolbox/modules/forest-management-monitoring/basic-knowledge/en
Disasters	
Community-based fire management: A review	https://www.fao.org/3/i2495e/i2495e.pdf
FAO SFM Toolbox module 'Forest pests'	www.fao.org/sustainable-forest-management/toolbox/modules/forest-pests/basic-knowledge/en
FAO SFM Toolbox module 'Forestry responses to natural and human-conflict disasters'	www.fao.org/sustainable-forest-management/toolbox/modules/forestry-responses-to-disasters/basic-knowledge/en
FAO SFM Toolbox module 'Vegetation fire management'	www.fao.org/sustainable-forest-management/toolbox/modules/vegetation-fire-management/basic-knowledge/en
Fire management: Voluntary guidelines	https://www.fao.org/3/j9255e/j9255e00.pdf
Occupational health and safety	
FAO SFM Toolbox module 'Occupational health and safety in forestry'	www.fao.org/sustainable-forest-management/toolbox/modules/occupational-health-and-safety-in-forestry/basic-knowledge/en
Occupational safety and health in forest harvesting and silviculture	www.fao.org/documents/card/en/c/ca8773en

For more information, please contact:

Forestry Division - Natural Resources and Sustainable Production
E-mail: NFO-Publications@fao.org
Web address: www.fao.org/forestry/en

Food and Agriculture Organization of the United Nations
Rome, Italy

ISBN 978-92-5-137974-5 ISSN 2664-1062

9 789251 379745

CC6780EN/1/11.23