Food and Agriculture Organization of the United Nations

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MANAGING FORESTS IN DISPLACEMENT SETTINGS

Guidance on the use of planted and natural forests to supply forest products and build resilience in displaced and host communities

Cover photo: Emergency shelters in Kule refugee camp, Ethiopia – © FAO/Arturo Gianvenuti

Managing forests in displacement settings

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Food and Agriculture Organization of the United Nations and

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Contents

Foreword vi
Acknowledgements viii
Acronyms and abbreviations ix
Executive summary x
1 Introduction 1
1.1 Background and rationale 1
1.2 Scope and objectives 2
2 Forest management planning 3
2.1 Defining the purpose of management planning 5
Forest rehabilitation 5
Plantations for woodfuel production 10
Plantations for timber production 12
Plantations for food and fodder production 13
2.2 Preparing for forestry interventions 14
Level of intervention 14
Identification of suitable sites 15
Tenure and access rights 16
3 Preliminary steps in plantation establishment 17
3.1 Site selection 17
3.2 Stakeholder involvement 17
3.3 Choosing the right species 18
Understanding growing conditions 19
Choosing species for different purposes 20
3.4 Timing 24
Time needed for different operations 24
Regularity of operations 26
4 Establishing tree plantations 27
4.1 Setting up a tree nursery 27
Basic considerations 28
Nursery equipment 29
Workers and management 30
Timeliness 31
Production capacity 31
Small infrastructure 31
Potting material 32
Seeds and reproduction 33
4.2 Seedling care 35
Watering 35
Weeding 36
Root system management 36
Hardening off 37
Timetables and organization 37

Expected production time 38
When is a seedling ready? 39
4.3 Site preparation and outplanting 39
Various techniques for various goals 40
Planning and spatial organization 41
Outplanting 42
Protecting outplanted trees 46
Soil management techniques 47
4.4 Harvesting and pruning 48
Techniques 48
Goal of harvest 49
Harvest level 51
5 Monitoring, evaluation and reporting 53
5.1 Why monitor and evaluate 53
5.2 Developing a monitoring system 54
5.3 Monitoring performance of forest management interventions 56
Collecting field data 57
Managing information 57
Reviewing the forest management plan 58
Continued feedback and long-term monitoring 58
Measuring achievements against the goals of the forest management plan 58
5.4 Quality control and work productivity evaluation 58
Indicators for quality control 59
Designing a quality management programme 59
Achieving higher productivity in work 59
5.5 Record-keeping and documentation 60
Financial record-keeping 60
Record-keeping of physical assets 60
Work documentation 61
6 References 63
7 Annexes 65
Annex 1. Checklist for planning forest management in displacement settings 65
Annex 2. Nursery management forms 71
Annex 3. Number of trees per hectare according to spacing 73

Tables

1. Examples of woodfuel plantation species in dry and tropical climates 22
2. Examples of species useful for land rehabilitation and protection 23
3. Example of a work schedule 24
4. Common seedling symptoms, possible causes and remedies 34
5. Example of weekly organizer at a tree nursery 38
6. Indicative times required for various nursery operations 38
7. Examples of seedling quality standards 39
8. Operational framework for site preparation 43
9. Operational framework for marking and digging pits 44
10. Operational framework for transporting seedlings 44
11. Operational framework for planting and watering 46
12. Example of key information in the forest management plan 48
13. Indicative operational framework for a given species in a coppicing regime 49
14. Key technical and environmental criteria for assessing the performance of forest plantations 54
15. Examples of key topics for monitoring operational performance of forest plantations 56

Foreword

An estimated 2.4 billion people rely on wood as their main source of energy for cooking and sterilizing water. In displacement settings, the numbers are even more dramatic: 80 percent of the 65 million displaced people worldwide rely on traditional biomass fuels – mainly woodfuel – for cooking and heating.

The massive increase in demand for woodfuel for cooking caused by sudden influxes of refugees and other displaced people is usually the main driver of forest degradation and deforestation in displacement settings. It places enormous pressure on nearby forests and woodlands and is often a source of tension between the host and displaced communities. A lack of sufficient cooking fuel also has an impact on the nutrition and health of vulnerable people in such settings.

The United Nations High Commissioner for Refugees (UNHCR) estimates that the duration of most protracted refugee situations, as of the end of 2016, is more than 20 years. The longevity of displacement crises means that both short-term emergency needs and long-term development must be better addressed. This is the idea behind the concept of "resilience" – which is at the core of the work of the Food and Agriculture Organization of the United Nations (FAO) to end hunger, malnutrition and poverty.

On 19 September 2016, UN Member States unanimously adopted the New York Declaration for Refugees and Migrants and committed to implementing the comprehensive refugee response framework (CRRF) in situations involving large movements of refugees and in protracted refugee situations as well as to work towards the adoption in 2018 of a global compact on refugees based on the framework. The New York Declaration and CRRF recognize that comprehensive responses must be adapted to the specific situation at hand and must engage the 'whole of society', including governments, humanitarian and development actors, civil society, the private sector and refugees. A key goal of the CRRF is to strengthen cooperation between humanitarian and development actors so as to address immediate and longer-term needs, to build resilience for refugees and their host communities, and to prepare for durable solutions.

A planning approach to the use of forest resources is crucial for building resilience and enabling sustainable development in both displaced and host communities. In particular, well-planned forestry interventions can ensure a sustainable supply of woodfuel, timber and non-wood forest products for those communities, thereby helping to ensure their well-being. Forests and trees also underpin core ecosystem services such as freshwater supply, soil stability and fertility, agro-biodiversity and biodiversity conservation, all of which contribute to the resilience of communities.

Building the resilience of forest-dependent people is a crucial part of FAO's efforts to improve food and nutritional security and alleviate poverty and thereby secure development gains and help achieve the 2030 Agenda for Sustainable Development. FAO and UNHCR are partnering to address sustainable forest management in displacement settings with the aim of ensuring safe access to wood energy for both for displaced people and host communities.

FAO and UNHCR are committed to working closely with member states and development partners to protect displaced and host communities and the surrounding environment, including by planning appropriate responses to ensure that households and communities have access to wood energy sources and by promoting sustainable livelihood opportunities through community-managed forests. This document has been prepared as part of that commitment.

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Acronyms and abbreviations

AAC	annual allowable cut
ANR	assisted natural regeneration
°C	degrees Celsius
cm	centimetre(s)
CRRF	comprehensive refugee response framework
FAO	Food and Agriculture Organization of the United Nations
ha	hectare(s)
m	metre(s)
MAI	mean annual increment
mm	millimetre(s)
UNHCR	United Nations High Commissioner for Refugees

Executive summary

Of the estimated 65 million forcibly displaced people worldwide, 80 percent are forest-dependent, relying at least in part on forest products for energy, shelter, fodder, nutrition and cash income. This document provides guidance on the management of natural and planted forests and woodlands in displacement settings, taking into account, for example, woodfuel demand and supply; land suitability; land tenure; livelihood opportunities; the prerequisites for suitable nursery and plantation sites; tree species selection; nursery establishment and management; plantation establishment and management; and monitoring, evaluation and reporting.

The main target groups of this document are government agencies, civil-society organizations, private and public decentralized management agencies, forestry and other land-use practitioners working at site level, educational, training and research institutions, and other groups involved in the planning, implementation and evaluation of forest management and plantation projects to meet the various needs of displaced and host communities.

The document has four substantive chapters, plus an introductory chapter.

Chapter 2 outlines the process of developing forest management plans for various purposes and provides a checklist of questions to address in planning forestry interventions in displacement settings. Forest management plans set the objectives of forestry interventions, which should be determined through participatory processes to meet the needs of specific communities and situations. The four main purposes of management interventions in displacement settings are:

- the rehabilitation, protection and use of degraded forest land;
- plantations for energy;
- plantations for timber production; and
- plantations for food and fodder production.

The chapter describes four main strategies for rehabilitating degraded forest lands: 1) protective measures; 2) measures to accelerate natural recovery; 3) measures to assist natural regeneration; and 4) tree-planting. A range of social, environmental and technical issues that should be considered in reforesting or afforesting areas in displacement settings and the surroundings for productive purposes such as woodfuel, food and fodder are also described.

Chapter 3 examines in detail the technical requirements for undertaking forestry interventions in the context of displacement settings. Aspects addressed in this chapter include site selection; stakeholder involvement; choosing the right species for planting; and timing (e.g. ensuring that seedlings raised in nurseries are ready for outplanting at the start of the optimal outplanting season).

Chapter 4 provides a step-by-step guide to establishing tree plantations in displacement settings, including advice on setting up tree nurseries; seedling care; site preparation and outplanting; and harvesting and pruning.

Chapter 5 presents guidance on monitoring, evaluation and reporting on forestry interventions in displacement settings, including developing monitoring systems; monitoring the performance of interventions; quality control and work productivity; and record-keeping and documentation.

1 Introduction

1.1 Background and rationale

There were 65.6 million forcibly displaced people worldwide at the end of 2016, an increase of 50 percent compared with 2012 (UNHCR, 2017). Of these displaced people, 80 percent are forest-dependent, relying on forest products for energy, shelter, fodder, nutrition and cash income. Refugees and other displaced people generally have limited access to sources of energy and no option other than to collect woodfuel[1] in surrounding forests and woodlands for cooking, heating and water sanitation. Moreover, both displaced and host communities frequently rely on short-term and unsustainable livelihood activities such as charcoal production and the sale of fuelwood. Large concentrations of displaced people, therefore, can place great pressure on surrounding forests and woodlands by causing massive increases in demand.

Increased demand for woodfuel is a main driver of forest degradation and deforestation in and around displacement settings. It is often a source of tension between the displaced and host communities, leading to increased competition over the same natural resources that are often already scarce in the areas where displacement camps are established. The lack of sufficient cooking fuel also has an impact on the nutrition and health of vulnerable households because food may be undercooked or meals skipped to save fuel, and food might be bartered for fuel.

The potential for establishing tree plantations in or near displacement settings should be assessed at an early stage to identify the specific needs and threats and current and future pressures on natural resources. In planning forestry interventions to address woodfuel demand in displacement settings, the following aspects should be assessed: the standing woody biomass available for use as fuel; the likely consumption over a given period; and the interrelationships and gaps between woodfuel demand and supply. Such a supply/demand baseline assessment can be used to determine whether the rate at which wood is harvested is outpacing the rate of regrowth in a given area and to provide options for improving energy-use efficiency (FAO and UNHCR, 2016). It can also be used as an entry point for planning forest resource management, determining goals and objectives, and identifying the role of governments, local authorities and the displaced and host communities in the short, medium and long term.

Fuelwood and charcoal are often the most accessible and affordable energy source for cooking and heating at the household level. Timber is also needed for various uses at the household level as well as for commercial and institutional uses (e.g. building schools and medical clinics), and it is often obtained from local forests. Forest resource management in displacement settings will have several objectives, which may require priority setting to avoid conflicts between objectives. Wood is expected to remain a primary source of energy for cooking among rural people for the foreseeable future, especially in displaced populations, because alternative sources are typically associated with higher costs and changing user behaviour can be a lengthy process. Wood is an environmentally friendly and renewable source of energy – but only when it is produced sustainably and used efficiently.

When sustainably managed, forests and trees are vital safety nets and life-supporting assets that can improve quality of life and livelihoods while acting as buffers that help communities to withstand extreme weather and other shocks. Woodfuel can be supplied through a variety

1 The term woodfuel is generally used to encompass all fuels derived from forest-based or woody biomass. The term fuelwood is generally used to encompass woodfuels in which the original composition of the wood is preserved. Thus, firewood qualifies as fuelwood but charcoal, which involves a transformation process, does not.

of tree and forest systems, such as mixed-forest plantations and integrated food–energy systems such as agroforestry and multiple cropping systems (FAO, 2010). Forests and trees also underpin core ecosystem services such as the provision of freshwater and the maintenance of soil fertility and biodiversity (Burgeon *et al.*, 2015).

When a settlement is created for displaced people, it is often in the belief that it will be temporary. In reality, however, displacements last, on average, more than 20 years, evolving into protracted crises and creating harsh living conditions that are seriously detrimental to human health and which prevent inhabitants from pursuing their usual livelihoods. Given the expected longevity of many existing displaced communities, there is a need to address both short-term emergency needs and long-term development objectives, especially building the resilience of displaced peoples and their host communities.

Planning the appropriate management of forests and woodlands in displacement settings is important – in both the short and long term – for ensuring sustainable energy access, minimizing environmental and social impacts, and building resilience in households and communities. The objectives of forest management will depend on the type of shock suffered by the displaced community and its specific needs; overall, however, the aim should be to move towards an integrated approach that will protect people and the environment while addressing both immediate humanitarian needs and longer-term development goals. The concept of resilience has emerged as a viable framework for integrating humanitarian and long-term development initiatives.

1.2 Scope and objectives

This document provides guidance on the management of natural and planted forests and woodlands in displacement settings, taking into account, for example, woodfuel demand and supply; land suitability; land tenure; livelihood opportunities; the prerequisites of suitable nursery and plantation sites (e.g. with respect to water supply, soil fertility and forest resources); tree species selection; nursery establishment and management; plantation establishment and management; and monitoring, evaluation and reporting.

The main target groups are those involved in the planning, implementation and evaluation of forest management and plantation projects to meet the various needs of displaced and host communities, such as wood energy, environmental restoration and livelihood opportunities. These groups include:

- government agencies dealing with land use and management in rural areas (e.g. departments of forestry, planning and finance) and development and extension agencies;
- non-governmental organizations, and private and public decentralized management agencies;
- forestry and other land-use practitioners working at site level; and
- educational, training and research institutions.

2 Forest management planning

The term forest management is applied in situations where an integrated, coordinated series of actions is taken towards the achievement of specified objectives. In the broadest sense, forest management is a process to effectively integrate decisions on economic, social and environmental factors, leading to the achievement of one or more specified objectives.

Planning is an integral component of forest management. It is about determining and expressing the forest-related goals and objectives of government, communities, companies and other forest-growers and deciding the steps that should be taken to achieve those objectives (FAO, 1998).

A forest management plan is an essential tool for achieving defined objectives. In the context of displacements, it should specify:

- the area of intervention;
- the density and size of the displaced and host populations;
- the quantity and type of woodfuel demand and other forest products;
- the accessibility of forest resources to both displaced and host communities;
- the potential existing supply of woodfuel and other forest products (including factors such as distribution and availability) and costed options for establishing agroforestry systems, plantations and hedgerows;
- the maximum area from which wood could be harvested sustainably, or the maximum quantity of wood that could be harvested sustainably from forests and woodlands to achieve a balance between annual growth and harvest;
- the forest protection operations to be carried out;
- the forest development operations to be carried out, including silviculture; and
- other factors that need to be taken into account for the effective implementation of management objectives and to ensure the sustainability of the operation. These might include forest inventories, mapping, technical and social surveys, and public consultation.

Planning should be based on a sound analysis of the following four key factors:

1. **economic** (e.g. the causes of degradation, the supply of, and demand for, specific forest products, marketing opportunities, and incentive systems);
2. **social/cultural** (e.g. the uses of forests and woodlands, use rights, value systems, community organization, sharing the costs and benefits, traditional knowledge, equity, and gender awareness);
3. **institutional** (e.g. the legal and regulatory framework, capacity, incentives and monitoring); and
4. **ecological** (e.g. climatic, edaphic, hydrological, productive and protective functions, biodiversity, and traditional/appropriate technology).

Annex 1 provides a checklist of the main aspects that should be kept in mind in the planning phase of forest management in displacement settings.

The decision-making process in forest management planning can be described as follows:

- determining goals and objectives;
- collecting required information;
- defining available lines of action;
- predicting the consequences of applying those lines of action;
- analysing the results; and
- making a decision, or returning to an earlier point in the decision chain.

A goal is a long-term aim derived from forest policies or determined as the endpoint of a strategy to achieve sustainable forest resource development.

Objectives are related to specific results to be achieved in a specified period. A forest management plan might set out several objectives. Each objective should be clear on:

- the main purpose of the planning;
- the activities to be undertaken;
- where the activities will happen;
- who will be affected and how;
- who is responsible for taking action;
- when activities should be performed; and
- when activities should be completed.

The role of women and men is another consideration: women, for example, are often strongly involved in collecting wood and non-wood forest products and water for their households, while men are usually more oriented towards market-based uses of forest products. For this reason, a gender analysis should be carried out to examine the differences and similarities between men and women in their roles, access to resources, needs (in terms of planting, harvesting and using forest products), involvement in participatory processes, and capacity to carry out the activities specified in the forest management plan.

Initial contact should be made with affected communities and other relevant stakeholders as part of a process to establish a systematic dialogue. Questions that could be posed include the following:

- What factors are affecting access to natural resources?
- Is there a difference between female/male use of forest products within families?
- For what purposes are forest products mainly needed?
- What kinds of forest products are most needed?
- Who obtains the forest products?
- Who decides on the use of forest products?
- Who has the right to manage and use the products of the land?

In-depth assessments of the use of forest products are needed to determine immediate needs and longer-term goals. FAO and UNHCR have developed a methodology for assessing woodfuel demand and supply in displacement settings that can be used as an entry point for identifying appropriate forestry interventions as part of sustainable resource management. This methodology also provides a baseline for monitoring, evaluating and planning interventions to enhance energy access, reduce the risk of land degradation and the overexploitation of natural resources, and build the resilience of livelihoods in and around displacement camps (FAO and UNHCR, 2016). *The Safe Access to Fuel and Energy (SAFE) toolbox: woodfuel assessment in displacement settings* (FAO, 2016) can assist in analysing multisectoral field data on the energy needs, woodfuel resources and associated risks and challenges facing people in displacement settings.

Forest management strategies in displacement settings should be viewed and planned in the context of an overall landscape approach, with the aim of enhancing the functionality and sustainability of forest resources. The four basic strategies, according to the specific context and objectives, are:

1. **the rehabilitation of degraded forests and woodlands,** applied where sites are so heavily degraded that the spontaneous regeneration of tree and shrub species is severely limited;
2. **the establishment and management of plantations,** applied where sites are not heavily degraded and where favourable physical conditions (e.g. water resources, infrastructure and proximity to settlements) exist for attaining the desired outputs at the needed scale;
3. **the natural regeneration of native forests** for sustainable management to maintain productive functions and ecosystem services over time; and
4. **the protection of remaining natural forests** (usually in fragments or patches), for example for their soil-stabilizing functions in erosion-sensitive areas, biodiversity conservation, soil and water protection, and the provision of habitat.

2.1 Defining the purpose of management planning

Forest management plans should set the actions to be undertaken for at least the next 5–10 years to protect and managing existing natural forests, rehabilitate or restore degraded forests, establish and maintain new forest and tree resources, raise awareness on forest management and protection among displaced people and host communities, and carry out monitoring and evaluation.

Forest management plans can have diverse objectives that should be set to sustainably meet demand for forest products and services in specific locations, situations and communities. The four main purposes of management interventions in displacement settings are:

1. the natural regeneration or rehabilitation, protection and use of degraded forest land;
2. plantations for energy;
3. plantations for timber production; and
4. plantations for food and fodder production.

Although forest rehabilitation, reforestation and afforestation interventions require considerable work and finance, they are essential to ensure an efficient and sustainable supply of woodfuel and other forest products in displacement settings.

Forest rehabilitation

Degraded forest land is "former forest land severely damaged by the excessive harvesting of wood and/or non-wood forest products, poor management, repeated fire, grazing or other disturbances or land uses that damage soil and vegetation to a degree that inhibits or severely delays the re-establishment of forest after abandonment" (ITTO, 2002).[2] Degraded forest lands are characterized by:

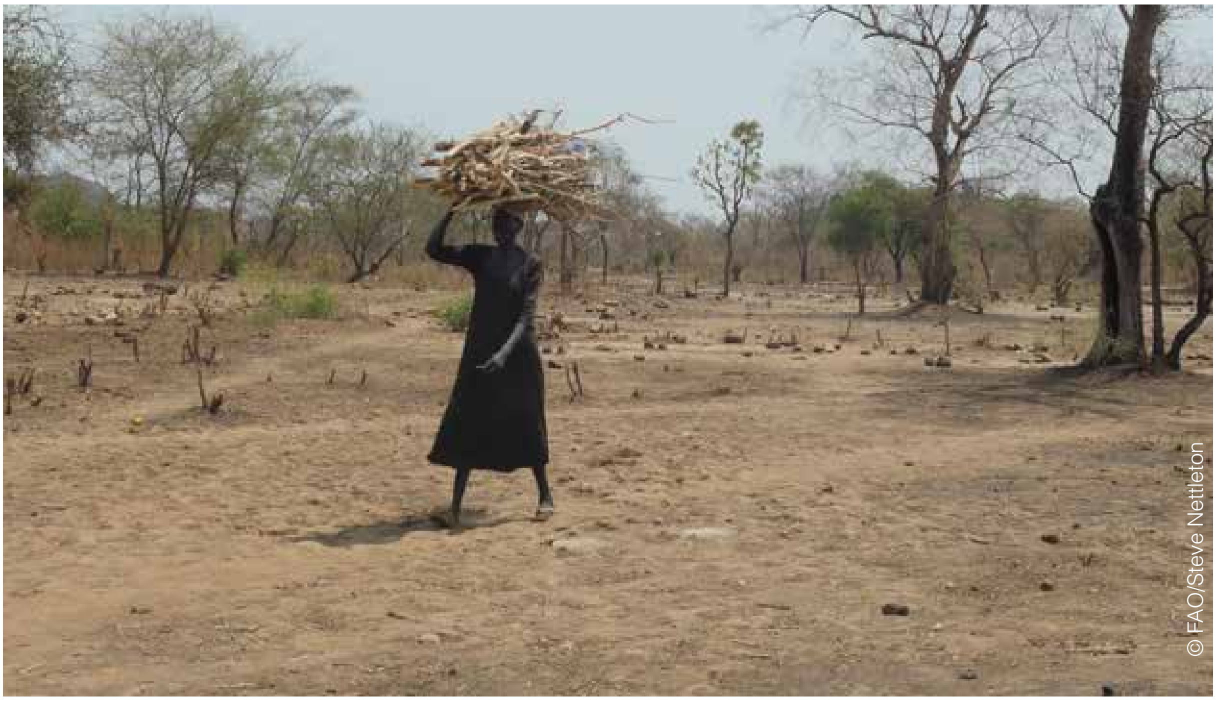
- a lack of forest vegetation (although single or small groups of pioneer trees or shrubs may be present);
- low soil fertility;
- poor soil structure (e.g. soil compaction, waterlogging, salinization and other physical and chemical limitations);
- soil erosion;

2 This section is based on ITTO (2002) and Sabogal (2005).

- recurrent fire and increased susceptibility to fire;
- severe competition, especially from grasses and ferns;
- a lack of suitable microhabitats for seed germination or establishment; and
- very low resilience to extreme weather conditions.

The persistent physical, chemical and biological limitations of degraded forest lands create barriers to natural forest regeneration. An accurate assessment of these factors is crucial for determining the necessary rehabilitation interventions based on the objectives, landscape context and available resources.

The prioritization of degraded forest lands for rehabilitation should take into account the location and condition of the land, the interests of stakeholders, and the availability of resources for the work. The following four strategies for the rehabilitation of degraded forest lands are described below: 1) protective measures; 2) measures to accelerate natural recovery; 3) measures to assist natural regeneration; and 4) tree-planting for rehabilitation and protection.



Degraded woodland near the Tierkidi refugee camp in Gambella region, Ethiopia

1) Protective measures

A strategy of protective measures usually consists of fire protection and erosion control as a means of reversing degradation and re-establishing the ecological functioning of landscapes. In some cases, it may be necessary to undertake preliminary restoration work before applying management interventions to improve soil conditions and hydrological functions at the rehabilitation site.

Fire protection. A good fire-protection programme begins with an assessment of the climate, areas of high value, areas of high fire risk, and priorities for fire protection. It usually has three components:

1. fire prevention to reduce fire risk;
2. pre-suppression work to reduce the fuel hazard; and
3. fire suppression.

Fire prevention requires the involvement of motivated local people. Dialogue with communities is crucial for understanding the reasons for fire ignition and for developing approaches to improve fire management. Discussions with community leaders on traditional fire practices, and ways in which these might be revived, can also be useful.

Fire pre-suppression aims to reduce fuel (e.g. through fuel-reduction techniques), thereby making a site difficult to burn or limiting fire spread (e.g. with fuelbreaks). Fuel-reduction techniques include the following:

- **Intercropping.** Grass is cleared between newly planted trees and replaced with other crops that do not burn easily. Such areas must be intercropped and weeded throughout the year to minimize grass growth.
- **Slashing.** Grasses and bush vegetation are cut and removed. Even if the cut grass is not removed it will be less flammable than standing grass.
- **Pressing.** The grass is pressed low to the ground by trampling or rolling a heavy weight over it. This reduces fire speed and height.

Fuelbreaks are strips of land in which flammable material, particularly grass, has been removed or reduced. Existing human-created firebreaks such as roads and trails and natural firebreaks such as streams, rocky outcrops and gullies should be used wherever possible. The establishment of live fuelbreaks entails the removal of dead plant material and flammable plants along the edges of existing forests and shrublands, the control of grazing animals to prevent them from damaging trees and crops, and the planting of trees at close spacing (e.g. 1 x 1 m) to achieve rapid crown closure and the early suppression of grasses. Species used in live fuelbreaks need to be easy to establish, capable of quickly shading out or outcompeting invaders, and able to survive or resprout if burned. In addition, such species should not drop flammable leaves and should retain succulent green foliage throughout the year. Species commonly used as live fuelbreaks in timber plantations in dry and tropical climates include *Acacia auriculiformis*, *Acacia mangium*, *Calliandra calothyrsus*, *Gmelina arborea*, *Leucaena leucocephala*, *Syzigyum cumini* and *Vitex pubescens*.

Fire suppression or firefighting is dangerous and difficult, even with good training and equipment. A trained community fire brigade should only attempt fire suppression on small, controllable fires, based on standard firefighting procedures. In restoration initiatives, the emphasis of fire protection measures should be on fire prevention and pre-suppression.

Erosion control. Erosion can be controlled economically and effectively through vegetative measures on all but the steepest slopes (where only solid structures will be able to provide the desired protection and stability). The desired characteristics of plants used for erosion control (Weidelt, 1976) include:

- the ability to grow on degraded and eroded sites;
- rapid development for quick protection;
- deep and widespread root systems for good anchorage in subsoils;
- dense and wide-spreading crowns to quickly form closed canopies;
- ease of establishment, preferably by cuttings, stumps or bare-root seedlings;
- the high production of litter or nitrogen to improve soil conditions;
- the ability to withstand physical stresses such as drought, falling rocks and landslides;
- the ability to survive when temporarily submerged and in strong currents (important for species used in streambank rehabilitation); and
- the ability to provide economic returns by producing timber, woodfuel, edible fruits or other useful products.

Because a single species rarely possesses all these qualities, it is usually necessary to plant a mixture of trees, shrubs and grasses with complementary characteristics.

Planting and sowing is the most commonly used method for slope stabilization. Planting is done in groups and clusters and spacing must be closer than in conventional plantations (i.e. those on more stable soils and land with gentler slopes). Often a less-demanding but site-improving nurse tree is planted first, and then more valuable but more demanding species are introduced by under- or interplanting as site conditions improve. In some arid areas, seedlings are planted along contour lines to intercept surface run-off, promote the infiltration of scarce rainwater, and control soil erosion.

Another option for controlling soil erosion is to leave unploughed strips of land 0.5–1 m wide along contours. These re-vegetate rapidly with native grasses and weeds, forming stable hedgerows with natural, front-facing terraces. Check-dams, soil traps or diversion canals may be needed to control water coming from upslope plots. Trees can also be planted on terrace edges to stabilize them and make maximum use of the land. Fruit trees can be planted just below the edges of terraces, where they will benefit from increased moisture. Strips of trees along riparian corridors and planted as windbreaks are also important for erosion control. They can serve as corridors for animal movement and seed dispersal and increase seedling establishment.

2) Measures to accelerate natural recovery

Passive rehabilitation through the natural recovery of degraded areas is a viable strategy, but the nature and extent of recovery will depend on the ecology and disturbance history of the area and the condition of the landscape. The biophysical barriers to recolonization will determine the suitability of different rehabilitation measures. Islands of natural vegetation, however small, are extremely important as sources of seeds, propagules and colonizers. Where such remnants are absent or where quicker recovery is needed, auxiliary vegetation may need to be introduced by planting or seeding. The three main approaches in the context of displacement settings – the use of remnant trees, sowing, and scattered tree-planting – are outlined below.

Use of remnant trees. Some of these trees are relicts of the original forest that were left standing when the area was cleared; others have regenerated naturally or have been planted by farmers. Many agricultural areas retain considerable tree cover, whether as individual isolated trees, live fences, windbreaks or clusters of trees. Isolated or remnant trees are typically retained in pastures and agricultural areas because of their value as sources of timber, fence posts, woodfuel, fruits and organic matter for improving soil fertility; or as shade and forage for cattle; or because cutting them is prohibited by law.

Sowing. This approach bypasses the problem of low seed-dispersal rates by sowing seeds directly onto the soil. In general, sowing gives acceptable results only when the soil is worked (i.e. tilled or scarified) to facilitate root penetration. It is also important that seeds are covered with a soil layer one to two times the thickness of the seed and, if possible, with a light mulch. To ensure establishment during the rainy season, sowing must be carried out at the very beginning of the rains so that the seedlings are strong enough to survive the dry season. Because success depends on so many unforeseen factors, small-scale experiments should be conducted before embarking on larger operations. To maximize the survival of seedlings of desired species, early weeding is essential because the seeds will face competition immediately on germination.

Scattered tree-planting. This approach aims to accelerate succession by increasing the structural complexity that attracts seed- or fruit-dispersing fauna into degraded landscapes from nearby intact forests. One method involves planting small numbers of scattered, single trees or clumps or rows of trees, which form perches for birds. Seedlings are produced from seed-shed below remnant perch trees and the clusters of seedlings eventually grow to form bird perches themselves: the clumps of trees enlarge and the process continues.

A variant of the scattered tree-planting approach is to use more closely spaced plantings of a small number of species, known as “framework species”, which provide resources such as nectar, fruit and perching sites to attract seed-dispersing birds and bats. Framework species need to be fast-growing, form dense canopies to shade out weeds, and have seeds that are easily collected and able to germinate in nurseries. Important groups of framework species include fig trees (*Ficus* spp., Moraceae), legumes (Leguminosae) and oaks and chestnuts (Fagaceae). This method is especially suitable for areas close to intact forests that can act as sources of seeds and wildlife. Maintenance is needed in the early years to ensure that weeds do not dominate the succession.

3) Measures to assist natural regeneration

Assisted natural regeneration (ANR) aims to liberate tree species from competitors, encourage their growth and therefore facilitate their dominance on a site. ANR assists the natural regeneration of forest trees (from wildlings and sprouts) by protecting them from fire, controlling weeds and attracting seed-dispersing wildlife. ANR may also include the planting of additional trees (enrichment planting). On appropriate sites, forest cover can be re-established more quickly and cheaply with ANR than with conventional reforestation.

ANR has four major component activities:

1. **Locating and releasing natural regeneration.** All broadleaf natural regeneration, including that hidden among grasses, is located and released by either pressing down (lodging) the grasses, spot brushing or complete brushing.
2. **Maintenance operations.** Silvicultural treatments, such as ring weeding, soil loosening and fertilization, are done as often as necessary until the trees emerge above the grasses.
3. **Enrichment planting.** Enrichment planting using nursery-grown seedlings (or sowing seeds or transplanting wildlings) is deployed in situations where there are wide gaps between naturally growing seedlings.
4. **Protection.** Areas subject to ANR are protected from fire – by establishing firelines or firebreaks – and other destructive agents (e.g. livestock grazing).

4) Tree-planting for rehabilitation and protection

The establishment of tree plantations, or afforestation or reforestation, is usually the preferred silvicultural strategy for rehabilitating degraded forest lands. Plantations can be highly capital intensive and require long periods of management. Tree plantations for land rehabilitation and protection need to be carefully planned, therefore, including the identification of suitable sites; appropriate soil conservation practices and site preparation methods; adequate sources of seeds and other plant propagules; suitable sites for nurseries; and other important aspects of plantation design, establishment and management.

Technical aspects of land rehabilitation and protection. Land rehabilitation and protection from erosion require fast-growing pioneer species to quickly cover bare soil. The focus should be on the root systems and soil-holding capacity of the trees, which can be enhanced by the judicious choice of species and the application of certain management techniques. The following list sets out some of the considerations (many of which are addressed in more detail later).

- Identify the rehabilitation site.
- Choose the right species – among other factors, species should be fast-growing and adapted to the climate and topography, and have strong root systems.
- Define the size and shape of the plantations, according to factors such as slope and areas to be protected.

- Calculate the number of seedlings needed for the site and divide this by a nursery mortality coefficient to determine how many should be grown in nurseries. Mortality and other issues can reduce the theoretical output of nurseries by a factor of two or more.
- Obtain seeds or cuttings of the selected species.
- Know how to grow the species in nurseries, including seed pretreatment and seedling hardening off.
- Define planting density: it should be high enough to quickly provide cover for the soil but not so high that it prevents trees from developing fully. Density will also depend on the species and might range from about 400 stems per hectare (5 x 5 m) to around 1 100 stems per hectare (3 x 3 m).
- Is thinning planned? If so, the final density should be indicated in the management plan (it can be given as a proportion of the original density).
- Determine the work required to prepare the site and to outplant and tend the seedlings.
- Determine the need for fencing. This will have major cost implications but may be essential for success.
- Specify the water-harvesting techniques to be used and the work involved in these (e.g. do pits need to be dug?).
- Determine whether additional watering will be required.
- Indicate the period over which the plantation should be guarded.
- Provide the theoretical harvesting age or diameter and indicate the potential sustainable harvesting volume and possible rotation period (e.g. beginning in years 3 or 4).

Plantations for woodfuel production

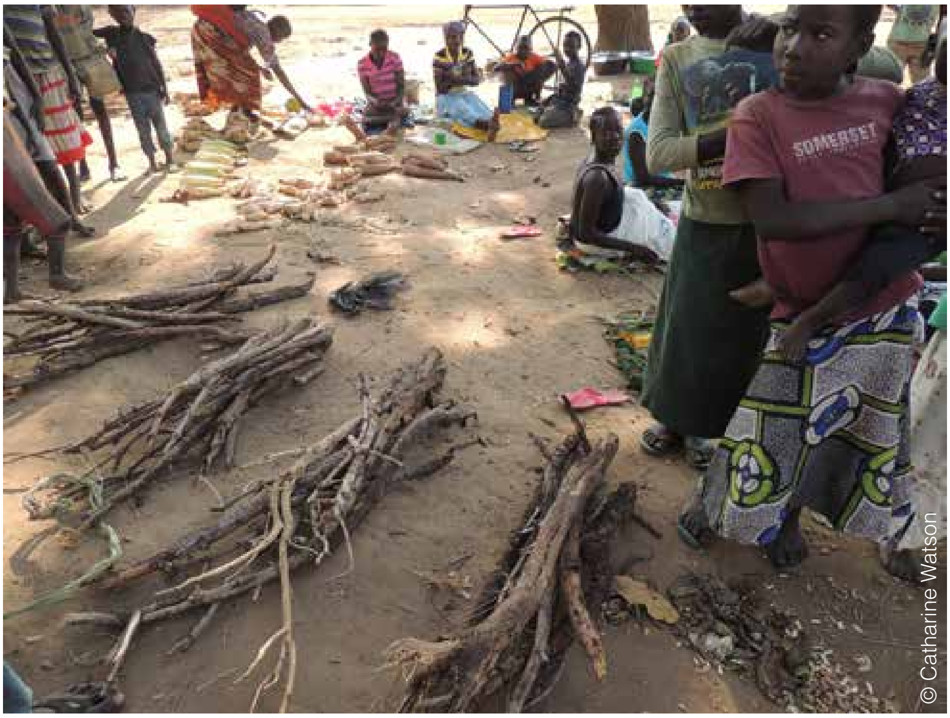
Wood is often the main – or only – source of energy for displaced and host communities. Rapid population growth due to the arrival of displaced communities increases the use of local forest resources. Inevitably, such use is unsustainable and leads to or worsens land degradation and the destruction of an otherwise renewable source of energy.

This problem can be addressed directly through the establishment of plantations of fast-growing species. The regular establishment (and, ultimately, replanting or coppicing) of woodlots can provide an ongoing source of woodfuel, small construction items and fodder. If well managed (e.g. if clearcutting and stump uprooting is avoided), tree plantations can also help prevent or minimize soil erosion.

The need for woodfuel can be urgent in displacement settings to ensure access to energy for cooking while in turn promoting food and nutritional security, and waiting nearly a decade to harvest planted trees may not be an option. In this case, management should focus on the sustainable use of existing forest resources and on maximizing biomass production through plantations of fast-growing species in the first few years to quickly meet woodfuel demand. Producing maximum biomass in the first years of tree growth (as opposed to, say, maximizing the diameter growth of individual trees) can be achieved with a high planting density: short-rotation coppice forest management can provide an ongoing supply of woodfuel for decades (El Bassam, 2010).

Technical aspects of woodfuel production

Decisions on the technical aspects of production are determined largely by the management objectives. A plantation designed to produce woodfuel will likely use different species, spacing and rotation time than a plantation designed to restore wildlife habitat. Climate, local edaphic and topographic conditions, vegetation cover, local demand,



The Bidibidi refugee settlement, Uganda. Refugees have collected fuelwood to sell at the market

infrastructure, the available workforce and its management skills, and, crucially, land ownership and land-use rights will all influence technical decisions.

Planting for energy production. Woodfuel plantations are usually densely planted stands of trees that will be cut young, allowed to coppice and cut again in short rotations. To obtain optimal productivity, forest management planners will need to:

- Gather the local and displaced communities together to discuss the possibility of tree-planting in and around the displacement setting, with a focus on the long-term needs and preferences of the local people. The displaced community must also be motivated to plant and manage the plantation, however. Their needs should be taken into consideration, and the management plan must specify their rights with respect to harvesting.
- Choose the right species – among other requirements, the species should be fast-growing and adapted to the climate, and have the ability to coppice.
- Find suitable sources of seeds or cuttings for the selected species.
- Know how to grow the species in nurseries, including seed pretreatment and hardening off.
- Determine planting density, which will depend primarily on water availability (the greater the availability, the higher the density can be). Densities can range from as high as 10 000 stems per hectare (1 x 1 m) when water is not limited to, say, 1 100 stems per hectare (3 x 3 m) in drier areas where soil conservation is also an objective (Siyag, 2014). Useful information to obtain in determining planting density is the density of nearby natural or successful planted stands.
- Define the shape of the plantation in light of fencing requirements (if any), slope and other factors.
- Calculate the number of seedlings needed for the site and divide this by a nursery mortality coefficient to determine how many should be grown in nurseries.
- Determine the work required to prepare the site and to outplant and tend the seedlings.

- Determine the need for fencing. This will have major cost implications but may be essential for success.
- Specify the water-harvesting techniques to be used and the work involved in these.
- Determine whether additional watering will be required.
- Indicate the period over which the plantation should be guarded.
- Indicate the quantity of trees to be harvested at a given time (e.g. one-quarter of all stems) and the technique to be used (e.g. coppicing height and the number of suckers to be left).
- Determine the interval between harvests.
- Provide the theoretical harvesting age or diameter and indicate the time of year at which harvesting should be carried out (this can be important for the success of coppicing and pollarding).

Plantations for timber production

Building materials such as poles, posts and sawn timber are often required in displacement settings, and both humanitarian agencies and displaced people usually harvest what they need from surrounding forests. Building materials are needed both in the immediate response when the camp is established and later for fencing, to improve and maintain structures, and to meet other institutional and commercial needs. Although the demand for timber is usually moderate compared with the demand for woodfuel, it might place additional pressure on the environment.

Technical aspects of timber production

Planting for timber production is a way of creating income opportunities and reducing the environmental impact of displacement settings. It can be done on the outskirts of a camp as regular plantations, but also within the camp. To obtain optimal productivity, forest management planners will need to:

- Gather the local and displaced communities together to discuss the possibility of tree-planting in and around the displacement setting, with a focus on the long-term needs and preferences of the local people. The displaced community must also be

The Bidibidi refugee settlement, Uganda. Locally harvested wood is commonly used to build shelters and other household structures in displacement settings

motivated to plant and manage the plantation, however. Their needs should be taken in consideration, and the management plan must specify their rights with respect to harvesting.

- Choose the right species.
- Find suitable source seeds or cuttings for the selected species.
- Know how to grow the species in nurseries, including pretreatment and hardening off.
- Determine how trees should be planted (e.g. in line or in groups).
- Calculate the number of seeds or seedlings required and divide this by a nursery mortality coefficient to determine the number to be grown in nurseries (if seedlings are to be planted).
- Determine the work required to prepare the site and to outplant and tend the seedlings.
- Determine whether protection is needed and indicate the period over which the plantation should be guarded. Individual protection is possible inside the camps because people are available to do this on a daily basis.
- Specify the type of pits to be dug and the harvesting techniques to be used.
- Calculate the theoretical harvesting age or diameter and indicate the sustainable harvesting level and rotation length.

Plantations for food and fodder production

Trees can be grown for their fruit or foliage (which can be used as fodder for cattle), and they can be interplanted with crops and used for different purposes. An interesting example of an agroforestry approach is the *taungya* system used in Côte d'Ivoire, where displaced people were given access to agricultural land and the responsibility of protecting and caring

Forests and trees contribute to food security through contributions to diet and nutrition in displacement settings

for the trees. In the local *taungya* system, the tree root systems and the shade cast by tree canopies restrict the productivity of crops growing underneath within two to four years; at that point, new plots are opened up nearby while the trees continue to grow on the original plot, providing a range of goods and ecosystem services. This technique is possible where the host country allows displaced people to cultivate land and confers on them the right to harvest trees.

Technical aspects of food and fodder production

Planting for food and fodder production can take advantage of small patches of land to produce small quantities of woodfuel, fodder and fruit. Trees are usually not grown to large dimensions to avoid excessive competition with crops, and coppicing can be used as a regeneration method. To obtain optimal productivity, forest management planners will need to:

- Bring together local farmers and displaced communities to discuss the possibility of tree-planting on farmland and determine the needs of each for products and ecosystem services such as fodder, woodfuel, fruit, shade and windbreaks as part of the process of choosing the most appropriate species.
- Obtain seeds or cuttings of the selected species.
- Decide whether the plantation will be established by direct sowing or by planting seedlings.
- Consider the use of grafting for the propagation of fruit trees in the nursery, with the aim of reducing the time before first fruiting.
- Know how to grow the species in nurseries (if seedlings are required), including seed pretreatment and seedling hardening off.
- Indicate tree arrangements (e.g. rows or groups).
- Calculate the number of seedlings or seeds required and divide this by a nursery mortality coefficient to determine the number to be grown in nurseries (if seedlings are to be planted).
- Determine the work required to prepare the site and to outplant and tend the seedlings.
- Determine the need for protection (e.g. with fencing) and the period over which the plantation should be guarded.
- Specify the harvesting techniques to be used and the work involved.
- Determine whether watering will be required.
- Is fodder harvest possible? If so, indicate the beneficiaries and the allowable harvest.
- For planting inside camps, seedlings can be distributed directly to the displaced community.

2.2 Preparing for forestry interventions

This section presents some of the issues to take into consideration when designing forestry interventions in displacement settings. It should be viewed as a reference list for generating more in-depth questions. Annex 1 provides a more detailed checklist of the main aspects to bear in mind in the planning phase of forest management in displacement settings.

Level of intervention

The scale of the intervention has a bearing on important characteristics such as materials and human resources, production goals, and authorizations. An assessment of the intervention's strengths and weaknesses will help in producing a realistic management plan that includes the views and expectations of all stakeholders. It may be wise to start small and grow bigger as interest and skills increase.

The first thing to determine is the number of people the intervention will benefit, from which the plantation area can be calculated and other needs for plantation establishment and management derived. Questions to bear in mind include the following:

- Should everyone in the displaced (and possibly host) community be targeted, or should certain people or groups be prioritized?
- What is the demand for woodfuel and other forest products in the targeted community?
- What area of plantation is required to meet this demand? (e.g. 10, 100 or 1 000 hectares? More?)
- Should the plantation be managed as a single large project or as several small, localized projects?
- What size should the nurseries be? Is it preferable to establish several small ones (e.g. an annual output of 5 000–10 000 seedlings), each of which would be relatively simple to manage, or one large centralized nursery (e.g. with an annual output of more than 100 000 seedlings)?
- What funding is required for the project?
- What needs to be done to obtain the necessary land-use authorizations? Can they be obtained from local leaders or the local administration only, or must they also be obtained at the state or national level?

Identification of suitable sites

Before choosing specific sites and types of plantations, it is important to know what is possible, given local climatic and environmental conditions. Site selection is a complex task requiring a socio-economic analysis; an understanding of issues relating to land tenure and land use; and a technical analysis (e.g. to understand soil and water dynamics, soil properties, water availability and logistics). The qualities of each site, and issues associated with it, should be recorded systematically to assist in planning the forest management intervention. Even though large patches would be more efficient to reforest, smaller areas may be easier to manage in terms of balancing customary rules and other uses. Consider other options, such as planting in the middle of fields, among crops, and along roads and rivers (although this might be more costly) (Siyag, 2014). The involvement of local government and leaders is essential.

Creating a map of the area will help in locating, managing and monitoring plantation, rehabilitation and protection sites taking into account: environmental conditions; site extent; distance from beneficiaries; land-use authorization; fire hazard and current land use/land cover. Depending on the objective, the map can serve various purposes. For example, sites requiring erosion protection and environmental rehabilitation can be ranked according to the severity of the problem and the feasibility of the project. Identify the most urgent needs on the map, calculate the area involved and estimate the work required (e.g. number of worker months), including the preparation phase (e.g. for nursery establishment). For woodfuel plantations, sites should be ranked according to, for example, their fertility, water availability, distance from the displaced community, available area and existing land cover. Start with the most suitable sites to increase the chances of success and to gather experience before tackling more challenging sites. Questions to bear in mind include the following:

- Is land available near the displaced community? Can large or small, but frequently vacant, areas of land be identified according to specific land use/land cover?
- Why is such land unused?
- Is there competition for land from other land uses (e.g. grazing)? Identify whether

common pastures are available and determine whether the displaced and host communities are seeking land to cultivate.

- Are the areas in and around the displacement setting forested? If so, it is important to raise awareness about the need to manage existing natural resources.
- What is the forest cover? How was it before establishment of the displaced community? Is there bare/degraded land?
- What is the topography of the surroundings? Topography affects the hydrological regime, and specific soil preparation measures may be needed.
- If the terrain is hilly, how does this affect the logistics of the forestry intervention? The selection of sites must take into account the fact that most people involved in the intervention will either walk to the sites or use animal-based transport.
- How accessible is the site? Are there any natural or artificial barriers? Rivers, cliffs, thorny vegetation and other features that could make movement difficult should be mapped and taken into account in site selection.
- Is suitable soil available for potting seedlings? Nurseries require potting media with certain characteristics. The availability of suitable soils should be taken into account in deciding on nursery sites.

Tenure and access rights

A proper management plan must include how and when wood and other forest products should be harvested. Just as importantly, it should also set out who owns the right to harvest.

This issue must be addressed at an early stage because it has a significant bearing on the success of forest management and the support it gains from the displaced and host communities. Project design should take into account laws and regulations affecting the extent to which a displaced community may use and harvest woodlots. The management plan should provide clarity on the ownership of new plantations, including the land, trees and other assets, and who will benefit from the harvest of wood and non-wood products.

An issue relating to the right to harvest is the need to protect certain individual trees or species for conservation purposes. Marking such trees and explaining the benefits of their conservation to both the displaced and host communities will help in restoring degraded forests and woodlands.

Rules and rights need to be communicated (e.g. through community leaders and by posters and other communication products) and enforced. Local authorities, community leaders and dedicated guards should be encouraged to inform people of their rights and responsibilities regarding both planted and natural forests in displacement settings.

Safety concerns associated with accessing forest and woodland sites – especially for women and children – should be taken into account. Questions to bear in mind include the following:

- Are displaced people permitted to leave the settlement area? If not, consider whether to advocate for this to enable the forestry intervention to go ahead.
- Do the displaced and host communities have rights to harvest and commercialize forest products? Check whether the host and displaced communities have the same rights under local laws and whether it depends on the types of product or the locality.
- What customary and self-assumed rights are in place?
- Is group harvesting or the establishment of collection points feasible as a way of increasing individual security, especially for women and children?

3 Preliminary steps in plantation establishment

The purpose of a plantation – for example the intended end use of the wood, or the plantation's environmental role – is the overriding consideration in determining its size. Political influences and social responsibilities are other factors that can influence the scale of plantation development. Although the rate of plantation development is closely related to its scale, it is useful to distinguish this time element because frequently there is a gap between the intended intervention size and what is actually achieved in the designated development period. Problems that can reduce the rate of development include those associated with finance, infrastructure, land availability (e.g. the slow acquisition of the right to plant trees), bureaucracy, labour and equipment (Evans, 1992). Addressing aspects such as local motivation, awareness, governance, rights and land tenure is crucial for the success of any sustainable forest management project, including in displacement settings, and no technical decisions should be taken without doing so.

UNHCR and IUCN (2005) provide a comprehensive guide on forest management in displacement settings, covering issues such as awareness-raising, the determination of needs, land tenure, and freedom of movement.

3.1 Site selection

The dramatic increase in population density associated with the establishment of a displaced community inevitably drastically increases pressure on nearby natural resources. Space can be an issue inside compounds, and the available area nearby is usually insufficient to meet the suddenly increased demand for wood for construction and fuel.

Factors affecting site selection for forest plantations include the terrain; the availability of forested and unoccupied land; water availability; and the rights of the various stakeholders. Such factors should be assessed before a commitment is made to proceed with an intervention.

Mapping the surroundings of the displaced community's compound and identifying potential zones for reforestation or afforestation are necessary but insufficient steps. Land should be assessed for both its physical attributes (e.g. distance from the community, size, terrain and hydrology) as well as in political, legal and social terms. The land-tenure regime and resource rights affect not only the feasibility of a plantation but also the motivations of beneficiaries in tending it.

Ideally, plantations will be established near the displaced community's compound to ensure ready access by those responsible for its management, but most nearby land is likely to be in agricultural use already. One approach is to plant trees on such land with objectives compatible with agriculture, such as providing shade, wind protection and fodder. For example, woodfuel plantations can also be used as shelterbelts.

3.2 Stakeholder involvement

Before planning a tree plantation, local and national services should be mobilized to obtain a clear understanding of the main challenges and opportunities ahead. Stakeholder engagement must be comprehensive and gender-sensitive, for example in determining the species to be planted. In one participatory forestry intervention, for example, it was noted that men preferred slow-growing species because this would produce higher-value wood, but women preferred short-rotation species because of their roles as caregivers and the capacity of such species to help meet needs for food, shelter, water and safety (FAO, 2011). It is essential that women are involved in the decision-making process for plantation establishment and management, in order to ensure that tasks typically performed by women (e.g. watering seedlings) are compatible with their other daily duties.

Gender roles may be subject to change, for example because of a change in the composition of the displaced community (families may become separated). This can cause tension between women and men when establishing routines in displacement settings. Often, women must assume roles previously performed by men, in addition to their existing tasks. On the other hand, men may be unable to earn money to sustain their families and may be frustrated because they are unable to protect their families from harm and conflict. Such factors must be taken into account when planning forest plantations in a displaced community to avoid exacerbating conflict between genders.

Who works, who benefits

Knowing who will benefit from the intervention is crucial to its success. The who, where, when and how of harvesting wood and other forest products should all be established early in the planning process.

Depending on national and local laws, it may not be possible to provide workers with access to the resource that they helped to create. It is important to address this in discussions with local authorities. Other aspects to take into consideration in identifying who works on and benefits from an intervention are:

- the sociocultural habits of the displaced and host communities;
- the reasons for displacement (e.g. conflict or natural disaster);
- potential sources of conflict and tensions between the displaced and host communities;
- the rights of the displaced people to access and use land in and around the displacement compound;
- the availability of local labour for each phase of implementation; and
- gender.

3.3 Choosing the right species

Selecting the right species for planting is crucial for a successful plantation. The effort to supply seeds and other materials, bring stakeholders together, raise awareness and build nurseries would be wasted if the trees are planted where they cannot grow. A given species might grow well in one location and fail completely a few hundred metres away because of a change in soils, terrain or hydrology. Light is also an important factor in choosing species for reforestation. For example, bare land should be reforested with pioneer species because they are adapted to open conditions, whereas secondary species would not perform as well on such sites because they are unable to take advantage of direct sunlight in the way that pioneer species do. It is important, therefore, to know the needs of a given species before deciding to plant it. Some species might look perfect for a given purpose; if they do not grow well on the site, however, it would be better to use an alternative that might have fewer desirable traits but which will grow well. Species that can serve multiple purposes might be especially important in displacement settings, helping to meet urgent needs, for example for housing, household items, woodfuel, fencing materials, non-wood forest products such as fodder and traditional medicines, and ecosystem services such as shade. Forests can provide foods that help to diversify diet, thereby improving nutrition.

Special attention should be paid to the choice of species when establishing intensive productive plantations to minimize competition with agriculture for water.

Understanding growing conditions

Basic tree biology

Selecting a species for reforestation requires an understanding of the basic biology of the species and knowledge of the climatic, edaphic and hydrological characteristics of the site. In displacement settings, the need to meet immediate humanitarian requirements tends to override an “ideal” approach to species selection. Nevertheless, it is essential to consider the limitations of local conditions – such as shallow or heavy soils, low rainfall or extreme heat – and to choose species best suited to those conditions because this will be a major determinant of the intervention’s success.

Climatic conditions

The primary climatic limitation is annual rainfall and its distribution throughout the year. The following questions should be addressed:

- What is the average annual rainfall?
- How long is the dry season?
- How severe are the droughts?
- Is the timing of the wet and dry seasons regular?
- Are floods frequent? If so, how long do they last?

Evaporation and transpiration are linked to annual and seasonal mean temperatures, making these parameters important in the choice of species. The following questions should be addressed:

- What is the annual mean temperature?
- What is the mean temperature during the dry period?

Taken together, rainfall and temperature determine the potential moisture conditions – or aridity – of the local climate.

These parameters will narrow the choice of species somewhat but are not sufficiently precise on their own and need to be combined with edaphic and other site-specific conditions.

Growing trees in dry conditions is challenging, and efforts to do so should only be made after full consideration of the difficulties and with knowledge of adaptive solutions. Much money has been wasted in the past by planting on sites where there is no source of water in the first year of the plantation’s life (USAID, 1989).

Edaphic conditions

Edaphic conditions determine how much moisture can be stored in the soil and how deep roots can penetrate. Fertility and chemical incompatibilities can usually be estimated from soil information. The following questions should be addressed:

- How deep are the soils in the area?
- How rich in nutrients and organic matter are the soils?

- Are the soils eroded or otherwise degraded?
- Are the soils heavy or light? Are they stony?

Local and site-specific scales

Site-specific criteria include topography; exposure to sun and wind; the nature and depth of the soil; the presence of water bodies or streams; acidic, alkaline or saline conditions; and vegetation or forest cover. Some trees will grow in the open, and others may require shade or protection from desiccating winds; some may survive long droughts only if they have access to very deep moisture; and some may be unable to grow in waterlogged soils.

The tree species already present at a site will help in assessing conditions; such species, if they meet the requirements of the management plan, should be assisted to grow and increase in number. Questions to be addressed include the following (Gautier *et al.*, 2002):

- What is the nature of vegetation cover and tree cover (or is it a bare site)?
- Are there steep slopes, and are they eroded?
- Is the site flat or basin-shaped, and is it prone to waterlogging?
- Has the site been deforested recently?
- Is soil salinity a problem?
- Are there streams or ponds, and are they perennial or seasonal?
- How deep is the water table?

A rule of thumb is to think like nature: for example, in bare, open conditions, favour pioneer species; on slopes, use species with strong root systems and vigorous suckers; and, if soils are saline, use salt-tolerant species, even if these do not grow as quickly as other species in normal conditions.

Predator pressure

In areas where there is little fodder for wild and domestic animals, grazing pressure can be so intense that even protection measures such as fencing may not prevent animals from feeding on young trees (Siyag, 2014). This is most likely in semi-arid and arid conditions, and identifying the grazing risk in advance could help to save a plantation from destruction. Where the risk is high, favour tree species that have low palatability as fodder. The host and displaced communities may know such species – one of many reasons why their participation in the process of species selection is crucial.

Choosing species for different purposes

If local species have all the required attributes for the chosen purpose in the given climatic and edaphic conditions, and if seeds are easily obtainable, they should be favoured over non-native ("exotic") species. It is important to ensure, however, that the local conditions – most importantly, the site's edaphic regime – are similar to those in which the species is known to have performed well. Exotic species may be a good choice for the rapid production of wood in suitable conditions, but avoid those that could become invasive and thereby create future problems.

The involvement of the host and displaced communities is key to the long-term success of forest plantations. It is necessary, for example, to take into account their preferences in species selection, with a focus on cultural keystone species. In many communities, certain tree species have significantly shaped cultural identity, as reflected in the fundamental roles those species play in diet, materials, medicines and spiritual practices (FAO, 2015), and their ongoing presence could be crucial for the well-being of both the host and displaced communities.

The practice of involving end users in both the host and displaced communities in the selection of multipurpose trees to be planted – already encouraged by UNHCR in reforestation programmes (UNHCR and IUCN, 2005) – could help to alleviate tensions, particularly if benefits in addition to fuelwood can be obtained (e.g. in the provision of food, fodder and shelter) and if reforestation helps to meet both subsistence and income needs.

Allowing space for the involvement of the host and displaced communities in species selection can also generate ideas for low-input and economically efficient management. Traditional knowledge on the natural environment and sustainable land management has been developed over generations in response to changing conditions and new opportunities. It can play a crucial role in ensuring food security and the sustainability of a plantation and provide important local insights into forest restoration and regeneration, biodiversity conservation, and sustainable resource management. Ease of management is an important factor to keep in mind in choosing species for a plantation.

Questions to be addressed in selecting local species include the following:

- Is the species still growing locally?
- If yes, can the seeds be harvested easily?
- Do the seeds need significant pretreatment?
- Do seeds generally have good germination rates?
- What is the growth rate of seedlings and mature trees?
- What are the water needs of seedlings and mature trees?
- Is the species suitable for coppicing?
- Which species do the displaced and host communities prefer for various uses?

Tree species for woodfuel plantations

If the objective is to quickly produce wood for energy with minimal investment and equipment, the selected species should:

- be pioneer species;
- be competitive and able to grow in dense stands;
- be fast-growing;
- have the ability to coppice; and
- produce good-quality woodfuel.

Table 1 provides examples of species that are suitable for use in woodfuel plantations (provided they suit local conditions). Some of the characteristics of the species that make them suitable for woodfuel plantations are listed.

Table 1. Examples of woodfuel plantation species in dry and tropical climates

Species	Characteristics
Acacia nilotica	• Fast-growing, but subspecies have differing requirements for soils: - Subspecies *nilotica* performs well on heavy, poorly drained soils (often waterlogged) - Subspecies *tomentosa* performs well on heavy soils with regular inundation - Subspecies *adstringens* performs well on sandy soils • Pioneer species – seedlings require full sun • Coppices well (except subspecies *nilotica*) and reproduces through suckers • Seed pretreatment involves boiling seeds for 45 minutes
Albizia lebbeck	• Fast-growing on well-drained soils but does not tolerate heavy clay • Can be pollarded and coppices well • Can be sown without pretreatment • Seedlings are drought-tolerant and require little weeding
Calliandra calothyrsus	• Very fast-growing in moist conditions • An aggressive colonizer with potential for erosion control • Coppices very well for up to 20 years • Recommended density is 1 x 2 m (5 000 stems/ha) • Good fodder
Dalbergia sissoo	• Fast-growing in relatively humid and well-drained soils, such as riverbanks • Pioneer species – will colonize through suckers • Coppices well for up to 20 years or 2–3 rotations • Block plantations in densities from 1.8 x 1.8 m to 4 x 4 m are possible
Faidherbia albida	• Needs deep soil for optimal growth rates but can also grow on laterites and stony and heavy clay soils • Grows well in drought conditions if it can reach the water table; can tolerate flooding • Seed pretreatment involves boiling then cooling for 24 hours, or scarification • Coppices well
Leuceana species	• Very fast-growing in moist conditions • Low yields on acidic soils • Coppices well • Seedlings produced in 8–12 weeks • Can be planted very densely (over 10 000 stems/ha)

Source: Compiled from various sources.

Tree and shrub species for land rehabilitation and protection

The following characteristics are desirable in species planted with the objective of retaining soils, restoring organic matter and protecting crops and other plants from wind:

- ability to grow on degraded land;
- strong root system to enable growth in unstable soils and improve soil structure;
- ability to grow in polluted or salinized soils; and
- ability to shoot from suckers.

Table 2 provides examples of species with some or all of these characteristics.

Table 2. Examples of species useful for land rehabilitation and protection

Species	Characteristics
Acacia auriculiformis	• Adapted to most soil conditions • Fast-growing when rainfall is above 800 mm per year • Planted for erosion control • Plantation density of 3 x 3 m or 4 x 4 m • Will coppice if cut at 50 cm above ground but will not coppice if cut at ground level
Dichrostachys cinerea	• Small tree with fast initial growth in average annual rainfall of 200–900 mm • Strong capacity for natural regeneration • Native to eastern and southern Africa and can be a weed elsewhere • Wood is termite-resistant • Planted at 3 x 5 m density for erosion control • Should not be disturbed for the first few years so it can spread through suckers • Can become hard to eradicate
Vetiver spp.	• Shrub species with very strong root system • High tolerance to pollution (Julliard *et al.*, 2001) • Will grow on wide range of soils • Aerial parts retain water and soils when species are planted in lines

Source: Compiled from various sources.

3.4 Timing

Reforestation operations, such as raising seedlings in nurseries and outplanting and tending them, are highly seasonal and should be planned well in advance using precise dates. For this purpose, managers should establish yearly and monthly schedules.

Time needed for different operations

Forest operations will be done more quickly and with less waste when they are better organized. Being aware of the time needed for each operation – e.g. planning, seedling production, site preparation, and outplanting – will ensure proper scheduling. Table 3 provides an indication of the time required for these and other forest activities for a medium-sized to large plantation, from which it should be possible to estimate the number of workers needed for efficient and timely operations. Scheduling should take into account local seasonal aspects.

Table 3. Example of a work schedule

Time relative to planting event	Action
12 months before	Survey project site; clarify legal and tenure issues; demarcate boundaries; engage stakeholders and establish consensus; produce topographic land-use/land-cover map, including designating forest functions; assess road accessibility and natural regeneration; draft preliminary project plan
9 months before	Start nursery establishment; start controlled seed collection and seedling production in nurseries
6 months before	Assess the number, quality and species of seedlings available in nurseries
2 months before	Begin hardening off in the nursery
4–6 weeks before	Demarcate planting plots in the field; mark natural regeneration; prepare planting lines; slash weeds on planting lines to ground level
1 week before	Brief stakeholders and planting teams
1–2 days before	Water seedlings and transport them to the planting site, along with planting equipment and material
Planting campaign (early in rainy season): plant at the specified spacing; plant height should be 25–50 cm	
1–2 weeks after	Check quality of planting; adjust poorly planted seedlings
3–6 months after	Survey growth and survival of planted trees; undertake weeding and apply fertilizer; repeat as appropriate
Start of dry season	Cut firebreaks; build fire watchtowers; organize fire patrols
End of dry season	Survey growth and survival of planted trees and assess need for replanting
6–12 months after	Replant failed areas (if required)
Subsequent years	Control weeds and climbers along planting lines

Source: Adapted from FAO (2017b).

Planning

Planning includes seeking authorizations, surveying needs and habits, selecting sites, mapping, and preparing the management plan and schedules. This process requires months, even though some of these activities can be conducted simultaneously. The time needed will depend on local conditions – political and physical – and the availability of skilled workers.[3]

Nursery

Activity	Approximate duration
Digging a nursery bed 10 x 1 x 0.30 m in size, including excavating and removing soil	1–2 beds per person per day, depending on soil hardness
Arranging, erecting and fixing shade over beds for 100 m^2 (10 beds of 10 m^2)	9–12 person-days, depending on the height of the poles holding the shade material
Filling polypots, including mixing and cleaning potting soil	300–1 000 polypots per person per day, depending on the size of the containers
Sowing seeds directly in the polypots	500–2 500 polypots per person per day, depending on the pretreatment needed (pre-soaking reduces sowing productivity to 2 000 per person per day and breaking down coats to 500 seeds per person per day)
Watering seedlings	Ranging from 200 m^2 per person per day (watering can) to 5 000 m^2 (flood irrigation) per person per day
Shifting containers from one bed to another, including root pruning	5–6 m^2 of nursery bed per person per day. This operation is labour intensive and may require additional personnel
Loading and unloading seedlings in containers	1 500–5 000 seedlings per person per day, depending on the size of the containers, the height of the truck or cart, and how closely the vehicle can approach the nursery beds

Site preparation

Soil hardness is a major determining factor in any digging operation, with the estimated times given here potentially multiplied up to tenfold.

Activity	Approximate duration
Digging pits 35 x 35 x 35 cm in size	30–70 pits per person per day, depending on soil hardness
Forming microcatchments (i.e. microbasins or "saucers" around each seedling)	60–100 microcatchments per person per day, depending on soil hardness
Weeding in and around saucers (1 m diameter)	100–180 saucers around plants per person per day, depending on soil hardness

3 Most of the information in the subheadings "Planning", "Nursery", "Site preparation", "Outplanting", "Protection" and "Care" is based on Siyag (2014).

Outplanting

Activity	Approximate duration
Transportation of seedlings by foot on site, including unloading	100–1 500 seedlings per person per day for a distance of 100 m. Divide productivity by two for a distance of 500 m
Outplanting seedlings contained in polypots, with refilling of pits and local transportation up to 250 m	40–200 seedlings per person per day. Divide productivity by two for hilly or rugged terrain
Watering of plants using jugs with a capacity of 12 litres each over a travel distance of 250 m or less from water tank or other source	500–600 plants per person per day, depending on topography and planting density
Transportation of water to planting site using small tanks on carts or other vehicles	5–6 m^3 of water per person-day per km

Protection

Activity	Approximate duration
Erecting a fence made from thorny shrubs locally available	20 m of fence per person per day
Digging a ditch and bund	1–3 m per person per day, depending on depth, height and width, and soil hardness

Care

Activity	Approximate duration
Weeding in and around saucers (1 m diameter)	100–180 saucers around plants per person per day, depending on soil hardness
Hoeing in and around saucers	80–160 saucers per person per day, depending on soil hardness

Regularity of operations

Some operations, such as hoeing around young trees, must be done regularly and continuously for a simple reason: the death of seedlings because of a lack of watering in (say) year 4 would waste all the work done previously. Such regularity will only be achieved through strict planning and by ensuring the schedule is followed.

Planning needs

Teams and people move and change. Good planning, therefore, requires documentation in two forms: a written plan made by a forester, which sets approximate times for the various operations to be undertaken over a given period (e.g. the next 5–10 years); and a schedule that sets out the actual dates of, and requirements for, each operation in the coming 12 months. A forester usually creates such a schedule at the beginning of each year, based on the five- to ten-year forest management plan.

4 Establishing tree plantations

4.1 Setting up a tree nursery

Setting up a tree nursery requires space, water, people, materials, tools and a certain amount of infrastructure. Methods for producing seedlings can vary depending on, for example, climatic conditions, the availability of water and equipment, and the technical skills of workers. There is no "perfect" method, and planners are encouraged to be creative. The following guidance describes proven techniques, crucial aspects of seedling production, and how to improve seedling survival and health. More information on tree nursery techniques is available in Department of Forestry and Wildlife (2003), Siyag (2014) and Stott and Gill (2014).

This section addresses the following questions:

- Where should a nursery be set up?
- How many seedlings should be produced and therefore how big should the nursery be?
- Who will run the nursery, how should it be organized, and what training is needed?

A tree nursery in the Mtendeli refugee camp, United Republic of Tanzania

Basic considerations

Roads and access

A tree nursery needs to be easily accessible to its workers. In a displacement setting it should be located within the compound of the displaced community.

The nursery should have road access so that materials can be delivered and to make it easier to transport seedlings to planting sites. A truck or cart would make this delicate operation quicker and thereby increase the survival rate of seedlings.

Ideally, therefore, nurseries should be located near the edge of a compound, but other characteristics, such as soils, water access and land availability must also be taken in consideration in selecting a suitable site.

Physical characteristics of the nursery site

Seedlings are fragile and should be protected from the elements – such as wind, harsh sun and excess water – as much as possible during nursery growth. In deciding on a nursery site, avoid areas prone to flooding because flood events can ruin months of work in a few hours; also avoid waterlogged areas and favour well-drained sites. Steep slopes are prone to erosion and water run-off and should also be avoided. Therefore, nurseries are ideally located mid-slope on well-drained land that slopes gently to allow gravity to transport water without a significant risk of erosion.

Winds have a desiccating effect and it is important, therefore, to provide seedlings with windbreaks. Natural elements such as shrubs or trees can be used, reducing the need for built windbreaks, and this aspect should be taken into consideration when choosing the nursery site.

A nursery should ideally face east so it is exposed to a warming sun in the morning and does not receive the harsher sun in the mid-to-late afternoon. In hot climates, avoid sun-facing exposures (i.e. to the south in the northern hemisphere and to the north in the southern hemisphere).

Space

Seedlings can be densely grown: using polypots (see below), approximately 100 seedlings can be grown per m^2. Theoretically, therefore, a production capacity of 10 000 saplings requires 100 m^2 of beds, to which must be added, for example, paths, water storage, a work area, a composting area, soil storage and a shed for tools and materials. Bearing in mind the cost of fencing, a total area of 500–800 m^2 (e.g. 20 x 25 m or 20 x 40 m) would be a good starting point for a site (assuming the aim is to produce 10 000 seedlings per year).

It is better to start small and gain experience in running a nursery before thinking bigger. The potential to expand the nursery should be kept in mind when choosing a site.

Water

Seedlings require regular watering, and the availability of water on site is therefore crucial. Nurseries should be located where water is most easily available in the compound, ideally near a well or borehole, pond, small stream or river (but bear in mind the risk of flooding). Alternatively, the site should be adjacent to a road so water can be delivered – but water delivery is expensive and should be avoided if possible.

The water source should be reliable, so ensure it will be available in the dry season when plants will need it most.

Water quality needs to be assessed regularly to ensure the young trees will not be killed or otherwise affected by saline or polluted water. Water salinity is a common problem in arid and semi-arid conditions; if only saline water is available in the nursery, choose species with high salt tolerance.

Fencing

Young trees make a tempting meal for grazing animals, which could ruin many months of work in a few minutes. A nursery needs fencing, the height of which may be in the range of 0.7 –2 m depending on the type of grazing animals in the area and locally available materials. The presence of jumping or climbing animals (such as nilgai and goats) makes the installation of effective fencing more difficult. Local people should be asked about the prevalence of wild grazing animals before nursery establishment.

Fence posts can be made from any material as long as they are sufficiently sturdy to bear the fence. A wooden stick 10 cm or more in diameter makes a good post, and its total length should be 1.25 times the required height so it can be buried in the ground. For example, a fence 1.3 m high would require posts 1.65 m long (i.e. 1.3 m × 1.25).

The fence can be made from wire, but this is likely to be costly and offers no protection from the wind, which can be crucial in hot climates. Scrap wood, branches or bamboo attached securely to the posts will work if the fence is well built and maintained.

Spacing between posts depends on the kind of fence chosen: it could range from, say, 1.5 m if scrap wood is used, to 3 m for long branches or wire. The total number of posts required will vary, therefore, and should be calculated before starting construction. Erecting a fence around a square plot with sides 30 m in length (i.e. an area of approximately 900 m^2 and a perimeter of 120 m) would require about 40 posts for wire or long branches (i.e. 120 m ÷ 3) and 80 posts for short scrap wood (i.e. 120 m ÷ 1.5).

Nursery equipment

Even though it is possible to raise seedlings with very simple means, doing it on a large scale requires equipment to control conditions such as water and direct sun and to make the work efficient and comfortable.

The basic tools for setting up nursery beds, preparing soils and weeding are shovels, rods, hoes, rakes and mallets. It may be possible to borrow such tools from other activities, but ideally they will always be on site.

The descriptions of equipment needed for nursery operations provided below can be used as a checklist and to help in estimating costs when starting up a nursery in displacement settings.

Pots

Polypots (black plastic bags) are commonly used for seedlings in forest operations because they are light and relatively inexpensive. The size depends on the time the seedlings will spend in them. Fast-growing species for woodfuel plantations require smaller pots than, for example, longer-growing fruit species. Note that bigger polypots can be used for fast-growing species but would require more work, more potting media and more space to grow the same number of seedlings. Polypot sizes vary from 7 × 10 cm to 20 × 40 cm. *Scoops* can be used to help fill the polypots; their diameter should be a few centimetres smaller than that of the pots for ease of use.

Punching holes in the polypots allows easier root pruning and helps in draining excess water. This is usually done using pincers; if these are unavailable, a metal rod a few

Polypots are commonly used for raising seedlings in nurseries

millimetres in diameter and a mallet can be used. Root pruning requires scissors or a sharp knife.

Buckets and sieves are used to produce fine, well-mixed potting media for use in the polypots. The same buckets can be used for soaking the filled polypots with water.

Watering

Watering is time consuming, but crucial for seedling survival, especially in hot, dry climates. Watering cans are the cheapest means, but they are also the most work-demanding and time-consuming. The water storage should have a tap or an opening wide enough to sink-fill watering cans. The use of a flexible hose with a manual pump will greatly increase watering efficiency. Sprinklers can also be used, but these require more infrastructure than is usually available in displacement settings.

Workers and management

A nursery requires well-organized workers to carry out diverse tasks on a daily basis. Some such tasks do not require a high level of skill but many require care. It is important, therefore, that workers are motivated, engaged and willing to learn.

Hiring former farmers or tree-nursery workers will help in spreading techniques, as such workers are likely to understand many of the issues in nursery management and will be able to explain them simply to others. They may also bring new ideas that require fewer materials or less work, which is important in displacement settings where few resources are available. Residents in the host and displaced communities will also know the climatic conditions and therefore can provide insight into optimal nursery practices in the local setting.

Seeking inputs from farmers or foresters on the local climate and traditional techniques is a good way to start discussions on nursery establishment.

Timeliness

Nurseries are at the root of the entire afforestation/reforestation campaign, and proper planning and respect for production times is crucial. A year of plantation growth can be lost because seedlings are not ready in time for outplanting, with potentially severe consequences in terms of funding and – most importantly – the availability of wood and other plantation products. It is recommended that:

- seeds, potting media, containers, beds, shading and water infrastructure are all ready at least one month before sowing, to allow for delays; and
- production schedules are set to ensure that seedlings are ready two weeks before the expected date of delivery to the outplanting site to provide flexibility in light of weather conditions.

Production capacity

Number of trees to be produced

The number of seedlings produced each year in a nursery determines the surface area that can be afforested/reforested. If seedlings are to be planted on a 3 × 3 m grid, 1 000 seedlings are required per hectare to be reforested (see Annex 3 to determine the number of trees per hectare according to spacing).

An area of 100 m^2 of nursery beds can house 10 000 seedlings at a time. Assuming a conservative survival rate of 60 percent, a total of 6 000 seedlings will be produced, which would be sufficient to replant 6 ha at 1 000 seedlings per hectare. Several small nurseries (rather than one large one) will improve the resilience of the production system and could also encourage positive competition between managers and workers.

The total number of seedlings required – and thus the nursery capacity – will be set in the management plan. Regular, clear communication between field managers and nursery managers is necessary. For this purpose, Annex 2 contains a blank nursery management form that field managers can use, for example, to keep relevant records on each species and to organize the nursery schedule.

Expandability

Running a nursery requires considerable organization and care, so it seems smart to start with a modest size, with potential to scale up. The tools and equipment will be roughly the same for small and medium-sized nurseries, but more work and organization would be needed in the latter.

Small infrastructure

Toolsheds

Tools are easy to move, borrow and forget. It is important, therefore, to always keep them in the same place, which can be locked. Seeds and plantation materials (e.g. polypots) should be protected from sun, rain and animals (e.g. mice). Toolsheds should be designed to store all such materials effectively.

Shading

Seedlings may require shade in their early growth and progressively less shade as the time nears for outplanting (a process known as hardening off). Frames can be constructed over seedbeds using vertical poles holding horizontal bars on which large leaves, branches, long grass or other shading equipment can be easily set, attached and removed as needed.

Water storage

Building a water-storage facility (such as a tank or a pond) can make watering easier and reduce the potential for water shortages at crucial times for seedlings. This may be difficult to do (e.g. finding the required equipment or funding) in displacement settings and should therefore be kept simple. Digging small ponds and drains to collect rainwater using gravity is labour intensive but may be feasible if the nursery site has a slope. Water-storage options are best explored in collaboration with water management specialists and the local community.

Potting material

Soil

Most seeds require moisture and air to germinate. The right potting medium should provide both, so it should be light to avoid waterlogging but not so light that it cannot hold sufficient water. Forest topsoil, if available, is usually good for potting because of its high organic matter content. Termite earth, dry riverbed soil and sandy soils also provide a good base for potting media. If none of these are available, it is possible to use any kind of earth if it is mixed with compost, manure or burned chaff at a ratio of one part compost to two parts soil or one part manure to five parts soil. The soil should be refined (broken into small pieces) before it is mixed thoroughly with the manure or compost. The mix should then be spread out in a layer roughly 5 cm thick, watered and dried in the sun for a day before storing in a covered pile. This process will provide a finer medium that is better suited to seed germination.

Compost can be produced on site from fresh and dry grass, plant residues, rotten fruit and other food scraps (excluding meat), bark and manure.

Containers

A good container must be strong enough to hold the soil and seedling for several months; easily movable; hold water but allow excess water to drain; and enable root pruning. The size and length of the container will vary depending on the time required for production (shorter times mean smaller containers) and the availability of water when tap-rooted seedlings are to be outplanted (longer containers allow the development of longer tap-roots, which means quicker access to water reserves in dry soils).

Polypots (or recycled plastic bags) are commonly used to grow seedlings; they are relatively inexpensive and widely available. They should be stored away from the light because ultraviolet radiation will cause them to deteriorate.

If polypots are unavailable, discarded plastic bottles that have been cut and drilled also make good (and sometimes reusable) containers. Banana leaves shaped into pots or thick bamboo sticks cut into pots are other options. Local brainstorming would likely produce other creative ideas.

Beds

Seedling beds receive the pots and keep them together; they can be of various types depending on the climate and soil conditions. Raised beds – about 10 cm high – will suit moist areas prone to flooding, and sunken beds – about 10 cm deep – will help in retaining moisture in arid conditions.

Raised beds are made with soil mixed with light matter to provide good drainage and can be edged with ditches to facilitate water run-off.

Sunken beds should be layered with gravel or other coarse material to avoid soil compaction beneath the beds and to help with drainage, a measure likely to prove useful in significant rain events.

Beds should be 1 m wide or less so that any given seedling can be picked up from either side without stepping on others. Bed length will depend on the size of the nursery and the materials available. Several shorter beds may help to prevent the spread of pests and diseases; on the other hand, longer beds may be easier to work efficiently.

Seeds and reproduction

Seed harvesting

A diversity of climatic and edaphic conditions means a diversity of species and of individuals within species. Seeds harvested from trees growing in a dry area are more likely to be drought tolerant than seeds of the same species harvested from trees growing in moister conditions (FAO, 2015). Selecting provenances within a species is a complicated task and requires fine-scale traceability, but it can produce significantly better survival and growth under given conditions and should be practised where possible.

Ideally, seeds are harvested before they fall to the ground to avoid insect attack and animal consumption. Collecting pods and seeds by shaking or gently beating branches is a good way to harvest ripe seeds without soil contact.

Seed conservation

The best technique for conserving seeds is to use them as soon as they are available, but this is not always possible. If seeds are to be stored, bear the following in mind:

- Seeds will last longer if stored in a cool, dry place. Storage conditions should be as stable as possible to reduce the risk of unwanted germination (changes in atmospheric conditions act as germination "start signals" in some species).
- Seeds are food for many animals, including insects, and should be kept in hard boxes and checked regularly.
- The ideal storage is a closed, insulated box kept in the shade and the dark (e.g. in a toolshed).

Seed germination

Where available, fresh seeds should be used because of their higher germination potential. Collected pods should be dried to make it easier to extract the seeds.

The people in charge of handling seeds should remove those seeds with faults or rot to avoid contaminating the entire batch and to avoid sowing unviable seeds.

The number of seeds placed in each polypot (or other container) depends on the germination rate of the seed batch: one seed per bag if the rate is above 80 percent, two seeds per bag if the rate is above 50 percent but below 80 percent, and three seeds per bag if the rate is less than 50 percent. If several seeds germinate in the one polypot, the additional seedlings should be transplanted to polypots in which no germination has occurred.

For many species, pre-sowing treatments will make the germination process faster and more reliable. They may involve:

- mechanically breaking or loosening the shell with a knife, file or sandpaper, etc.;

- pre-soaking seeds by adding boiling water and soaking for 24 hours as the water cools; or
- a combination of these techniques.

If possible, determine (from the literature or local knowledge) whether pretreatment is necessary or helpful for the species selected for plantation.

Propagation techniques

Large seeds (i.e. a size at which they can be handled without precision tools) can be sown directly into pots. Small seeds (such as those of *Eucalyptus* spp.) may be too difficult to sow by hand and usually have lower germination rates. Preferably, such seeds are sown mixed with light sand onto germination beds and later transplanted to pots.

Germination beds are made from light soil, raised up a few centimetres, thoroughly watered, and kept moist using a cloth or chaff – free of other seeds – until seedlings germinate and begin growing. It is important to protect seeds and shoots from mice, birds and other animals using boards on the sides and a cover on top and by transplanting them as soon as possible after they emerge.

The following procedure can be followed for transplanting:

- Carefully extract the seedling from the germination bed, using fingers and a stick to ease it from the soil.
- If possible, prune the roots to stimulate growth.
- In the seedling container, make a hole in the soil with a finger.
- Place the seedling in the hole.
- Fill the hole with soil to the base of the stem (also called the “collar”).
- Water the transplanted seedling.

Note that keeping the roots moist is crucial when transplanting seedlings to pots and the procedure, therefore, is ideally done on still, cloudy days.

Seedling health

Seedling health should be monitored to ensure quality and vitality, thereby enhancing outplanting survival rates. Table 4 presents some common symptoms and actions that can be taken.

Table 4. Common seedling symptoms, possible causes and remedies

Symptom	Possible explanations	Actions to take
Yellow leaves	Low fertility; high temperatures; excessive light; root rot	Perform hourly checks to ensure seedlings are shaded all day
Round or dying yellow leaves	Fungal, bacterial or viral infection	Urgently remove infected seedlings and carefully water those remaining, avoid wetting the leaves
Death around leaf tips or margins	Excess fertilizer/manure; hot winds	Improve wind protection with non-permeable fencing
Slim leaves	Low light; excess water; root rot	If not yellow, reduce shade
Wilted leaves	Lack of/excess water; root rot	Adjust watering and check moisture in containers before watering
Very slow growth	Small pots; compacted substrate; low fertility; root pests; root pathogens	Check whether roots are coiling and prepare for outplanting if in the right season

Cutting reproduction techniques

When plant reproduction from seed is difficult (e.g. because of the unavailability of seeds or low germination rates), it may be possible to use cuttings. These are small branches (with two internodes or ramifications, 1–2 cm in diameter) cut from a mother tree and transplanted into pots (as per seedlings). This technique is "true to type" and produces exact reproductions of individual trees (i.e. cloning), which may be desirable if individuals are especially adapted to local conditions or exhibit high growth rates.

Cuttings are harvested using a sharp instrument, such as pruning clippers, and should be treated with care (they are fragile living plants). Immediate transplantation into pots is crucial; if this is delayed, wrap cuttings with a wet cloth. It is also possible to harvest entire branches, which are later cut into cuttings for easier handling.

Cuttings should be transplanted into containers filled with potting media and watered thoroughly and frequently to stimulate root growth. It is also possible to reduce the number of leaves by trimming to decrease evaporation and force the cuttings to produce roots.

Note that this technique can be problematic in fragile forest ecosystems because cloning reduces diversity and may change pest resistance and the balance between species.

4.2 Seedling care

Seedlings require ongoing care to ensure that they grow vigorously and are ready for outplanting at the appropriate time. The main regular practices are described below (Annex 2 provides a form for keeping notes on the various nursery management tasks).

Watering

Watering should be carried out at least once per day, and twice per day on very hot (> 40 °C) or windy days (Siyag, 2014). The best watering times are early morning and evening – thereby avoiding the hottest parts of the day, when evaporation can mean that a large part of the applied water volume is lost and therefore unavailable to the seedlings.

A worker waters acacia seedlings in a tree nursery

Watering must be applied equally to all seedlings to ensure equal growth and development. Neglecting this aspect would lead to a seedling population of uneven size, requiring sorting.

If water is available on site, two trained workers with watering cans – or better, with a flexible hose and a sprinkler – can water 10 000 seedlings in a few hours. If water must be delivered, the number of workers will vary depending on the means available (e.g. whether the water is delivered by truck or must be carried by hand).

Weeding

Seedling watering stimulates the germination and growth of weeds, which need to be removed regularly to avoid proliferation. Forest topsoil and compost are not guaranteed seed-free, and unwanted plants may sprout in containers alongside the desired seedlings. Water and space are crucial for the young trees, and careful weeding should therefore be conducted once a month. This involves picking out the weeds, which should be done delicately to avoid damaging the desired seedlings. It is important to remove weeds early because larger plants are more difficult to remove and the act of doing so is more likely to disturb the root systems of tree seedlings. Note that weeding can be integrated with other operations such as root pruning and health checks.

Root system management

The root systems of seedlings grown in containers will not develop freely. Seedlings should be outplanted before roots start coiling (i.e. when they start becoming entangled inside the container; Siyag, 2014), but the time it takes for this to happen varies by species, container size and other factors (e.g. growing conditions). One indication that seedlings have fully

Workers hand-weed at a tree nursery in the Nyarugusu refugee camp, United Republic of Tanzania

colonized the available soil volume is that they appear to stop growing. The time taken to reach this point should be noted to improve timing in the next round (i.e. to ensure that the outplanting season coincides with the time just before the containers become too small for their seedlings).

Seedling beds are made with soil, thus seedlings are likely to send their roots beyond their containers through drainage holes. To avoid having to sever large roots before outplanting, they should be trimmed regularly, which involves picking up each container and cutting off any roots outside the container using scissors or a knife (Stott and Gill, 2014).

Hardening off

The aim of hardening off is to prepare seedlings for the harsher light and water conditions they will encounter when outplanted. Suddenly exposing seedlings to such conditions could lead to high rates of mortality, so hardening off is done in stages.

One approach is to remove shade for one hour per day in the first week, two hours per day in the next week, and so on until the seedlings are exposed to the sun for the entire day.

If the seedlings are to be planted in a dry zone, they should also be hardened off by gradually reducing the quantity of water they receive and the frequency of its application. Such hardening off should begin about one month before outplanting. For example:

- Week 1 – apply a little less water each day.
- Week 2 – apply half the quantity of water applied before commencement of hardening off.
- Week 3 – apply water only every second day.
- Week 4 – apply water only once.

The actual timing of hardening off will depend on local conditions and should be determined by an experienced person. Hardening off should include a regular check of seedling health – if plants start wilting during the hardening-off watering routine, for example, water them immediately to avoid damage (Stott and Gill, 2014). The seedling stock should be examined before hardening off and undersized or weak specimens removed.

Timetables and organization

The nursery operations described above must be carried out according to a schedule; a failure to do so could trigger serious health problems for the seedlings. This is especially true in the first stages of germination and growth and in the hardening-off period.

Close management – or self-management – is essential. A large blank weekly organizer painted on a blackboard is a good way of displaying the operations to be performed each day in a nursery. The organizer can be filled in (using chalk) with the upcoming schedule – perhaps at weekly meetings with teams in which the manager reviews all needed operations in the week ahead and assigns people to do them (Table 5 provides an example of such a weekly organizer; see also Annex 2). The organizer should be visible to all staff. Remember that certain operations may need to be performed even on holidays, and this should be arranged in advance with staff.

Table 5. Example of weekly organizer at a tree nursery

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Watering: [name of *person responsible*] Weeding: [name of *person responsible*] Remove shade for ½ day bed No. 1: [name of *person responsible*]	Watering: [name of *person responsible*] Weeding: Root pruning bed No. 3: [name of *person responsible*]	Watering: [name of *person responsible*] Weeding: [name of *person responsible*] Health check: [name of *person responsible*]	Watering: [name of *person responsible*] Weeding: [name of *person responsible*]	Watering: [name of *person responsible*] Weeding: [name of *person responsible*] Root pruning bed No. 1: [name of *person responsible*]	Watering: [name of *person responsible*] Weeding: [name of *person responsible*] Root pruning bed No. 2: [name of *person responsible*]	Watering: [name of *person responsible*] Weeding: [name of *person responsible*]

The weekly organizer should be complemented by an annual, month-by-month schedule for implementing the work plan, such as seed pretreatment and sowing, hardening off, and the delivery of seedlings to the outplanting team. This annual schedule should factor in seasonal changes, and it should be used to help avoid unmanageable spikes in workloads. The annual schedule should be made in consultation with workers so they can plan their own duties in the coming months and provide useful field input, such as on seasonal factors and the feasibility of planned operations. Annex 2 contains an example of an annual schedule for this purpose and some of the operations that should be included. A version of such a schedule could be reproduced in large format and displayed in the nursery in a prominent place.

Expected production time

In some areas, the climate is suitable for outplanting only for a short period, meaning that the nursery has a considerable bearing on the success of the project because it must ensure that sufficient seedlings are ready at the required time. Knowing how long it takes to produce robust seedlings ready for outplanting is crucial and should be calculated carefully. The duration of each phase of production depends on species and climate; Table 6 provides indicative times only.

Table 6. Indicative times required for various nursery operations

Action	Duration and comments
Pretreatment	A few days
Germination	1–2 weeks, depending on species
Growing	3–10 months, depending on species, climate and size of container
Hardening off	1–2 months, depending on climate
Selection	2 weeks (weak seedlings should be removed)

With this information, the nursery manager can prepare production plans for all species to be grown.

When is a seedling ready?

A seedling is considered ready when it has reached a size that allows it to compete with weeds and is sufficiently hardy to survive the elements.

Seedling qualities

One way of judging the readiness of a seedling for outplanting is by its physical size: for example, the criterion might be "when the seedling is 50 cm high" or "when the stem is 1.5 cm thick" (Table 7). Another criterion might be when a seedling's roots have filled the available soil volume in its container but before root coiling. It is tempting to grow seedlings as big as possible, but there is a risk that large seedlings will outgrow their containers and their root systems will become deformed, increasing the chance of mortality soon after outplanting. It is important, therefore, that seedlings are neither too large nor too small (HDRA, 2002).

If seedlings attain their maximum healthy size for their containers but cannot be outplanted immediately, they should be transplanted to bigger containers. This is a labour-intensive operation, however, and requires additional materials (e.g. containers and soil); it should be avoided if possible.

Table 7. Examples of seedling quality standards

Species	Propagation method	Quality standards for outplanting
Acacia auriculiformis	Seed	15–30 cm tall
Acacia nilotica	Seed	5 months old
Albizia lebbeck	Seed	5–6 months old
Azadirachta indica	Seed	1 year old
Casuarina equisetifolia	Seed/nodal cutting	35–45 cm tall, 5–6 months old
Dalbergia sissoo	Seed	60 cm tall, 3–4 months old
Dendrocalamus strictus	Seed	45–60 cm tall, 1 year old
Eucalyptus spp.	Seed/leafy cutting	30–45 cm tall, 6–8 months old
Gmelina arborea	Seed	20 cm tall, 6 months old
Sesbania grandiflora	Seed	60 days old
Tectona grandis	Seed	1–2 cm collar diameter, 3–4 months old

Source: Ratha Krishnan *et al.* (2014).

Before outplanting

After hardening off, the seedlings are moved to new beds two weeks before outplanting. This ensures that only seedlings that survive this move (which may cause uprooting if the seedlings have grown roots outside their containers) are outplanted (HDRA, 2002).

4.3 Site preparation and outplanting

This section describes the material needed, the actions to be conducted and the techniques for successfully planting nursery-grown seedlings in the field. These techniques are taken from the literature and should be used as guidance.

In displacement settings, make sure that all necessary authorizations are secured well in advance of the outplanting campaign, to avoid missing the planting season due to administrative delays.

Various techniques for various goals

Planting density and site preparation techniques vary depending on the intervention's objectives. The management plan must give clear instructions on planting sites, including maps of plots, and it should indicate planting density. Experienced field workers may vary the planting operations if conditions are not as expected – the management plan should be used as a guide, not a law.

The quality of the planting operation is crucial for ensuring optimal tree growth, especially in dry zones where the development of root systems is the key element for survival. Guidance on outplanting is provided below, by intervention context or goal.

Densification of existing woodlands

Existing trees provide shade and keep moisture in the ground and in the air, thereby helping young trees to grow in hot, dry climates. Protecting existing forests and woodlands from harvesting and increasing their quality with selected species is an efficient way to restore ecosystem services. Densification is done in existing canopy gaps; for example, perhaps a dozen seedlings are planted in each gap in dense clumps that offer mutual protection.

Creating new woodlots for woodfuel or erosion control

The goal of woodfuel plantations is to maximize biomass production, and this can be achieved with high-density (e.g. 8 000–10 000 stems per hectare) plantations and short rotations. Planting on bare land is likely to require site preparation; digging trenches rather than pits can be an efficient way of achieving very high-density plantings, with the ditches acting as microcatchments.

A worker plants acacia seedlings in the field

Dense plantations can be highly labour intensive and should be planned carefully to ensure that planting is completed in the best planting season. It may be best to start with a small area in the first year to gain experience in local conditions, which can be used to improve planning in subsequent years, when the scale can be increased.

Agroforestry plantations

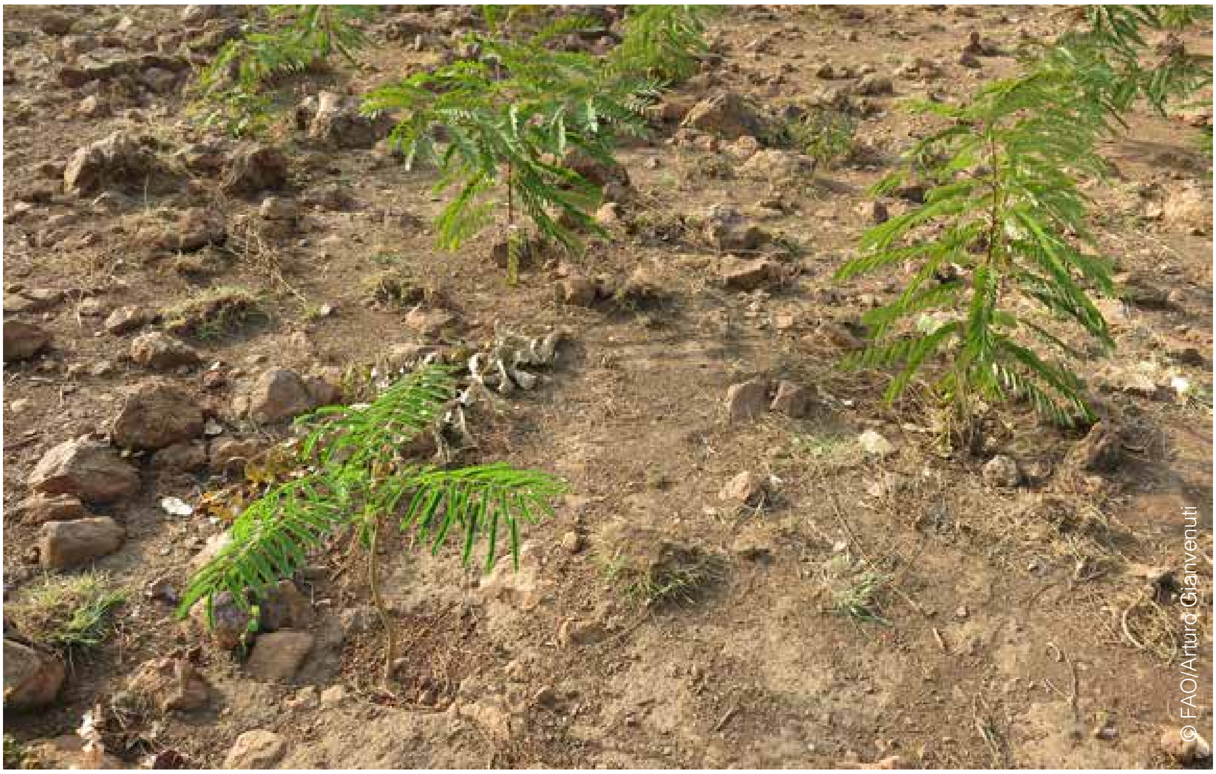
Farmers should be encouraged to pursue agroforestry on their cultivated and grazing lands to produce wood, fodder and fruits. The most common approach is to plant trees in lines with orientations that protect crops and livestock from prevailing winds and minimize competition with crops for sunlight.

Planning and spatial organization

Time of intervention

Seedlings are usually outplanted at the beginning of the main rainy season so that trees can grow their roots and prepare for the ensuing dry season. Planting in the rainy season also helps to keep seedlings moist during transportation and in preparing soils. Local people will bring their own experience to bear on the timing of planting and should be involved in planning. It is important to allow for delays, and nurseries should also plan their production with safety margins of a few weeks.

In dry areas, soil preparation should occur a few weeks before the rainy season to allow water to penetrate the soil more easily when the rains start. This is only possible in light soils – it may not be possible to prepare heavy soils until they are softened by rains. In hot conditions, it is recommended that planting take place in the evening or on cloudy days to reduce evaporation (HDRA, 2002).



Seedlings planted at a high density for early woodfuel harvesting

Control of density and separation of operations

Planting density depends partly on rainfall and the water reserve, or the "carrying capacity" of the environment. The management plan should estimate the carrying capacity (and therefore the density), allowing for on-site adjustment in view of landscape heterogeneity. Low-lying areas, for example, will have a higher carrying capacity and can be planted more densely, while upper slopes will retain less water and should be planted at lower densities.

To ensure that the specified planting density is achieved in the field, a marking operation should be conducted before planting using sticks, stones, branches, paint or some other suitable material to indicate to planters where they should place each seedling. An effective approach is to have separate marking and digging/planting teams.

Reducing risks for seedlings

Outplanting is rough on seedlings, and how it is done can have a big impact on survival and growth. The main risks to newly planted seedlings are lack of water, excess water, competition and predation; transportation to the site can also be an issue. Ensure that water is available at the site to water-in the seedlings after planting. If water is unavailable at the site, seedlings should be watered thoroughly before transportation and planted immediately while the soil in the containers is wet; such seedlings must also be planted in moist ground or in the knowledge that sufficient rain will fall in the next day or two.

Weeds (including the roots) should be removed from the earth around each seedling to reduce competition and increase survival rates. If individual protection or fencing is needed, this must be planned and set up before the outplanting operation commences.

Nursery–planter interface

Ensure good communication between the people producing the seedlings and those preparing for outplanting. Regular checks of seedling growth in the nursery should be communicated to the outplanting team to ensure optimal coordination.

Organization of workers

Outplanting is a labour-intensive operation and requires sufficient workers for it to be done promptly – which is especially important if the planting season is brief or if large quantities of seedlings are available simultaneously and need to be put into the field quickly. The number of people required also depends on the area to be planted and the extent to which it is possible to prepare planting sites in advance (e.g. digging pits, trenches or microcatchments). Some tasks, such as planting, require a certain level of skill (Siyag, 2014), and workers should be selected for those tasks based on their experience and ability. Other activities, such as weeding and hoeing, are less difficult, and most people can perform them if properly instructed. Experience can be a good proxy for skill in the workforce.

Small teams (e.g. a few dozen people per team) can be easier to manage than large groups, with each team specializing in an activity (e.g. marking, digging or planting) and with a supervisor to simplify communication with management. Mixing skilled and unskilled workers can raise the average skill level of workers and should therefore be considered.

Outplanting

Outplanting can be divided into four operations: site preparation, which includes surveying, fencing and preliminary weeding;

- marking and digging pits or mounds and making microcatchment formations (e.g. semi-circular bunds, contour bunds);

- transporting seedlings and material; and
- planting techniques, weeding, making microcatchments, and watering.

Each operation requires specific materials, observations and skills.

Site preparation

The extent of site preparation required depends on the conditions and topography of the site. The manager should evaluate the need for terracing, mounding (in areas prone to waterlogging), water-harvesting formations and fencing and how long the work will take and the number of workers required (Table 8). The location of such infrastructure should be marked on site using poles and paint, and workers should be provided with clear instructions.

For fencing, determine the technique to be used (see section 4.1). Post-and-wire fencing requires considerable material but is less labour intensive than some other fencing types, which might be cheaper. If locally available, thorny bushes piled to a height of 1 m or more can make a good fence. Fence construction can be spread over weeks or months and should be planned well in advance of planting.

Preliminary weeding will be needed in locations covered with herbaceous species and shrubs. For dense plantations, weeding can be done in lines, which can be quicker than weeding around each planting spot. The same applies for water-harvesting formations – ditches and bunds (e.g. 20 cm deep or high) can be built along contours. Individual microcatchments should be installed after planting.

Table 8. Operational framework for site preparation

Action	Equipment	Workload	Remarks
Evaluation and marking of terracing or fencing needs	Measuring chain and compass, poles and paint, paper and pens	A few days; requires knowledge and experience	
Fencing, terracing, mounding and microcatchments	Spades, shovels, digging bars, pans, other (depending on fencing type)	Hard and intensive; depends on terrain and soil conditions	Should be planned well in advance (individual microcatchments should be installed after planting)
Weeding	Hoe, machete	Labour intensive	First weeding (before planting)

Marking and digging pits, and second weeding

Pit marking can be done well in advance of pit digging. A trained team, following instructions given in the management plan on planting density, uses a measuring chain and compass to mark out the locations of the pits to be dug.

Pits should be dug just before outplanting. The manager should give clear instructions on pit dimensions; it is helpful to provide "rules of thumb" for measuring pits (e.g. "arm depth" or "mid-calf depth"). A size of 35 x 35 x 35 cm is often used but this requires considerable effort, especially for dense plantings and in highly compacted soils, and smaller dimensions might be sufficient.

Efforts should be made to crack the bottom of pits with a spade or digging bar to help roots to penetrate below the hole. In digging the pits, the first 20 cm or so of the soil ("topsoil") should be kept in a separate pile from the soil lower down ("bottom soil"). The topsoil tends to be finer than the bottom soil and hence should be used in direct contact with the roots. If well-decomposed manure or compost is available and can be brought to the site, it can be mixed with some of the bottom soil and put back into the pit to increase fertility. Never apply fresh manure directly because it may "burn" the roots of the seedlings.

Weeding around pits should include the uprooting of unwanted plants. This requires more work than simply scraping them off at ground level but can reduce the frequency of weeding. Table 9 provides an outline of the activities involved in digging tree pits.

Table 9. Operational framework for marking and digging pits

Action	Equipment	Workload	Remarks
Marking pits	Measuring chain and compass, poles and paint, paper and pens	A few days; requires knowledge and experience	
Digging pits	Spades, shovels, digging bars, pans, compost or manure	Labour intensive and hard work; depends on planting density and soil conditions	Should be planned well in advance and done just before planting
Weeding	Hoe, machete	Labour intensive	The second weeding – 1 m around each seedling

Transporting seedlings

Transport to the planting site of the large number of seedlings required for a planting season can be spread over several weeks, depending on the availability of water and protection at the site.

Seedlings can be moved to the planting site after selection and hardening off. The soil-filled containers are heavy and it may be necessary to move them in small batches (if no truck is available), which makes the operation labour intensive but cheaper. Ensure that water can also be transported to keep the pots moist while awaiting outplanting. Seedlings housed at the planting site are vulnerable to predators; therefore, the time between delivery and outplanting should be minimized or protection measures (such as guarding) provided (Table 10).

A truck is ideal for transporting seedlings from the nursery to the planting site, but this may not be available in displacement settings. Carts drawn by animals or people are good replacements; carrying by hand may be feasible over short distances if no other mode is available. The longer the journey, the more risky it is for the seedlings; if a truck is available, therefore, the priority would be to use it for the furthest sites to minimize the time that seedlings spend out of the ground.

Table 10. Operational framework for transporting seedlings

Action	Equipment	Workload	Remarks
Transport	Head load, carts, truck	Labour intensive; can be spread over weeks	Very large numbers of seedlings
On-site storage	Fence, guard, water reserve	Committed workers needed	Can be risky

Planting techniques and watering

However simple planting might seem, it is possible for it to fail if certain important details are neglected. First, planting should ideally be done on rainy days or after rain so that earth will stick to the roots and provide them with access to water and nutrients.

Each planter should have a pan or tray on which to carry the seedlings for planting. The tray can be covered with a wet cloth to help the containers to retain their moisture before planting.

At the pit, the container is held in one hand and cut open with the other hand using scissors or a sharp knife.[4] The planter holds the root ball and carefully places it into the pit, trying to keep the soil and roots together. Roots must be oriented towards the bottom of the pit. Fill the pit first with bottom soil and finish with topsoil. It is important to ensure that the seedling collar is out of the ground (HDRA, 2002). Finally, the planter tamps down the soil with a foot to assist soil–root adherence.

Depending on conditions, two techniques can be followed. In one, the pit is refilled with soil so that the seedling collar is 10 cm below the general level of the ground (but still not covered by soil); this is termed "deep planting", and it provides seedlings with extra water reserves in dry areas. The other basic technique is to plant seedlings on mounds so that

A recently planted acacia seedling is watered

4 It may be tempting to reuse the polypot, but the most important concern at this point is ensuring that the seedling is not damaged in the process of extracting it from the container.

their collars stand 15–20 cm above the general level of the ground (but with soil to just below the collars), which assists seedlings in areas prone to waterlogging.

Watering the freshly transplanted seedlings can help to increase survival rates and should be attempted where possible – such as when the planting site is near a stream, pond or spring. Watering can be labour intensive but it can also save work in the long run by reducing the need for replacement planting. Where possible, mulch seedlings with leaves, straw, herbs, pebbles or other available materials to help retain moisture and avoid topsoil compaction. Table 11 shows the operational framework for planting and watering.

Table 11. Operational framework for planting and watering

Action	Equipment	Workload	Remarks
Planting	Mulch	Labour intensive but requires skill	Ensure that workers understand the techniques (e.g. collar height)
Watering	Watering can	Labour intensive; carrying water is physically demanding	Hard to do but may be essential for survival

Protecting outplanted trees

Identifying predators

Herbivores such as goats, sheep, cows and wild mammals are all potential predators of seedlings with fresh, tender leaves. Protecting seedlings from such animals is fairly easy but requires time and materials. The main idea is to prevent their mouths from reaching the leaves, and this can be done in two ways:

- with individual protection for each tree, consisting of, for example, small frames, fences or thorns; and
- by providing wider protection with a large fence enclosing several (or many) seedlings.

Adapting protection to predators and type of management

Installing protective measures for individual seedlings is time consuming, but it is relatively easy to do because it does not require heavy materials or major digging. Bamboo sticks or other branches can be arranged to form a cage around a seedling so it is not reachable by animals; the cage needs to be adjusted as the young tree grows. This technique is suitable for relatively small numbers of trees (e.g. in agroforestry or enrichment planting in natural forests), but it is likely to be impractical for large numbers of seedlings planted for woodfuel production. Before installing a protective fence it is essential to ensure that it is compatible with the prevailing land tenure and rights.

Fencing a plot of land is more practical when large numbers of seedlings are in need of protection, but doing so is a major operation that requires a large quantity of materials. Techniques include posts and wire; thorns or branches; drystone walls; and ditches and bunds.

Fencing techniques

Drystone walls about 1 m in height could be a good option if many stones are available at the site or within a short distance of it. Large, flat stones are better than small round ones, which are unlikely to hold together well. To assist stability, place larger stones at the bottom and progressively smaller ones towards the top. There are only a few equipment requirements (e.g. digging bars, pans, and rope to assist in building the walls in straight lines), but workers must be skilled and the work is physically demanding.

Ditch-and-bund fencing might be considered on relatively flat sites on soils that are not too light (e.g. sand is unsuitable) (Siyag, 2014). Streams need to be fenced with another technique (e.g. post-and-wire or thorn bushes) because flowing water will destroy bunds. Construction involves excavating soil using shovels and piling it into a bund on the inside of the area to be fenced. The slope of the bund should not be too steep to be unstable and not too flat to be ineffective. Combined, a 50 cm-deep ditch and a 50 cm-high bund make a 1 m-high barrier, which is generally sufficient. Bunds can be sown with thorny plant species to increase their effectiveness and stability. Although few tools are required for ditch-and-bund fencing, it is highly labour intensive. Fences must be well maintained to ensure their effectiveness over time.

Thorny shrubs, if piled up, will act as a fence for non-jumping animals. They should be secured in place using posts or stones and regularly checked and maintained.

Post-and-wire fencing is likely to be too costly for afforestation/reforestation interventions in displacement settings.

Installation

The three basic steps for installing a fence are sourcing the materials; transporting them to the site; and constructing the fence. Tools similar to those used for digging pits can be used for the digging required in post-and-wire and ditch-and-bund fences. Transportation equipment such as carts and pans will help in the construction of drystone walls and thorn fences.

Marking is required for straight, regular fencing. A long rope, whitewash or ashes can be used to mark direction and width.

Guarding

Guards can help to protect plantations from both animals and humans. They must be a regular presence to be effective, and they can also help to maintain fencing and tend trees. The provision of incentives for high rates of seedling survival can help motivate such guards (UNHCR and IUCN, 2005). High demand for woodfuel can lead to trees being felled prematurely. Reducing the potential for this requires awareness-raising, communication and, perhaps, guarding.

Soil management techniques

Water is managed by effective site preparation and regular interventions after planting. Techniques that help to make sufficient moisture available to seedlings include weeding to reduce competition, and hoeing. Weeding and hoeing can be carried out simultaneously because similar tools and techniques are involved. Weeding is a precise operation, however, and requires a certain level of skill (proper uprooting is necessary for efficient weeding, whereas simple hoeing will allow weeds to regrow).

Weeding should be done a week or so after the first rains of the wet season, when weeds start growing (Siyag, 2014). This is efficient because the small plants are easily grubbed out before they start competing with trees for water.

Hoeing loosens the topsoil, which in turn prevents capillarity and hence reduces water loss from soils; hoeing also helps rainfall to penetrate the soil. It should be carried out after rain or irrigation when the soil has dried out (Siyag, 2014). Placing straw or mulch around seedlings would provide the same effect for much less work, but such material may be scarce in displacement settings.

Assuming that weeding and hoeing takes five minutes per tree, one person can tend 12 trees per hour and 60 per day (assuming a five-hour workday).

4.4 Harvesting and pruning

Whatever the management objectives, harvesting must conform with certain rules to be sustainable and effective. Most importantly, clearing should be avoided: for individual trees, for example, a sufficient amount of stump should be retained to allow coppicing; moreover, some trees should be left standing in harvested stands to assist regeneration by providing shade and retaining moisture. Harvesting is not only to provide much-needed supplies of, for example, woodfuel, timber and fodder: it should also be used as an opportunity to enhance the remaining stand and ensure the maintenance of soil quality.

Thus, the management plan should include indications (e.g. time period or tree size) of when, where and what to harvest. Growing trees is not an exact science and the weather may bring surprises, so it is important to allow flexibility in the harvesting plan so as to meet people's needs while maintaining a functioning plantation. Table 12 indicates the key information that should be specified in the management plan.

Table 12. Example of key information in the forest management plan

Name of camp	XXX
Name of site	Hills
No. of site	23
Distance from compound (km)	4
Year of plantation	2017
Goal of management:	Woodfuel production
Responsibility for management	
Responsibility for harvesting	
Rights to harvest	
Final beneficiaries	Refugees – Block A
Species	*Albizia* spp.
Pruning possible from	
Expected year of harvest (or tree size at harvest)	2022 (or 10 cm diameter at chest height)
Level and type of harvest, and regeneration approach	80% of trees, coppicing
Rotation	5 years or 10 cm diameter at chest height
Expected mean annual increment	

Controlling what is harvested when and by whom is, in itself, a way to restore degraded forestland. Thus, harvesting plans should include all forested land near the displacement community, not only those areas planted with new seedlings.

Techniques

Coppicing/pollarding

Coppicing (cutting stems to the stump) and pollarding (cutting stems to a given height of, say, 0.5 m, 1 m or 2 m) are ways of producing small-sized woodfuel and fodder regularly, taking advantage of the tree's remaining root system. Some species are good at coppicing, such as *Gliricidia* spp., *Leucaena* spp. and *Eucalyptus* spp. But not all species react to coppicing and pollarding treatments in the same way, so it is important to ensure that the technique is suited to the species before including it in the management plan. The rotation length – the number of years the coppicing plantation should grow before the next harvest – will depend on the species, soil and climatic conditions and on how the coppicing or pollarding is done.

Even though they will not kill the tree, coppicing and pollarding are traumatizing and should be done outside stress periods (e.g. not immediately before the dry season or inundation).

When available, saws should be used rather than axes or machetes because they produce cleaner stumps that are better able to resprout.

Pruning

In dense stands, low branches and leaves are shaded out and hence do not photosynthesize much, and trees will rapidly shed them. This phenomenon can be used to produce small-sized woodfuel without slowing plantation growth. In less dense stands, or where species do not self-shed their lower branches, branches can be removed manually, preferably using saws.

Depending on the length of the rotation, pruning may be done once or twice per rotation.

A rule of thumb for pruning a tree is to never cut more than one-third of its total foliage. Pruning is ideally conducted outside the growing season – during the dry season, for example.

Goal of harvest

Tree harvesting produces a range of outputs, and the marketing or use of these should be planned in advance to minimize waste and damage to the forest.

The management plan should set a harvesting schedule – based on expected growth and adjusted as necessary in light of periodic measurements – for fodder harvesting, pruning, coppicing and logging. Table 13 presents an example of a harvesting schedule for a certain species in a coppicing regime.

Table 13. Indicative operational framework for a given species in a coppicing regime

Action	Examples of possible timing
Pruning branches up to a certain height	When the tree reaches a specific height
Direct fodder use or harvest of leaves	At a specific time of year or when the tree reaches a specific height
Regular harvest of branches	When the tree reaches a specific diameter at chest height
Coppicing of the whole stump	When the tree reaches a specific diameter at chest height

Stand improvement

Improving a stand does not mean “no felling”. It is possible to increase the productivity of a natural woodland, for example, by enrichment planting with species based on criteria such as end use (e.g. high-quality woodfuel, fodder or timber) or productivity (e.g. fast-growing or drought-resistant).

The "quality" of a stand is a subjective concept that can be characterized according to the goals specified in the management plan. The nature of stand-improvement interventions will depend on the situation, with two examples given below.

1. **A natural woodland** is improved by selective felling and treatment of the best individuals, as follows:
   - The trees to be retained are marked. This requires workers with the skill to identify species; clear instructions for the marking team (e.g. the species to be retained, the desired tree density, and the minimum density); high-visibility paint; and paintbrushes. Other information, such as pruning instructions for retained trees, is provided to the local forest manager or guard.
   - Trees not marked for retention are harvested, either by the host or displaced community or by commercial harvesters. In either case, clear instructions ensure that workers know to retain marked trees and ensure that those trees are not damaged during harvesting. Pruning instructions for the retained trees are reinforced.
2. **A plantation** is improved by thinning and selecting the best individuals, as follows:
   - The management plan for a plantation aimed at growing trees to sawlog size (for example) specifies both the planting density and the final density of mature trees (in number of trees per hectare). The forest manager determines the number of trees to retain in each thinning in order to reach the final density.
   - Instructions to workers in thinning operations are along the lines of "keep one tree in four, on average, choosing the most vigorous and straight and best-developed". Using criteria such as these, the marking team identifies trees to be retained before the thinning crew commences its operations.

Wood production

Wood production is one of the primary goals of forest management and may indeed seem to be its "final step". It is, however, just one step in a sustainable cycle, and conducted bearing in mind the long-term future of the forest area subject to harvesting. Done well, wood harvesting can also perform a cleaning, thinning or pruning function.

In displacement settings, wood harvesting is not usually a big, one-off organized operation (UNHCR and IUCN, 2005). Although this may be the case in some situations, it is more likely that displaced and host communities will collect wood continually by hand. An important part of the management plan is to identify what should be harvested first (and what should not be harvested for some time). The management plan should specify the order in which sites should be harvested and the harvesting priorities at each site.

- **Site access.** Prepare a schedule and a map indicating which areas are available for harvesting at a given time. The area to be made available should be calculated in light of the number of people harvesting, the stock of wood on the site, and the distance to camp.
- **Priorities on site.** Deadwood should be removed first – it is lighter to carry by foot or cart and is more efficient and safe to burn. Prunings should be removed second – these are relatively small branches that will be quick to dry and easy to burn (if used as a primary fuel). Trees may be felled in a third step – to produce wood for use by the displaced and host communities as fuelwood, timber or charcoal.

Harvest level

Sustainable harvest level

Calculating the sustainable harvest is challenging and is further complicated by the limited availability of basic data such as the current wood stock; the rate of wood growth/yield; the wood demand and energy needs in the host and displaced communities; and the harvesting methods and type of wood harvested (e.g. living or dead). The allowable harvest must be communicated clearly to the harvesting community. Site-specific information on wood supply and demand is essential for the identification and development of appropriate and sustainable forest management practices and harvest level.

Maintaining a sustainable harvest may be the ideal, but woodfuel is often the primary or only energy source for cooking and therefore essential for the food and nutritional security of both the displaced and host communities. The sustainability of woodfuel extraction can be evaluated by assessing: the standing woody biomass available for use as fuel (woodfuel supply); consumption over a given period (using woodfuel consumption as a proxy for woodfuel demand); and the interrelationships and gaps between demand and supply. This evaluation method determines whether the rate at which wood is harvested outpaces the natural or managed rate of woody regrowth in nearby areas and can supply options for improving energy use (FAO and UNHCR, 2016).

Estimates of woodfuel supply require the assessment of accessible wood stock and wood annual increment, as well as the distance travelled to collect woodfuel and accessibility in order to determine the area of woodfuel collection in a displacement setting. Data from existing national forest inventories are a fundamental resource for improving knowledge on status and trends in woody biomass production, collection and use. The combination of field measurements and analyses of satellite imagery for those land-cover classes that provide woodfuel (mainly tree cover and shrub cover) can be used to derive maps and to estimate the available woody resources.

A number of factors influence energy demand for cooking and other basic needs in displacement settings. The amount of woodfuel used for cooking can range from 0.7 kg to 3 kg per person per day (Gunning, 2014). The precise quantity and type of fuelwood and charcoal used for cooking depends on several site-specific factors, including the availability and quality of wood; climate; the type and quantity of food cooked; stove efficiency; and cooking practices.

The interrelationships and gaps between demand and supply represent the baseline for planning the required sustainable harvest through forestry and energy-related interventions, such as afforestation/reforestation, rehabilitation, agroforestry and improved stoves.

To avoid damaging the forest, continual monitoring and assessment is required by the forest management authorities to ensure that target regeneration and growth rates are being achieved, and to determine whether the allowable cut can be increased or must be reduced.

A commonly used measure for estimating the sustainable level of wood harvesting is the volume of timber that may be cut in one year in a given area, known as the annual allowable cut (AAC). The AAC is calculated on the basis of the management objectives, the standing stock and growth rates of trees in natural forests and woodlands, and the area under forest management. The AAC is a practical measure of the sustainable yield in a given period and can be used to monitor forest production and set limits for forest use. For some purposes, the AAC is aggregated for all commercial species, but in forest management planning it is usually broken down by species or species group and by harvesting compartment or stand. Where there is little or no information on the growth rates of desirable tree species (e.g. where forest management is being introduced for the first time), the AAC should be based on classical empirical procedures (FAO, 2017a).

5 Monitoring, evaluation and reporting

5.1 Why monitor and evaluate

Monitoring and evaluation help to demonstrate public and internal accountability in terms of impacts and resource efficiency and provide assurance that an intervention is on track. Monitoring implies keeping watch over the progress, quality and success of the work. The evaluation of progress and the quality of work involves comparing results with the prescribed standards, milestones, aims and objectives. Changes in strategy, technology, management practices or any other component or subsystem of an intervention can be made in light of the outcomes of monitoring and evaluation (Siyag, 2014).

Monitoring can be defined as the ongoing assessment of the technical, environmental and social performance and effects of management. A monitoring system is a way of steering and organizing the monitoring work so that it is efficient and easy to implement. Monitoring systems vary in sophistication, from paper-based to electronic. The most important factor is not the sophistication of the system but its capacity to collect, analyse and make available the information needed for decision-making and for adapting the management plan, where necessary.

Monitoring is crucial for the following (adapted from Buckingham *et al.*, in press):

- understanding success, failure, and change over time;
- supporting implementation and providing feedback for adaptive management;
- increasing transparency and providing evidence of progress, achievements and impacts in relation to specific goals and objectives;
- communicating results and outcomes to encourage positive momentum, inspire replication, encourage scaling, and allow the transfer of results;
- supporting the sharing of evidence with investors and increasing trust as a way of fostering additional investments; and
- supporting reporting at various levels.

Monitoring and reporting on progress towards the achievement of forest management objectives, as set out in the forest management plan, also helps in:

- controlling forest operations, including the performance of contractors and other actors working under contract or licence in the forest;
- identifying under- or overachievement, determining the causes of underachievement, and taking action to rectify the situation and to adjust annual operational plans as necessary;
- detecting inefficiencies or fraud;
- providing information for the future revision of the plan; and
- providing information for the evaluation of the management plan or its prescriptions (FAO, 1998).

5.2 Developing a monitoring system

There are three broad stages in developing a forest monitoring system: scoping, design and implementation.[5]

1. **Scoping.** The goals, objectives, desired outcomes, impacts and scope (e.g. scale, boundaries and stakeholders) are clarified at this stage. The steps (or intermediate targets) for reaching the goals and objectives are defined.
2. **Design.** The scale, methodology and data-collection methods are determined. A detailed monitoring strategy is developed and agreed by all stakeholders. This usually includes:
   - defining the baseline situation;
   - determining the economic, social and environmental information needed – the criteria;
   - selecting the variables for measuring progress towards each goal and objective – the indicators;
   - identifying available information and datasets;
   - identifying the methods of assessment and grouping these into a coherent monitoring framework;
   - developing a sampling plan and identifying measures (e.g. means of verification, frequency) and tools; and
   - distributing responsibilities among stakeholders.
3. **Implementation.** This stage involves information collection, storage, analysis, evaluation and reporting.

It is necessary to determine the baseline situation for assessing progress achieved through project interventions. The baseline assessment documents the initial situation and constitutes the start of trend lines as changes in performance measures are tracked over time.

Criteria are the categories of information needed for the baseline at the project level. Table 14 lists some key technical and environmental criteria relevant to forest plantations.

Table 14. Key technical and environmental criteria for assessing the performance of forest plantations

Legal requirements	Health of trees	Soil protection
Management plan	Pest control	Pollution control
Site selection	Staff training	Water protection
Species selection	Nutrient dynamics and soil fertility	Transport planning
Native species component	Protection of biodiversity	Landscape design
Growth rates	Protection of natural habitat	

The indicators for assessing the criteria should be chosen carefully with the aim of providing relevant, accurate, timely, feasible and sensitive information. Indicators can be divided into three types (Buckingham *et al.*, in press):

- **Performance indicators** identify specific project objectives. For example:
  - survival of trees planted in an area;
  - quantity of seedlings produced;
  - area enclosed by fencing;
  - implementation of management and environmental criteria in specific instances (e.g. contour

5 This section draws on the following sources: Buck *et al.* (2006, 2014); Buckingham *et al.* (in press).

ploughing on steep slopes, development of a planting mosaic, and protection of natural vegetation fragments).

- **Outcome indicators** assess progress against specified outcomes. For example:
  - water quality;
  - soil loss;
  - tree health and growth;
  - production of a given volume of woodfuel at rotation age;
  - extent to which guidelines are followed in road construction, harvesting practices and silvicultural tending, etc.
- **Impact indicators** describe the changes that have occurred as a result of interventions. For example:
  - adequacy of woodfuel supply in the host and displaced communities;
  - number of jobs created;
  - social data on income, health, education, etc.

A range of methods and data sources can be employed to establish baselines and track the progress of project indicators, and all have trade-offs.

Data-collection methods include top-down (e.g. remote sensing) and bottom-up (i.e. ground-based) approaches and a combination of the two. The method selected for collecting and analysing data will depend on the scale, indicators chosen, cost and available resources.

Remote-sensing techniques using satellite imagery or other aerially collected data can help in monitoring certain biophysical and socio-economic indicators over large areas with a high degree of accuracy.[6] Tools such as Open Foris, the System for Earth Observation Data Access, Processing and Analysis for Land Monitoring, and Google Engine can help in monitoring biomass stock changes using a combination of high-resolution satellite imagery and field surveys.

Field-based monitoring is usually more expensive but can generate more accurate data and capture local socio-economic conditions. Possible approaches include:

- regular inspections;
- spot-checks on operations;
- plot-based sampling for forest inventory;
- research plots;
- process studies in field and laboratory;
- environmental audits;
- destructive sampling;
- field experimentation, including testing responses to treatments and productivity trials;
- visual checking of key habitats;
- biological sampling;
- use of comparative photographs;
- rapid or participatory rural appraisal methods;
- questionnaires.

To obtain the best results, satellite and airborne methods should be combined with field assessments and participatory approaches.

Responsibility for monitoring rests with project personnel and other relevant stakeholders. For monitoring performance, data should be collected at the various levels of supervision within the project, as specified in the forest management plan. Monitoring the outcomes and impacts of a project is more demanding of resources, expertise and skills – it requires

6 See, for example, www.openforis.org/tools/collect-earth.html

the involvement of stakeholders such as government agencies, research and educational institutions, and knowledgeable people in the displaced and host communities. The management plan should set out the necessary arrangements and financial provisions for the monitoring programme.

5.3 Monitoring performance of forest management interventions

This section offers guidance on planning, organizing and carrying out performance monitoring in the implementation of the forest management plan, with a focus on forest plantations. Table 15 summarizes key topics that can be used as indicators for monitoring the operational performance of a forest management unit.

Table 15. Examples of key topics for monitoring operational performance of forest plantations

Activity to be monitored	Key topic	Monitoring method	Frequency of assessment
Seed collection		Records, field inspection	Monthly
Nursery establishment and operation		Records, field inspection	Monthly
Area definition and delimitation	Surveyed boundaries	Maps, field inspection	Annually
Road construction	Road length, types	Maps, records, field inspection	Monthly
Site preparation		Maps, records, field inspection	Weekly
Planting		Field inspection, records	Weekly
Silvicultural tending	Management plan prescriptions	Records, field inspection	Monthly
Area protection	Management plan prescriptions	Records, field inspection	Monthly
Technical staffing	Staff recruitment and resignations	Employment records	Annually
Environmental management	Management plan prescriptions	Records, field inspection	Annually
Continuous forest inventory	Establishment and measurement of permanent sample plots	Records, field inspection	Annually

Source: Adapted from FAO (1998).

Collecting field data

The ongoing inspection of fieldwork is the keystone of monitoring.[7] The following points should be considered for the inspection of fieldwork:

- Some inspections should be planned in advance and others should be carried out randomly without notice.
- A comprehensive schedule of inspections at different levels of management should be drawn up and meticulously followed.
- A checklist of inspection points should be kept ready during inspections. Almost all items of work should be seen and checked visually, if not with measuring instruments.
- Walkthroughs of different kinds can be designed for inspecting a plantation, but "random walkthroughs" are best. Diagonal and border walkthroughs are also good strategies.
- The clothes and shoes worn by inspectors, and their physical fitness and attitude, can all have a bearing on the quality of inspection. In remote areas, inspectors should carry drinking water and lunch packs.
- Although inspecting a small plantation site is unlikely to require sampling, a suitable sampling strategy should be used to obtain field measurements for entire afforestation/reforestation interventions.
- Data obtained from field functionaries or supervisors should be test-checked during inspections to ensure their accuracy.
- Numerous inspections scheduled at different times of a plantation's life cycle should be carried out with relevant data sheets in hand – especially the original record of work – such as measurement books, maps and plantation journals.

Field data should be collected at all stages and in as much detail as possible. The following points should be considered:

- It is desirable that all data are collected using prescribed forms, which should be standardized across all divisions, units and subunits.
- Inspectors should fully understand the set of forms to be completed, which should be done in real time on the basis of actual field measurements.
- The most important real-time data come from the daily work measurement log, which is a journal containing descriptions and measurements of the work executed each day. The daily work measurement log records site-specific, real-time and original data, such as the number of polypots filled, pits dug or plants weeded. The daily work measurement log is fundamental, therefore, to data collection and an invaluable resource for field monitoring.
- Periodic progress reports are forms designed specifically for monitoring the progress of work and can be completed weekly, monthly or quarterly. Periodic progress reports do not present original data; rather, they are compiled from real-time field data. A comprehensive system of such reports will ensure that no aspect of the programme is inadvertently overlooked.

Managing information

Data collected through monitoring must be compiled, analysed and interpreted to draw conclusions and enable meaningful action. Data can be compiled either manually or using computers; in both cases, the use of standardized forms can be helpful. The reporting procedure should be decided in advance, and the compilation process should be automated as much as possible.

If a computer is used, the forest manager (or a computer expert) should develop spreadsheets for ease of data entry, analysis and reporting; macros can help to automate

7 The main source for this section is FAO (1998).

certain elements in the process. Alternatively, a management information system can be developed and deployed to help automate analysis and reporting.

Financial changes are commonly tracked in monthly progress reports, and weekly or two-weekly reports may be preferred for tracking project implementation. Each report should be viewed against targets and plans and practices adjusted accordingly.

Reviewing the forest management plan

It is usual to continually fine-tune a management or operational plan, but from time to time it may also be necessary to significantly reorient or redesign an intervention, qualitatively or quantitatively, in light of monitoring or field experience. For example, the management plan may have envisaged a certain intensity of soil- and water-conservation structures (e.g. bunds), and these might prove inadequate to protect the plantation sufficiently. In such cases, the entire intervention might need to be reviewed and redesigned, affecting both physical and financial outcomes. Also, real growth may differ significantly, both positively and negatively, from that forecasted.

Mid-term appraisals and reviews are undertaken to assess the impacts of ongoing interventions and determine whether they are on track to achieve their goals. It may be possible to use remote-sensing imagery in conjunction with a geographic information system to quickly assess progress in plantation establishment as part of such mid-term appraisals.

Continued feedback and long-term monitoring

The cycle of monitoring and review should not be confined to periods in which works are being executed. Monitoring continues to play an important role in later stages of plantation management and maintenance – because an absence of appropriate maintenance would undo previous work. Longer-term monitoring tends to involve the collection of fewer data, but the number of field inspections should be maintained. An intensive inspection regime can help to ensure the integrity of ongoing management.

Measuring achievements against the goals of the forest management plan

At the conclusion of the term of a forest management plan, the extent to which its original aims and objectives have been achieved should be assessed. The tangible outcomes can be measured quantitatively, and the assessment of intangible benefits should also be as objective as possible.

Intangible outcomes may have been included in the original aims and objectives, or they may be counted as co-benefits. For example, the educational impact of implementing a forest management plan is an intangible benefit, but its assessment should be based on measurable parameters. Other (arguably) intangible benefits include landscape conservation, aesthetic or microclimatic improvements, soil conservation, groundwater recharge, increased capacity to meet woodfuel and fodder demands (thereby saving natural forests and protected areas), and the creation of habitats for wildlife.

5.4 Quality control and work productivity evaluation

Quality control is crucial for success in plantation projects.[8] The purpose of a quality control programme is to identify clear, measurable quality objectives and to devise ways and means of realizing those objectives at various stages of planning and execution. Work

8 This section is based on Siyag (2014).

productivity is a measure of the efficacy of the methods, techniques, tools and equipment used in maximizing output and minimizing consumption of resources.

Indicators for quality control

A large number of factors determines the quality of plantation work, each of which should be monitored to ensure quality. A basic action is to monitor adherence to specifications in materials and the execution of work. For example, the quality of plants produced in a nursery will be poor if the quality of the potting medium is highly variable, with flow-on effects in plantation performance.

Specifications and standards are designed with a view to achieving the desired quality of work. Considerable effort should be put into setting specifications with the aim of striking a balance between cost and quality. For example, plants planted in larger pits are likely to achieve better growth because of the increased availability of moisture, but the increase in cost would need to be justified by a proportionate increase in wood production. In most cases, the optimum specifications will only emerge through trial and error.

Designing a quality management programme

A quality management programme involves identifying the factors essential for ensuring quality, depicting these in clear ways such as charts, networks, pamphlets and posters and communicating them to the workers (the "quality assurance" component). Inspections are conducted to ensure that the required quality standard is maintained for all factors (the "quality control" component).

A system of incentives and rewards for exceptional work quality, such as an awards programme at various levels of management, could help to increase overall quality in plantation operations. Assessment forms may be useful for establishing the quality of the work of supervisors and unit managers in clear, quantitative terms.

Achieving higher productivity in work

Productivity is the ratio of output to effort. With good management it is possible to achieve a greater work output of equivalent quality for the same amount of effort. Nevertheless, a balance between quality and productivity needs to be struck. If the quality programme has been thoroughly communicated and well received by workers, productivity can be increased by using correct techniques, appropriate work tools, and management methods involving accountability, fairness in the disbursement of wages, and organization of the workforce.

Using the appropriate tools for each operation will increase work productivity. As far as possible, the highest-quality, most appropriate tools should be used.

Training workers in correct techniques also improves productivity. When digging planting pits, for example, the excavated soil should be placed on the downside of the pit, thereby reducing the effort required to construct saucers. Similarly, using the correct technique to open polypots will reduce the time taken to fill them.

Seasonal factors – especially the weather – affect worker productivity in forestry because most work involves physical effort outdoors. Productivity declines in extremely hot and cold conditions, and this should be taken into account in scheduling work to reduce the impacts of such conditions on productivity (e.g. on hot days, the most physically demanding work could be done in the early morning, when it is coolest).

5.5 Record-keeping and documentation

Records and accounts are integral parts of project management. Financial statements and procedures and records of materials and machinery used and assets created should all be maintained meticulously. Financial record-keeping may also be a statutory requirement. Modern practice is to use simple but complete sets of procedures. Duplication and redundancy in paperwork can be avoided by prescribing a standard set of forms for each kind of activity. With good records, the frequency of monitoring can be reduced.

Financial record-keeping

Financial record-keeping is mandatory in every organization. Accounts are drawn monthly and usually submitted to the next higher authority. The basic entity in financial accounts is the voucher. For example, each piece of paper that is evidence of a payment made to workers, and every bill of purchase of materials, is a voucher. A bill of payment becomes a voucher when it is entered into the office cashbook (cash account). All vouchers entered into a cashbook are classified according to work activity and, each month, a schedule of such vouchers is drawn up.

A summary of the schedules of all work activities constitutes the monthly account of expenditure. This is prefaced with an abstract of the cashbook for that month.

A form of bill that is important in plantation projects is the workers' wages bill. More than 90 percent of all expenditure in plantation projects is on labour and it is crucial, therefore, to design a system for engaging workers, measuring their work, verifying it, preparing the wages bill, and disbursing the wages. The format of a wages bill might also enable the recording of socio-economic information characterizing the employment generated.

Another common form of bill is for payment of salaries to project staff, such as supervisors and managers. Bills of payment are drawn up on forms prescribed by the funding agency or in local practice.

The cashbook is the most important part of financial record-keeping in an office. Every item of expenditure must be recorded in it. A standard double-entry system is often followed. The serial number assigned to a given bill when it is entered in the cashbook constitutes the voucher number of that bill.

Audit reports are another important financial record. These are evaluations of the state of records and of an entity's practice of record-keeping and observance of financial rules and procedures. The financial procedures to be followed will differ according to the situation, but they should be as simple as possible and easy to grasp, and they should provide for adequate delegation to lower levels of staff.

Record-keeping of physical assets

In addition to financial records, it is necessary to maintain records of physical achievements and assets. This can be done in various ways, and the actual record-keeping practice used may vary considerably depending on statutory requirements or those of the funding agency. The system presented here is a simple, minimal framework.

Measurement books are the original records of all physical work done at a plantation site or nursery. Each site or nursery must have a separate measurement book. All bills are entered into the measurement book and confirmed by the supervisor and unit manager. Measurement books provide a bill-by-bill history of the work done at a given site, in chronological order, and they form the basis of progress reports on the work carried out.

Stock ledgers and logbooks record the purchases and use of materials, vehicles and machinery. These are original records and should be entrusted to a person at the rank of supervisor or above. Nurseries use a large variety of materials, and various ledgers are required (e.g. for plants and seeds).

The work control register is similar to a measurement book, but the bills are entered into it in a classified manner so that bills pertaining to a given item of work (e.g. excavation) are entered in the same column, thereby enabling the quick calculation of the total quantity of a particular item of work executed at a site. A similar register – the budget control register – is maintained for recording monthly expenditure for the various works to track expenditure against budget allocations.

Work documentation

As work progresses, it is desirable to produce consolidated annual reports. The introduction of an annual report describes the genesis of the intervention, its aims and objectives, and the general work programme. This description can be used in successive annual reports. The second part of an annual report describes, in concrete terms, the achievements made to date and the visible and invisible impacts. Textual descriptions should be accompanied by visual content such as graphs, charts and photographs. Annual reports should be published and made available to all stakeholders, including the host and displaced communities. Clear, well-prepared annual reports increase transparency and can help to win public support for an intervention. The process of documenting progress in annual reports helps managers to gain an overview of the work done.

A plantation journal is a systematic record of all information relating to a given plantation. It is a history of what has happened at the site, summarizing all key facts in a tabular format. Plantation journals should include photographs of the site taken before plantation establishment and periodically thereafter to show the changes brought about by the project. Time-sequenced photographs can be excellent educational materials for training, exhibitions and other presentations.

A nursery journal is an annual record of all events, activities and achievements of a nursery. It includes balances of plants and materials, thereby also helping in work control over the years. Nursery journals are important for keeping track of a nursery's history and helping to fine-tune future activities. Photographs of the nursery, taken periodically, should be used to illustrate changes over time, as well as specific issues.

Videos of the work carried out in a plantation project can be powerful visual aids in communicating impacts and benefits. They can be used, for example, in presentations to the evaluation committees of funding agencies, for training and extension, and to communicate the importance and benefits of plantation projects to the wider public.

Impact assessment reports are important parts of project documentation. The aim of such reports, which are prepared by experts and require in-depth study, is to provide comprehensive evidence of the overall impacts of a project. They can be powerful tools for educational, training and extension activities.

6 References

Buck, L.E., Milder, J.C., Gavin, T.A. & Mukherjee, I. 2006. *Understanding ecoagriculture: a framework for measuring landscape performance*. Ecoagriculture Discussion Paper No. 2. Washington, DC, Ecoagriculture Partners (available at http://ecoagriculture.org/wp-content/uploads/2015/09/Discussion-Paper-Understanding-Ecoagriculture-A-Framework-for-Measuring-Landscape-Performance.pdf).

Buck, L.E., Kozar, R., Recha, J., Desalegn, A., Planicka, C. & Hart, A.K. 2014. *A land perspective on monitoring and evaluation for sustainable land management: trainers' manual.* Washington, DC. EcoAgriculture Partners.

Buckingham, K., Ray, S., Stolle, F. & Zoveda, F. In press. *Measuring progress for forest and landscape restoration*. Working Paper version 1.0. FAO & World Resources Institute (WRI).

Burgeon, D., Hofer, T., van Lierop, P. & Wabbes, S. 2015. *Unasylva*, 243/244(1–2): 86–89 (available at www.fao.org/3/a-i4447e/i4447e10.pdf).

Department of Forestry and Wildlife. 2003. *Farmer's tree planting manual: a practical guide from seed to tree*. Ministry of Agriculture, Forestry and Fisheries, Cambodia.

El Bassam, N. 2010. *Handbook of bioenergy crops: a complete reference to species, development and applications*. Abingdon, UK, Earthscan.

Evans, J. 1992. *Plantation forestry in the tropics*. Second edition. Oxford, UK, Clarendon Press.

FAO. 1998. *Guidelines for the management of tropical forests. 1. The production of wood*. FAO Forestry Paper No. 135. Rome.

FAO. 2010. *Making integrated food-energy systems work for people and climate: an overview*. Rome (available at www.fao.org/docrep/013/i2044e/i2044e.pdf).

FAO. 2011. *Gender analysis for forestry development planning*. [video] (available at https://www.youtube.com/watch?v=rZ2EJsvDBnY).

FAO. 2015. *Global guidelines for the restoration of degraded forests and landscapes in drylands: building resilience and benefiting livelihoods*. Forestry Paper No. 175. Rome.

FAO. 2016. *Safe Access to Fuel and Energy (SAFE) toolbox: woodfuel assessment in displacement settings*. User guide. Rome (available at www.fao.org/documents/card/en/c/b1e6ca6a-9cc5-4538-8a97-e713037f7898).

FAO. 2017a. Forest management planning. In: *SFM toolbox* [online]. Rome (available at www.fao.org/sustainable-forest-management/toolbox/modules/forest-management-planning/tools/en/?type=111).

FAO. 2017b. Forest restoration and rehabilitation. In: *SFM toolbox* [online]. Rome (available at www.fao.org/sustainable-forest-management/toolbox/modules/forest-restoration-and-rehabilitation/in-more-depth).

FAO & UNHCR. 2016. *Assessing woodfuel supply and demand in displacement settings*, by R. D'Annunzio, A. Gianvenuti, M. Henry & A. Thulstrup. Rome, Food and Agriculture Organization of the United Nations and United Nations High Commissioner for Refugees.

Gautier, D., Hautdidier, B., Ntoupka, M., Onana, J. & Perrot, N. & Tapsou, T. 2002. *Fiches techniques des arbres utiles aux paysans du Nord Cameroun. Caractéristiques de l'arbre,* *ce qu'en font les paysans et ce qu'ils pourraient en faire*. Maroua, Cameroon, Institut de Recherche Agricole pour le Développement.

Gunning, R. 2014. *The current state of sustainable energy provision for displaced populations: an analysis*. London, Royal Institute of International Affairs, Chatham House (available at www.chathamhouse.org/sites/files/chathamhouse/field/field_document/20141201EnergyDisplacedPopulationsGunning.pdf).

HDRA. 2002. *Planting out firewood and fodder trees*. Coventry, UK, Garden Organic, formerly the Henry Doubleday Research Association.

ITTO. 2002. *ITTO guidelines for the restoration, management and rehabilitation of degraded and secondary tropical forests*. ITTO Policy Development Series No. 13. Yokohama, Japan, International Tropical Timber Organization (ITTO), Center for International Forestry Research (CIFOR), Food and Agriculture Organization of the United Nations (FAO), International Union for Conservation of Nature (IUCN) & WWF International.

Julliard, C., Truong, P., Diatta, M. & Goudiaby, V. 2001. *Pourquoi le vetiver (espèce herbacée) utilisé avec succès dans une centaine de pays pour la reforestation ne pourrait pas jouer le même rôle au Sénégal?* Paper presented at the International Symposium against Desertification and Reforestation, Dakar, Senegal. February 2001.

Ratha Krishnan, P., Kalia, R.K., Tewari, J.C. & Roy, M.M. 2014. *Plant nursery management: principles and practices*. Jodhpur, India, Central Arid Zone Research Institute.

Sabogal, C. 2005. Site-level rehabilitation strategies for degraded forest lands. In: International Tropical Timber Organization (ITTO) & International Union for Conservation of Nature (IUCN). *Restoring forest landscapes: an introduction to the art and science of forest landscape restoration*, pp. 101–108. ITTO Technical Series No. 23. Yokohama, Japan, ITTO.

Siyag, P. 2014. *Afforestation, reforestation and forest restoration in arid and semi-arid tropics: a manual of technology & management*. Dordrecht, the Netherlands, Springer Science.

Stott, G. & Gill, D. 2014. *How to design and manage a basic tree nursery*. Brief 4. Global Trees Campaign.

UNHCR. 2017. *Global trends: forced displacement in 2016*. Geneva, Switzerland, United Nations High Commissioner for Refugees.

UNHCR & IUCN. 2005. *Forest management in refugees and returnees situation: a handbook of sound practices*. Geneva, Switzerland, United Nations High Commissioner for Refugees and International Union for Conservation of Nature.

USAID. 1989. *Project assistance completion report: CDA forestry phase I, refugees area project*. Final report. Washington, DC, United States Agency for International Development.

Weidelt, H.J. 1976. *Manual of reforestation and erosion control for the Philippines*. Eschborn, Germany, Deutsche Gesellschaft fuer Technische Zusammenarbeit.

7 Annexes

Annex 1. Checklist for planning forest management in displacement settings

This checklist highlights the main aspects of forest management that should be borne in mind in the planning phase.

General aspect to check	Observations
1. Clear goals of the forest management plan?	
2. Hierarchy of needs? Woodfuel, timber, land rehabilitation, other?	
3. Alternative energy sources for cooking available?	
4. Available land for planting trees in and around the displacement setting?	
5. What knowledge is there on protected areas and environmental sensibilities?	
6. Authorization of local government on the use of land and for harvesting woodfuel?	
7. Time of the forest management plan? 5, 10 years? More?	
8. Existing organizations and groups of people to involve in planning forest management?	
9. Awareness and implications of unsustainable forest management?	
10. What role could the displaced people and host communities play in planning forest management?	
11. What role could the displaced people and host communities play in implementing forest management?	
12. What role could the displaced people play and host communities in monitoring?	
13. Main barriers and challenges for the implementation phase?	
14. What is the expected time for the forest management plan to become self-sustaining?	
15. Site conditions: climate, soil and topography?	
16. Drainage: is the area known for flooding?	
17. Wet and dry seasonality (in months and mm of rains)?	

PEOPLE

Displaced community	Observations
1. Right to leave the camp?	
2. Right to cultivate small plots? Inside the camp? Outside the camp?	
3. Right to harvest wood/cut trees (dead/green wood)?	
4. Main uses of forests (e.g. collecting woodfuel, food and other forest products, livestock grazing)?	
5. Competition for access to forest resources with local people?	
6. Gender of people in charge of harvesting wood?	
7. Assault/sexual violence issues?	
8. Sources of energy for cooking/heating?	
9. Maximum distance willing to walk for woodfuel collection?	
10. Existing organizations for wood harvesting?	

Host community	Observations
1. Sources of energy for cooking/heating? Only wood?	
2. Maximum distance willing to walk for woodfuel collection?	
3. Existing organizations for wood harvesting?	
4. Right to harvest wood/cut trees (dead/green wood)?	
5. Forestry professionals? Participation in previous reforestation programmes?	
6. Competition for access to resources with displaced people?	

Aspect to check	Observations
7. Gender of people in charge of harvesting wood?	
8. Assault/sexual violence issues?	
9. Main uses of forests (e.g. collecting woodfuel, food and other forest products, livestock grazing)?	

LOCAL AND INTERNATIONAL PARTNERS

Aspect to check	Observations
1. National forestry agency involved? Local government projects, concerns?	
2. NGOs or agencies with forestry skills in the camp?	
3. Trained and experienced forest managers in teams?	
4. Compatible projects in agriculture, horticulture, composting?	
5. Awareness-raising specialists in camp?	
6. Incentives programmes?	
7. Possibility of multiyear programmes?	

MAPPING INPUTS

Aspect to check	Observations
1. Are maps of camp surroundings available?	
2. What types of maps are useful for planning forest management?	
3. What land use/cover classes are useful for mapping?	
4. What change detection is essential for planning purposes (e.g. forest, shrubland, infrastructure, agriculture, burnt areas)?	

FOREST RESOURCE

Aspect to check	Observations
1. Three most common indigenous tree species and their use?	
2. Three most common exotic tree species and their use?	
3. Available estimates of wood in stands (m^3/ha) in the surrounding land use/cover classes?	
4. Available estimates of mean annual increment (MAI, in m^3/ha/yr) of surrounding natural forests and woodlands?	
5. Available estimates of the MAI (m^3/ha/yr) of tree plantations? (differentiate between indigenous and exotic tree plantations)	
6. Presence of seedlings/young trees?	
7. Forest degradation? Effect of distance from camp?	
8. Herding, grazing? Displaced/host communities?	
9. Pressure from other activities (e.g. agriculture, extension of camp)?	
10. Sites with stumps that could be protected? Regeneration zones?	

NURSERIES

General – nurseries	Observations
1. One central or several small nurseries?	
2. Seed sources – local, remote?	
3. Seed treatment material?	
4. Available space in the camp?	
5. Specific conditions (e.g. flooding)?	
6. Fencing material?	
7. Accessibility of site?	
8. Can displaced people work in the nursery?	

Water and protection	Observations
1. Is water available on site? (at least 0.25 litres per day per seedling)	
2. Need to pump water? Water quality?	
3. Regularity: is water available throughout the year, including in the dry season?	
4. Watering material?	
5. Sheds, buildings?	
6. Shading material or trees?	

Potting material	Observations
1. Sources of material for potting mix (e.g. compost, forest soil, light soil, manure)?	
2. Is compost available on site (camp)?	
3. Are containers (e.g. polypots) available?	
4. Are small tools (e.g. cutters, screens, shovels) available?	

OUTPLANTING

Outplanting	Observations
1. What transportation means are available (e.g. trucks, carts)?	
2. Is material available for fencing or individual tree protection?	
3. What tools are available for digging, weeding?	
4. Are skilled workers and managers available?	
5. Is the workforce flexible (e.g. to work given a few days' notice)?	
6. Is water available on site? Irrigation? Can water be transported to site?	

FENCING AND PROTECTION

Fencing and protection	Observations
1. Is it locally acceptable to fence parts of the forest or woodland?	
2. Are there known areas or water sources used for herding? Is there competition for such sites?	
3. Are fencing materials available on site?	
4. Are there any local construction companies?	
5. Will local people work alongside the displaced people?	
6. Will local people work as guards?	

Annex 2. Nursery management forms

1 - Nursery record for each species

Tree species – Common name	....
Tree species – Scientific name	....
Batch no.	....
Seed	....
Origin	....
Date of collection	....
Sowing	....
Date sown	....
Number sown	....
Pre-sowing treatments	....
Date of germination	....
Percentage of germination	....
Nursery care and outplanting	....
Fertilizer applied	....
Pest/disease control	....
Shading	....
Date of outplanting	....
Number of seedlings	....
Growth stage at outplanting (e.g. no. of true leaves)	....
Other information/comments	....

2. Blank nursery management calendar

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Setting up the nursery												
Seed pretreatment												
Select site for beds												
Mobilize guards and other workers												
Prepare material and equipment												
Sowing preparation												
Fill plastic pots												
Sowing												
Seedling care												
Weeding												
Fertilization												
Watering												
Pest/disease treatments												
Hardening off before outplanting												

Annex 3. Number of trees per hectare according to spacing

	Spacing of plants in the lines																					
Spacing between lines (m)	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.50	1.60	1.80	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00
0.5	40.000	33.333	28.571	25.000	22.222	20.000	16.667	14.286	13.333	12.500	11.111	10.000										
0.60	33.333	27.778	23.810	20.833	18.519	16.667	13.889	11.905	11.111	10.417	9.259	8.333										
0.70	28.571	23.810	20.408	17.857	15.873	14.286	11.905	10.204	9.524	8.929	7.937	7.143										
0.80	25.000	20.833	17.857	15.625	13.889	12.500	10.417	8.929	8.333	7.812	6.944	6.250										
0.90	22.222	18.519	15.873	13.889	12.346	11.111	9.259	7.937	7.407	6.944	6.173	5.556										
1.00	20.000	16.667	14.286	12.500	11.111	10.000	8.333	7.143	6.667	6.250	5.556	5.000	4.000	3.333								
1.20	16.667	13.889	11.905	10.417	9.259	8.333	6.944	5.952	5.556	5.208	4.630	4.167	3.333	2.778								
1.40	14.286	11.905	10.204	8.929	7.937	7.143	5.952	5.102	4.762	4.464	3.968	3.571	2.857	2.381								
1.50	13.333	11.111	9.524	8.333	7.407	6.667	5.556	4.762	4.444	4.167	3.704	3.333	2.667	2.222								
1.60	12.500	10.417	8.929	7.812	6.944	6.250	5.208	4.464	4.167	3.906	3.472	3.125	2.500	2.083								
1.80	11.111	9.259	7.937	6.944	6.173	5.556	4.630	3.968	3.704	3.472	3.086	2.778	2.222	1.852								
2.00	10.000	8.333	7.143	6.250	5.556	5.000	4.167	3.571	3.333	3.125	2.778	2.500	2.000	1.667	1.429	1.250	1.111	1.000	909	833		
2.50						4.000	3.333	2.857	2.667	2.500	2.222	2.000	1.600	1.333	1.143	1.000	889	800	727	667		
3.00						3.333	2.778	2.381	2.222	2.083	1.852	1.667	1.333	1.111	952	833	741	667	606	556		
3.50												1.429	1.143	952	816	714	635	571	519	476		
4.00												1.250	1.000	833	714	625	556	500	455	417	385	357
4.50												1.111	889	741	635	556	494	444	404	370	342	317
5.00												1.000	800	667	571	500	444	400	364	333	308	286
5.50												909	727	606	519	455	404	364	331	303	280	260
6.00												833	667	556	476	417	370	333	303	278	256	238
6.50																385	342	308	280	256	237	220
7.00																357	317	286	260	238	220	204
8.00																313	278	250	227	208	192	179
9.00																278	247	222	202	185	171	159
10.00																250	222	200	182	167	154	143

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