Kenya's Water Towers Protection and Climate Change Mitigation and Adaptation (WaTER) Programme

Component 4: Science to Inform Design of Community-Level Actions and Policy Decisions on Rehabilitation and Conservation of Water Towers

Training Manual for Forest Managers, Community-Based Organizations and Other Stakeholders

On

NATURAL FOREST REHABILITATION TECHNIQUES

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Kenya Forestry Research Institute (KEFRI)

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Captions for cover photographs
Top: A forest degradation hotspot in Cherangany Hills Forest Ecosystem. *Photo by J. Amwatta.*

Bottom left and right: A rehabilitated forest site in South Nandi showing the situation prior to rehabilitation interventions and six years after forest restoration interventions. *Photo by J. Otuoma.*

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Background to the WaTER Programme

The Kenya Water Towers Protection and Climate Change Mitigation and Adaptation (WaTER) Programme is a bilateral support by the European Union to the Government of Kenya. Its objective is to contribute to poverty reduction through the rehabilitation and sustainable management of forest ecosystem functions in Cherangany and Mt. Elgon water towers. Since Kenya's economy is largely nature-based, the project identifies forest degradation as a major cause of poverty because of its adverse effects on sustainable provision of forest ecosystem goods and services.

Ordinarily, degraded forests regrow naturally, but most of the degraded forests in Kenya have failed to regenerate due to repeat incidences of disturbance. A great deal of time and resources have gone into tree planting efforts to restore the degraded forest, but the outcome has been dismally poor. The situation has been attributed to inadequate capacity of forest managers and community forest associations (CFAs) to design, implement and successfully maintain natural forest rehabilitation projects. The purpose of this forest rehabilitation training manual is to build the capacity of forest managers, community-based organizations and key stakeholders in conservation and management of water tower ecosystems to successfully undertake rehabilitation of degraded forests.

The training manual is expected to serve as an invaluable material both for capacity building and for the design and implementation of forest restoration projects. For ease of reference, the training manual is subdivided into four modules, namely: (i) Module 1: Introduction to the training manual, (ii) Module 2: Levels of forest degradation, (iii) Module 3: Forest rehabilitation methods, and (iv) Module 4: Application of forest rehabilitation methods.

MODULE 1: INTRODUCTION TO THE TRAINING MANUAL

Introduction

- Why a training manual?
- Scope of this training manual
- Terminologies in forest rehabilitation

Learning objectives

By the end of this training module, trainees should be able to:

- Understand the significance of this rehabilitation training manual,
- Outline its scope, and
- Describe the terminologies often used in forest rehabilitation interventions

1.1 Why a training manual?

A significant proportion of Kenya's water towers and forest ecosystems are degraded and require forest restoration interventions. Several efforts have been made to rehabilitate most of the degraded forests and water towers, but lack of technical know-how on the procedures for carrying out forest restoration has led to poor results. Apart from ensuring the continued provision of forest ecosystem goods and goods, forest restoration is also important in mitigating the anticipated impacts of global climate change. The situation calls for the development of training manuals and extension guides on forest restoration and rehabilitation procedures.

This training manual has been developed by the Kenya Forestry Research Institute (KEFRI) with the support of the European Union with the aim of training forest managers, community groups, key stakeholders and other actors in forest conservation and management on the techniques and procedures of rehabilitating degraded forest sites. It is expected to strengthen their capacity in forest conservation and restoration leading to higher success rates in natural forest rehabilitation interventions for enhanced ecological and economic benefits for the people of Kenya, as outlined in Vision 2030.

1.2 Scope of this training manual

The training manual outlines the methods and procedures of rehabilitating degraded forest and woodland ecosystems. It links different levels of forest degradation with appropriate forest rehabilitation methods, and provides the procedures for carrying out rehabilitation in each case. It also illustrates a few examples of successful forest rehabilitation cases that have been carried out by KEFRI in selected forests in Kenya over the past decade.

1.3 Terminologies in forest rehabilitation

1.3.1 Forest restoration - the restoration of a degraded forest to its original state by re-establishing the presumed structure, productivity and species diversity of the forest originally present at the site.

1.3.2 Forest rehabilitation - the restoration of the capacity of a degraded forest to deliver forest products and services. It re-establishes the original productivity of the forest and some, but not necessarily all, of the plant and animal species thought to be originally present at the site.

Both forest restoration and forest rehabilitation are implemented on sites or in landscapes where forest loss has caused a decline in the quality of environmental services. They aim to strengthen the resilience of forest sites and landscapes with regard to ecological and economic functions. In this training manual, the two will be treated to mean the same thing, even though most attention will focus on forest rehabilitation.

1.3.3 Reconstruction – the restoration of native plant communities on land that had been converted to other forms of land use, such as crop production or pasture. Reconstruction approaches could include enriching the soil to increase organic matter content, weed control, and planting seedlings or direct seeding. Passive approaches rely on recolonization of the open land by natural dispersal means, but success can be limited by distance from appropriate source plants and the composition of initial colonizing species.

1.3.4 Reclamation - the restoration of severely degraded land, generally devoid of vegetation, often as a result of belowground resource extraction activities, such as mining or oil and gas drilling. Such sites require intensive management techniques in order to reestablish vegetation. Reclamation methods may include site amelioration to improve soil quality; seeding or planting seedlings; and providing regular irrigation and weed control to ensure early survival of seedlings. Occasionally, non-native species are used as nurse plants to encourage the emergence and growth of native vegetation. Reclamation may require multiple interventions to achieve subordinate objectives, with the ultimate desired function not being achieved for decades.

MODULE 2: LEVELS OF FOREST DEGRADATION

Levels of forest degradation

- Interrupted forest
- Disturbed forest
- Bushland
- Open fields
- Bare soil

Learning objectives

By the end of this training module, trainees should be able to differentiate the following terms, as used in forest rehabilitation:

- Interrupted forest
- Disturbed forest
- Bushland
- Open fields
- Bare soil

Several levels of forest degradation are recognized.

2.1 Interrupted forest

Interrupted forests are sites within old growth primary or secondary forest with huge canopy gaps as a result of selective harvesting of wood that leads to alteration of the forest structure, functions and dynamics beyond the short-term resilience of the ecosystem. The tree cover in these sites ranges between 50 and 75% and such sites may manifest very high vigour for natural recovery, with most of the regrowth arising from stumps. Depending on the species composition and habitat condition, they require at least 20 years, in the absence of further disturbance, to attain a continuous forest cover.

2.2 Disturbed forest

Disturbed forest sites include areas where the forest cover has been severely reduced by excessive harvesting of wood and / or non-wood forest products, poor management, repeat incidences of fire, grazing or other disturbances to a degree that delays forest regeneration after abandonment. The tree cover in these sites ranges between 10 and 50%. Recruitment and regrowth of woody species in these sites may be delayed because of site quality limitations, competition from herbaceous and shrubby life-forms, low species diversity and isolation of the site from potential seed sources.

2.3 Bushland

These are sites that were previously under closed canopy natural forest cover, but which have been degraded and consequently dominated by shrubs, scrub and saplings of 1– 3m in height.

2.4 Open fields

Open fields are sites where the forest cover has been lost through clear felling of trees causing damage to the soil and vegetation to a degree that inhibits or severely delays the recruitment and growth of woody species. These sites are devoid of trees and are dominated by a continuous layer of grass, herbs, scrubs or low shrubs of ≤ 2 m in height. In cases where some vegetation is left in the landscape, the tree cover is normally ≤ 10 %. In forest restoration interventions, it is important to differentiate open fields arising from forest degradation from natural glades.

2.5 Bare soil

This is forest land that has been denuded of all forms of vegetation through processes such as fire, landslide, cultivation or extreme exploitation of forest resources. These sites are prone to soil erosion.

MODULE 3: FOREST REHABILITATION METHODS

Forest rehabilitation methods

1. Passive forest rehabilitation methods
    - Natural regeneration
    - Liberation thinning
2. Active forest rehabilitation methods
    - Enrichment planting
    - Strip planting
    - Group planting
    - Mixed stand planting

Learning objectives

By the end of this training module, trainees should be able to understand the following forest rehabilitation methods:

i. Passive forest rehabilitation methods
- Natural regeneration
- Liberation thinning

ii. Active forest rehabilitation methods
- Enrichment planting
- Strip planting
- Group planting
- Mixed stand planting

There are two broad approaches to forest rehabilitation, namely: passive forest rehabilitation methods and active forest rehabilitation methods.

3.1 Passive forest rehabilitation methods

Passive forest rehabilitation methods are forest restoration techniques that do not entail tree planting. They rely on the capacity of the degraded forest site to regenerate naturally.

3.1.1 Natural regeneration

Natural forest regeneration is a passive forest restoration technique that involves protecting a degraded site from external interference, such as fire and grazing, to allow it to recover naturally. The technique is employed in situations where some trees are left in the landscape to act as seed sources during forest regeneration. This approach is best suited to situations where degradation is not extensive and residual forest patches remain or some advanced forest regrowth is already present. It relies on dispersed seed, seeds stored in the soil and stump sprouts. Assessing the capacity of these sources of regeneration to capture new growing space is essential for the success of this forest restoration technique. Natural regeneration methods are generally less expensive than active regeneration methods and always result in species that are well adapted to the

rehabilitation site. KEFRI has successful applied this forest rehabilitation method in Wire (Figure 1) and Kibiri forest ecosystems in western Kenya.

Figure 1: Changes in vegetation structure at Got Nyaksure site in Wire Forest as a result of natural forest regeneration by KEFRI between 2007 and 2016. (*Photos*: John Otuoma)

Natural regeneration approaches are most likely to succeed under the following conditions:

a) The topsoil remains onsite after disturbance.
b) Availabilityof well-preservedforest fragments in close proximity withthe degraded site.
c) Availability of sprouting natural vegetation that promotes rapid early growth and soil stabilization.
d) Availabilityofseeds of early and late successional woody species in the soil seed bank and in seed rain.
e) Availability of common and rare native species that are able to colonize the site over the long term.
f) Weed suppression occurs rapidly after site abandonment.
g) A high diversity of fauna (insects and vertebrates) serving as pollinators and seed-dispersal agents in the landscape.
h) Site protection against frequent fires.
i) Controlled harvesting of litter and forest products or total lack of it.
j) Site protection from grazing and agricultural use.

3.1.2 Liberation thinning

This refers to clearing a degraded forest site of herbs and shrubs that inhibit natural forest regeneration. It applies where a degraded forest site has high potential for natural regeneration, but woody regrowth is swamped by herbaceous and shrubby life-forms. Liberation thinning creates space for light capture and lessens competition from shrubby and herbaceous plants. The practice is akin to carrying out thinning in a naturally regenerating stand.

3.2 Active forest rehabilitation methods

These are forest restoration techniques that rely on planting of trees to rehabilitate degraded forest sites. They apply in situations where degraded forest sites have limited or no potential for natural regeneration.

3.2.1 Enrichment planting

Enrichment planting,also referred to as aided or assisted regeneration in some cases, seeks to supplement biological diversity by reintroducing key native species to hasten the process of natural recovery. This intervention is suitable for naturally regenerating degraded sites with low species diversity and stem density. It involves opening gaps or strips of 2m to 5m in an east-west orientation in the forest canopy to plant seedlings or sow seed of the desired tree species. The size of the canopy opening should be adjusted to match the light tolerance levels of the species being planted.

Enrichment planting can also be applied in situations where exotic monoculture timber plantations have been established, but the management objective has changed from production to conservation.

It is often referred to as aided forest regeneration in situations where naturally regenerating woody plants are still young and planting is, therefore, carried out in order to introduce framework species to accelerate natural forest regrowth. The planted tree species often constitute fast growing late successional pioneers (light demanding) and early intermediate species (shade tolerant) e.g., *Harungana madagascariensis, Bridelia micrantha, Blighia unijugata, Bersama abyssinica, Cordia africana, Measa lanceolata, Neoboutonia macrocalyx, Polyscias fulva, Albizia gummifera, Ekebergia capensis* and *Allophyllus abyssinica*. KEFRI successfully applied this forest restoration method in Gwassi hills to rehabilitate a degraded forest land between 2009 and 2017 (Figure 2).

Figure 2: Changes in vegetation cover from farmland to closed canopy forest at the Kisaku rehabilitation site in Gwassi hills between 2009 and 2017 as a result of aided forest regeneration by KEFRI (*Photo*: John Otuoma).

3.2.2 Strip planting

Strip planting is a form of enrichment planting where strips are cleared within a thicket in a degraded forest site in an east-west orientation in order to plant trees along the strips. Holes are made along the strips in which trees are planted. The purpose of trip planting is to enhance woody species richness or stem density, or both.

3.2.3 Group planting

Group planting refers to planting groups of widely spaced seedlings of different native tree species in open spaces measuring between 1 and 10 ha located either within or on the edge of an intact natural forest. Large gaps are left unplanted in between different groups of seedlings. Over time, the unplanted spaces are occupied by recruits arising from the soil seed bank and / or dispersed seed, while planted trees spread their crowns to cover the natural recruits. It results in a forest stand comprising trees of different ages, sizes, stem-form and crown shape. This forest restoration technique creates an artificially planted forest that closely resembles a natural stand. It is appropriate for extensively degraded forest sites using preferably fast growing secondary pioneers to accelerate faster emergence to out-compete herbaceous and shrubby life-forms. At least three tree species should be planted in a mixed formation. The planted trees generally act as nurse trees. Within a group, slow growing species and those with spreading crowns should be planted on the outside. It may be necessary to reconstruct the pre-disturbance spacing between naturally growing trees in deciding on the appropriate spacing regime for seedlings. A group can consist of any number of seedlings, between 3 and 25 (Figure 3). It is often applied in degraded forest sites with limited potential for natural forest regeneration.

KEFRI successfully demonstrated this forest restoration method in Lomuge area in Cherangany Hills Forest to rehabilitate a degraded forest in 2014. Ten restoration tree species were planted in a random mix of at least five species in a group. Fast growing and nitrogen fixing species were planted at the centre as nurse trees as shown in figure 3.

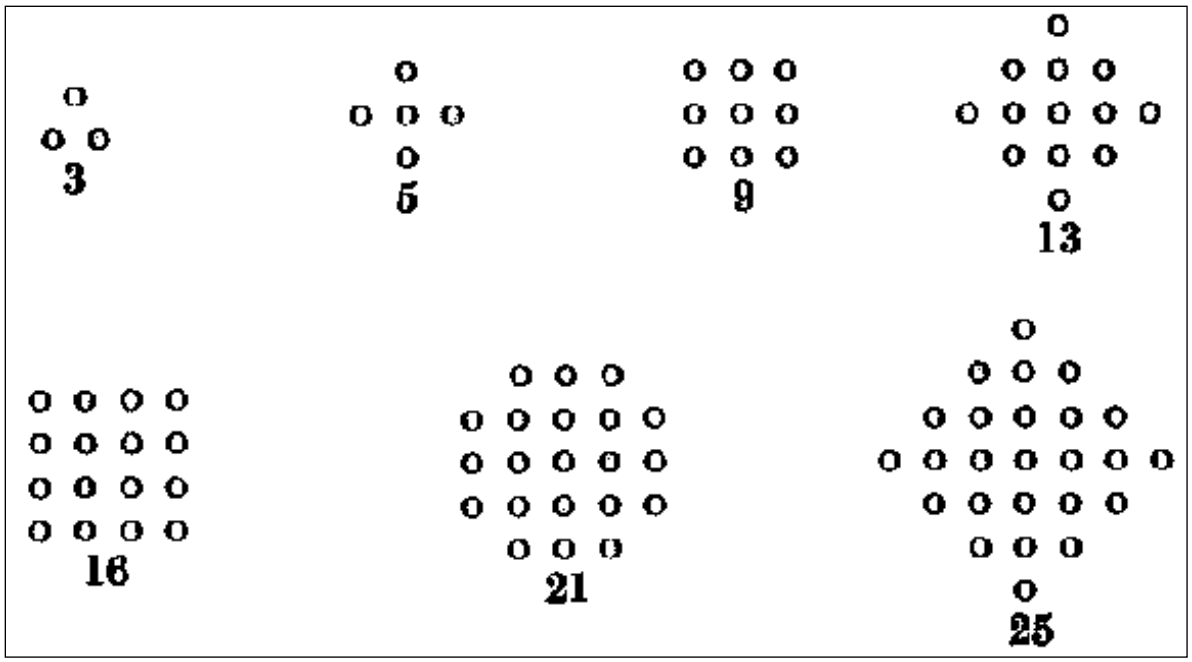

Figure 3: Different formations of group planting in natural forest restoration

3.2.4 Mixed stand planting

Mixed species planting is similar to establishing a forest plantation, only that it involves planting a wide range of indigenous native species. It is applicable in very large open fields. Seedlings are planted at a density of 1600 – 2500 stems per hectare in a mixed design under standard plantation practices.

Where spacing between planted seedlings is reduced to between 2m and 1m, in which case the number of planted seedlings if between 2,500 and 10,000, the method is referred to as dense planting with several tree species. This forest restoration method is applicable in degraded forest sites without potential for natural regeneration, which makes planting inevitable. KEFRI has successfully applied this rehabilitation technique in South Nandi Forest and Sinen area in Cherangany Hills Forest using a mix of light-demanding and shade-tolerant woody species at varying spaces of 0.3 and 1m (Figure 4).

Figure 4: Changes in vegetation structure between 2009 and 2016 under dense planting by KEFRI in South Nandi Forest.

MODULE 4: APPLICATION OF FOREST REHABILITATIONMETHODS

Procedure for carrying out forest rehabilitation

- Key guiding principles
- Implementing a rehabilitation plan
- Maintenance and monitoring

Learning objectives

By the end of this training module, trainees should be able to understand:

- Procedures for implementing forest restoration methods, and
- Key guiding principles for planning, implementing and monitoring forest rehabilitation projects.

4.1 Procedures for implementing forest restoration methods

The following procedures are applicable in implementing the rehabilitation methods discussed in Module 3 above.

4.1.1 Key guiding principles

- Identify the level of forest degradation and match it to the most appropriate forest restoration method (use Table 1 below a reference guide)
- Identify target forest restoration species based on pre-disturbance species associations
- Source for quality seed / seedlings, preferably from approved distributors
- The recommended seedling size for enrichment planting is 45 cm. Group planting and mixed stand planting require seedlings of at least 30 cm in height.
- The recommended minimum size of wildings is 45 cm.
- The species mix depends on the rehabilitation objectives and the inter-specific interactions between target species.

4.1.2 Carrying out planting

- Pitting - the pit size should be 45 cm diameter by 45 cm depth
- Planting - ensure enough moisture buildup before planting- approximately 2 weeks after the first rains
- Maintenance -spot weeding should be done at 1 m diameter and 4 inches depth
- Weeding should be done twice a year, preferable during the long and short rains, for the first two years

4.1.3 Protecting the rehabilitation site from disturbance

The following measures should be taken to protect the rehabilitation site from disturbance:

- Erect barriers / enclosures - where necessary, barriers should be erected to keep away browsers and grazers, including livestock

- Protect the site from fire hazards using standard practices e.g. firebreaks, education and awareness on fire risks.
- Adequately sensitize forest adjoining communities to participate in forest protection

Table 1: Recommended rehabilitation approaches for different levels of forest degradation

Degradation level/ type		**Area (ha)**	**Proximity to natural forest (m)**	**Intervention methods/approaches**
Bare soil condition	Abandoned Quarry	0 - 10	All proximities	Mixed stand planting, with closely-spaced trees
	Landslide sites	0 – 10	All proximities	Mixed stand planting
	Fire disturbed sites	> 10	All fire disturbed sites	Natural regeneration / enrichment planting
Open fields (excluding natural glades)		0 - 10	0 – 500	Group planting / mixed stand planting
		> 10	All proximities	Mixed stand planting
Bushland		0 - 10	All proximities	Natural regeneration / enrichment planting
		> 10	All proximities	Natural regeneration / enrichment planting
Disturbed natural forest		All	All	Natural regeneration / enrichment planting
Interrupted forest		All	All	Natural regeneration

4.2 Planning, implementing and monitoring forest rehabilitation projects

The following guiding principles are important to consider when planning, implementing and monitoring a forest rehabilitation project.

4.2.1 Site selection for rehabilitation

Sites for forest rehabilitation projects may vary in size from a few hectares to several thousand. The selection process requires careful consideration of social and legal factors, such as land tenure and prevailing policy and legal framework. It is crucial to clarify ownership and tenure at the outset to avoid future disputes. Any forest restoration initiative should have strong buy-in from key stakeholders, both public and private, who should see clear benefits from the initiative.

Possible sites for forest rehabilitation projects include: logged-over or poorly stocked secondary forests in need of supplementary natural regeneration through enrichment planting; degraded natural forest ecosystems in protected areas to be used for watershed management, wildlife conservation, ecotourism or community development; wildlife habitats or migratory corridor; alluvial sites along streams, rivers and other water bodies

to preserve riparian zones; steep slopes at risk of soil erosion and landslides; unproductive sites that are suitable for producing forest products; and unproductive industrial wood plantations that are suitable for conversion to natural or semi-natural forest.

4.2.2 Understanding drivers of deforestation or forest degradation

Understanding and effectively addressing the drivers of deforestation and forest degradation at a specific site or in a specific landscape is key to the success of any forest restoration plan.

4.2.3 Identifying the rehabilitation goals

In order to design and deploy an effective rehabilitation approach, rehabilitation goals and desired outcomes must be clearly defined and understood by key stakeholders for ownership of the process. For example, is the goal of the rehabilitation effort to provide environmental services (e.g. water and soil protection), enhance land productivity, produce wood and non-wood products, support livelihoods, contribute to poverty alleviation (e.g. by supplying a variety of forest products to local communities), or create landscapes that sequester large quantities of carbon and are diverse, productive and resilient to adverse changes? Is it some combination of these? Once a goal is identified, rehabilitation approaches can be refined through considerations of site size, shape, and context. Although multiple benefits can derive from a single rehabilitation strategy, species mixes and rehabilitation techniques can be unique to each goal. Generally, understanding restoration and rehabilitation needs and priorities prior to designing an approach will likely lead to higher success at a lower cost.

4.2.4 Stakeholder engagement

Forest rehabilitation efforts are only sustainable if they are accepted and owned by relevant stakeholders. Principal stakeholders in forest rehabilitation interventions include forest managers, local communities, concessionaires and county governments. They should be engaged from the start, for example when preparing the rehabilitation action plan. The engagement may involve discussions on long-term objectives of the rehabilitation initiative, roles and responsibilities of each party, distribution of costs, incentives and benefits, and dealing with trade-offs in addressing the drivers of forest degradation. It is important to identify potential incentives and benefits at this stage and discuss how the same will be shared out. The most obvious financial benefits from forest rehabilitation may include employment opportunities, proceeds from harvesting of forest products, ecotourism and payments for environmental services, where applicable. It is also important to considered non-financial benefits, such as improvements in the environment and strengthening of land-tenure.

4.2.5 Developing a forest rehabilitation plan

It is important to follow defined rehabilitation goals and objectives agreed upon by various stakeholders and select suitable rehabilitation methods. In degraded logged-over forests that still have populations of desirable tree species, natural forest regeneration is likely to be most effective. It is particularly promising if tree seedlings (or other forms of natural regrowth) are already present at the site, indicating that site conditions are suitable

for natural regeneration (and possibly that viable seeds are being dispersed by parent trees). The success of a natural forest regeneration approach will be determined by, among other things, adequate production of regenerative materials, such as seeds by the parent vegetation at suitable times, good weed control, and the receptiveness of the site to seedling establishment at the time of seed fall.

In open, largely deforested areas that have been subjected to, for example, intensive livestock grazing or mining, natural regeneration of trees or shrubs may be difficult due to lack of seed sources and loss of topsoil. In such cases, it may be necessary to plant trees, shrubs and grass species for successful forest restoration and rehabilitation. Tree-planting is one of the most common activities in forest rehabilitation projects, but it is not as simple and easy as it may appear and by no means is it the end of the rehabilitation process – the long-term commitment of all stakeholders is to manage and maintain rehabilitated forest areas.

Choice of species to be used for forest restoration is also an important aspect in forest rehabilitation. The choice of species depends on the goals of the forest rehabilitation project, the prevailing site conditions and the availability of parent trees or planting stock. In general, native species should be used in preference to exotic ones because they are likely to pose a lower environmental risk (especially in terms of invasiveness) and have biodiversity benefits. If, however, there is a lack of native species suitable for colonizing barren land, grassland or forest clearings, the establishment of a suitable "nurse crop" of sturdy pioneer or introduced species may be beneficial.

Potential adverse environmental and social impacts of the rehabilitation intervention should be assessed, and mitigated where possible. For instance, species should be selected in consultation with local communities, taking into account ecological, social, economic and cultural factors.

4.2.6 Seedling production for rehabilitation

In forest rehabilitation projects where the aim is to restore or re-establish a natural forest, efforts should be made to obtain seeds of suitable plant species and raise seedlings for planting. It may be necessary for the rehabilitation project to produce its own tree seedlings, possibly with community groups. Alternatively seeds can be sown directly in the rehabilitation area after experimentation to determine the most successful direct-seeding techniques.

4.2.7 Tree planting

For planting to succeed, the following considerations should be made:

- A combined density of planted and / or naturally regenerating seedlings or trees in the range of 400–1,000 stems per ha is usually sufficient to rehabilitate a forest site.
- The optimal height of seedlings for planting is generally considered to be in the range of 30 to 45 cm. When planting into existing vegetation, however, a seedling height of 50–75 cm may be required because taller plants are more likely to compete successfully with other plants, particularly weeds.

- Planting deforested or degraded sites requires sturdy plants that have been hardened off in the nursery and watered prior to planting. In bare areas, it may be necessary to establish nurse crops of fast-growing species prior to planting or to maintain secondary vegetation for site protection.
- The best time to plant trees is early in the rainy season to ensure that newly planted seedlings receive adequate moisture in their first months as they develop their root systems.

4.2.8 Capacity building and training of stakeholders

Ongoing capacity development through training, extension support services and the strengthening of local capabilities is essential for improving planning, management and technical decision-making in forest rehabilitation to enable actors to understand and respond to the priority needs and aspirations of stakeholders. In particular, nursery managers and staff should be trained and supported to produce high-quality seedlings with the best possible chance of establishing in the field and growing rapidly when planted out in the often difficult environment of a deforested or degraded site.

4.2.9 Establishing a realistic budget and work plan

Forest rehabilitation is a long-term investment with short-term and long-term financial needs. For instance, it requires costs for seedling production in the nursery. A simple community tree nursery with the capacity to produce 10,000 to 20,000 seedlings per year can be established with about KES 100,000. Thereafter, the costs associated with site preparation for rehabilitation, planting, weeding, replanting (beating-up) and monitoring from the first to the third year after planting can be estimated at 250 man-days per ha per year (assuming KES 500 per man-day), which translates to KES 125,000 per ha, excluding costs associated with site protection. Thus, the total cost of executing a successful forest rehabilitation project, including seedling production, all materials and labour for planting, maintenance and monitoring for three years, is likely to be in the range of KES 675,000 per ha.

It is a common mistake to underestimate the total time required to implement and maintain forest rehabilitation projects. Sometimes, it is better to plant relatively small areas annually over several years than to plant a large area in a single season and have a large number of planted trees wither because of poor maintenance, wrong choice of species or adverse weather conditions in a particular year.

4.2.10 Maintenance and monitoring

Tree seedlings, whether planted or established naturally, need to be protected for up to five years after establishment against competition from weeds; wildfire; and browsing by wild and domestic animals. In seasonally dry climates, an effective fire prevention programme is essential. Survival counts should be conducted 3–6 months after planting to assess the establishment rate. Dead seedlings should be replaced early in the next rainy season, ideally with seedlings of a similar species to those surviving at the site. Maintenance activities should include the following silvicultural treatments:

Weed control **-** Dense weed growth retard the growth of both naturally regenerating and planted seedlings, and can cause their death as a result of competition for moisture, nutrients and light. Weed control helps newly established trees to survive and grow by minimizing competition. Chemical weeding in forest rehabilitation projects is risky and, for ecological reasons, should be avoided as much as possible.

Tending and thinning **-** Tending and thinning in naturally regenerating and planted stands are silvicultural operations to improve stand quality by eliminating or suppressing undesirable vegetation, including climbers and vines, and removing poorly formed, damaged or diseased trees. The objective is to increase crown development and diameter growth of desirable trees, concentrate future increment on the best-formed trees, and increase the stability of the stand by giving more growing space to the roots and crowns of the potential final crop trees. Tending and thinning operations are decisive factors in the achievement of production goals.

4.2.11 Scaling out results

Although scaling up successful forest rehabilitation results normally comes much later during the rehabilitation project, it must be planned early to ensure the sustainability of the project. This may entail incorporating scaling up strategies in the rehabilitation plan and also making it part of stakeholder engagements. Similarly, it can be made part of long-term costs in the rehabilitation budget.