Insights into Reforestation Practices with Indigenous Species at the Kafa Biosphere Reserve, Ethiopia

Handbook for Practitioners

Imprint

NABU project

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BMZ	German Federal Ministry for Economic Cooperation and Development
BR	Biosphere Reserve
EBI	Ethiopian Biodiversity Institute (former Ministry of Environment, Forests and Climate Change (MEFCC))
EWNHS	Ethiopian Wildlife and Natural History Society
FAO	Food and Agriculture Organisation
GIS	Geographical information system
GPS	Global positioning system
ha	Hectare/s
IBC	The Institute of Biodiversity Conservation
IUCN	International Union for Conservation of Nature
m.a.s.l.	Meter above sea level
MoST	Ministry of Science and Technology
NABU	The Nature and Biodiversity Conservation Union
NGO	Non-governmental organisation
PFM	Participatory forest management
SSA	Sub-Saharan Africa
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
WBISPP	Woody Biomass Inventory Strategic Planning Project

How to use this manual

Dear extinguished reader,

The aim of this manual is to share our experience and lessons learned from more than 10 years of reforestation at the Ethiopian Kafa Biosphere Reserve. We would like to give insights, share challenges and potential solutions and inspire other practitioners to follow our example – in Ethiopia and beyond!

The manual could be your reference guide for prospective reforestation. You will find information on definitions on forest topics, the status of forests at the Kafa Biosphere Reserve, drivers of deforestation, and a step-by-step guide for implementing reforestation activities. In a step-by-step approach you will be led through the process NABU is usually following, including potential challenges as well as recommendations.

Please share this manual with relevant actors in your surroundings in order to achieve the biggest outreach possible for effective reforestation!

Your NABU team

1. Introduction

1.1 Forest degradation in Africa and Ethiopia

Forests in Africa play a critical role in supporting livelihoods of millions via timber and non-timber forest products, including food and nutrition, energy, and other environmental services. However, mismanagement of forests has resulted in **deforestation and forest degradation**. The highest deforestation and forest degradation rates in sub-Saharan Africa (SSA) typically occur in the Sahel and dry forests, due to increasing demand for land coupled with rampant poverty and lack of alternative livelihood options. Furthermore, the land and forest tenure and access to forest resources are largely not defined or non-existent to many people in the SSA (FAO, 2008). With regards to deforestation in Africa, agricultural activities account for 80% and inappropriate firewood collection coupled with charcoal production are responsible for 45%. Logging contributes 35% and fire plays a minor role with 10% (Hosonuma et al., 2012).

Hence, the drivers of forest degradation can largely be linked to economically driven human activity such as land degradation and clearing of forests. These pervasive human activities add to the ecological challenges, which normally occur with forest degradation and fragmentation that have a serious effect on forest function. Fragmented forests are usually more degraded than the intact forests due to the high degree of edges. Those create a hard boundary and ecological challenges: a more altered microclimate at the edges than in the forest's interior resulting in a higher rate of mortality in seedlings as well as trees (Laurence et al., 1998). Just like other tropical forests, Ethiopia's moist evergreen forests have become extremely fragmented (Getahun et al., 2013), with the Global Forest Resource assessment 2015 (FRA, 2015) putting the deforestation rate for forest estimated to be 1.25% per year and for other woodlands 1.8% per year.

1.2 The case of Ethiopia: Background information and useful definitions

Forest fragmentation can be defined as the "breaking apart" of continuous forest into distinct pieces. When it occurs, three interrelated processes take place: habitat loss, subdivision into remnants or fragments, and introduction to other forms of land use that replace the forest. Among several issues, institutional instability has been considered as one of the main obstacles for sustained and successful forest management practices in African countries such as Ethiopia. Although sporadic, there have been some interventions focused on conserving, developing and managing forests in Ethiopia. Among the main measures, preventing further degradation and deforestation were the main objectives, while other efforts were focused on the restoration of degraded forestlands. Reforestation and afforestation (see Box 1 to 3 for definitions) are among the earliest forest management interventions promoted in Ethiopia.

"**Deforestation**" is the conversion of forest to another land use or the long-term reduction of tree canopy cover below the 10% threshold (FRA, 2000).

Deforestation implies the long-term or permanent loss of forest cover. Such a loss can only be caused and maintained through a continued man-induced or natural perturbation. Deforestation includes, for example, areas of forest converted to agriculture (including agroforestry), pasture, water reservoirs, and urban areas. The term specifically excludes areas where the trees have been removed due to, for example, harvesting or logging, and where the forest is expected to regenerate naturally or with the aid of silvicultural measures within the long term. Unless followed by clearing of the remaining logged-over forest for the introduction of alternative land uses, and the maintenance of the clearings through continued disturbance, forests commonly regenerate, although often to a different, secondary condition. In areas of shifting agriculture, forests, forest fallows and agricultural lands appear in a dynamic pattern, where deforestation and the return of forest occur frequently in small patches. Deforestation also includes areas where over-utilisation or changing environmental conditions influence the forest to an extent that it cannot (currently) sustain a tree cover above the 10% threshold; this includes for example (i) burnt-over areas where severe ground conditions or recurring fires prevent the return of forest formations in the long-term; or (ii) areas that, after clear-cutting, cannot regenerate because of frost, competing vegetation, or other natural conditions. The concept "long-term" is central in this definition and is defined as ten years. Local climatological conditions, land use contexts, or the purpose of the analysis may however justify that a longer time frame is used.

Box 1. Definition of deforestation

For instance, the forest areas that harbour wild coffee in the southern part of the country have been modified or destroyed by various causes such as settlements, agricultural activities, and timber extraction in the last thirty years (Reusing, 1998). The traditional agroforestry production systems in this part of Ethiopia include the so called "forest coffee" and "semi-forest coffee", in which the difference is the management intensity (Aerts et al., 2011).

"**Reforestation**" is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but has been converted to non-forested land (FRA, 2000).

The definition of forest clearly states that forests under regeneration are considered as forests, even if the canopy cover is temporarily below 10%. Many forest management regimes include clear-cutting followed by regeneration, and several natural processes, notably forest fires and windfalls, may lead to a temporary situation with less than 10% canopy cover. In these cases, the area is considered as forest, provided that the re-establishment (i.e. reforestation) to above 10% canopy cover takes place within the relatively near future (Figure 1). As for deforestation, the time frame is central. The concept "temporary" is central in this definition and is defined as less than ten years. Local climatological or land use contexts, or the purpose of the analysis may however justify that a longer time frame is used.

Box 2. Definition of reforestation

"**Afforestation**" is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources (FRA, 2000).

Afforestation is the reverse of deforestation and includes areas that are actively converted from other land uses into forest through silvicultural measures. Afforestation also includes natural transitions into forest, for example on abandoned agricultural land or in burnt-over areas that have not been classified as forest during the barren period (Figure 1). As for deforestation, the conversion should be long-term. Therefore, areas, where the transition into forest is expected to last less than ten years, for example due to recurring fires, should not be classified as afforestation areas. The concept "long-term" is central in this definition and is defined as ten years. Local climatological conditions, land use contexts, or the purpose of the analysis may however justify that a longer time frame is used.

Box 3. Definition of afforestation

The semi-forest coffees are characterised by rigorous interventions such as removal of competing shrubs and selective thinning of the upper canopy, while the coffee forests exhibit almost no human intervention to increase coffee productivity (Schmitt et al., 2009). In order to arrest and reverse this situation, the government of Ethiopia and its people are committed to plant trees. Among these initiatives, afforestation on open lands and reforestation/ rehabilitation of degraded forestlands are the main actions in pursuit. Over the last two decades, various plantation campaigns have been underway, in which a great number of open and degraded lands were put under tree plantation. Despite this fact, however, the survival rate of the plantations remained challenging to narrow the net forest loss in effect.

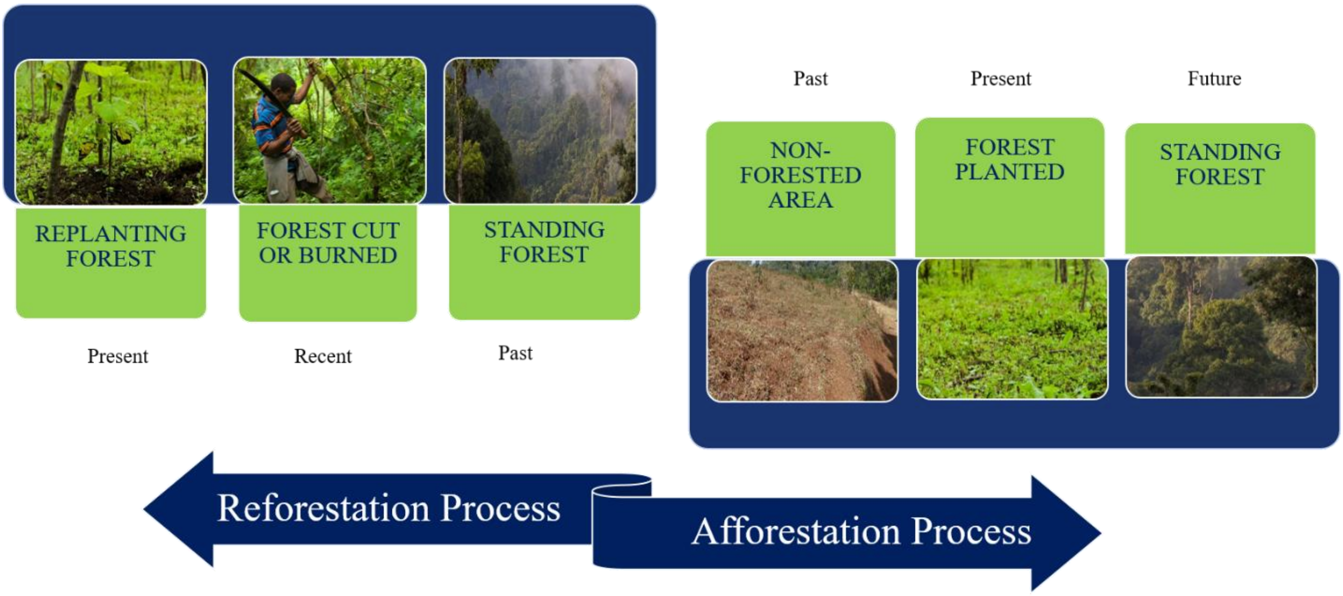

Figure 1. Reforestation and afforestation processes

2. NABU's work in Kafa

Since 2006 NABU has been supporting people and nature in Ethiopia. NABU is a registered international NGO and operates offices in the capital Addis Ababa and in different parts of the country. Starting with the establishment of Kafa Biosphere Reserve, NABU pursued implementing large scale conservation projects in the area, funded by the German government. Upon the establishment of Kafa Biosphere Reserve, NABU, UNESCO, and the Ministry of Science and Technology of the Federal Democratic Republic of Ethiopia signed a Memorandum of Understanding to establish a network of biosphere reserves in Ethiopia. Since then, NABU became one of the main stakeholders supporting UNESCO biosphere reserves in the country. NABU implements projects on biosphere reserve management, sustainable development and income generation, conservation, rehabilitation, and adaptation to climate change. In particular, NABU promotes community-based resource management systems as an effective tool against habitat fragmentation and degradation.

NABU is Germany's oldest and largest conservation NGO with its headquarter in the capital and 15 regional branch offices in almost every federal state of Germany. 2,000 volunteer groups around the country support NABU's work. NABU is the German partner of the global alliance BirdLife International and works closely with its partner organisations around the world. NABU has established partnerships with IUCN, UNESCO or FAO and runs an alliance partnership with the German Federal Ministry for Economic Cooperation and Development (BMZ). NABU has gained wide-ranging experiences in Ethiopia and is well accepted as technical advisor and partner, for instance for the Ethiopian Biodiversity Institute (EBI), the former Ministry of Environment, Forests and Climate Change (MEFCC), and the former Ministry of Science and Technology (MoST). Our expertise comprises (1) biodiversity/ ecosystem assessments and monitoring, (2) ecosystem restoration and management, (3) conservation of habitats and set up of UNESCO biosphere reserves, (4) climate change, (5) education and awareness creation, and (6) sustainable development.

Since 2009, NABU is implementing reforestation with indigenous species at the Kafa Biosphere Reserve. Since then we reforested at least 800 ha of natural Afromontane cloud forests, set up Community Forests with fast growing species and supported the reduction of CO_2 emissions of annually 56.742 tons.

3. Forests at the Ethiopian Kafa Biosphere Reserve

3.1 Abiotic and biotic factors

The Kafa Biosphere Reserve is located in the Kafa Zone, in the Southern Nations, Nationalities and Peoples Regional State in Southwest Ethiopia, covering an area of 760,000 ha. The rainfall in the area is uni-modal, with low rainfall from November to February, and the wettest months between May and September (Schmitt, 2006). The annual rainfall is around 1,800 mm per year. It also has an extremely diverse topography with altitudes ranging from 1,020 m.a.s.l. to 3,350 m.a.s.l., and an average annual temperature of 19.45°C (Dresen, 2014).

The ranges of altitudes create a transition of flora: at the highest altitudes, a complex vegetation structure of evergreen mountain forests and grasslands is dominant, while further down the mountain slopes the Afromontane moist evergreen broadleaf forest or cloud forest is home to the wild *Coffea arabica*. For instance, the forests around Bonga town or region are classified as Afromontane rainforest (Friis, 1992). The biosphere reserve (BR) harbours 45,000 ha of extensive wetlands and floodplains that are parts of the headwater of Gojeb, Baro, and Gilo, draining into the Omo-Gibe and Baro-Akobo river basins (NABU, 2017a).

According to the IBC (2005), there are five main habitat types at the Kafa Zone (see Table 1).

Table 1. Main habitat types at Kafa (NABU, 2017a)

Habitat type	Description
Evergreen montane forest and grassland complex	This complex habitat occurs between altitudes of 1,900 and 3,300 m.a.s.l. and covers 52% of the BR. It includes much of the highlands located within the proposed buffer area of the BR. This habitat occurs in areas which are often densely populated, leading to pressures from expansion of arable land.
Moist evergreen montane forest	This habitat occurs between 1,500 and 2,600 m.a.s.l. and covers 26% of the BR. This type of forest is of global conservation significance due to the occurrence of the wild *Coffea arabica*. In addition to deforestation for arable land, timber extraction is a major threat to this habitat.

Wetlands	A complex system of wetland habitats occurs between 900 and 2,600 m.a.s.l., covering 6.6% of the BR. These sensitive ecosystems are of utmost importance for the local communities, for example in providing materials for building shelter, for grazing and freshwater supply. At the same time wetlands are also increasingly under pressure due to intense grazing and other land uses.
Combretum-Terminalia woodland	IBC (2005) has classified some areas of the Kafa Biosphere Reserve as Combretum-Terminalia woodland, which were later corrected to bamboo forests by Dresen (2014).
Sub-Afroalpine habitat	This habitat occurs at altitudes higher than 3,200 m.a.s.l. and covers only 0.3% of the total BR. This vegetation type is under severe threat due to agricultural expansion. Indigenous tree species such as *Hagenia abyssinica* are under high pressure.

Based on the soil map produced by the WBISPP (2004), the dominant soils in the Kafa Zone are dystric nitosols (Nd). Adiyo, the south-western part of Telo, and north and northwest of the Gewata districts are dominated by orthic acrisols (Ao). In addition, eutric fluvisols (Je), chromic luvisols (Lc), chromic vertisols (Vc), and pellic vertisols (Vp) can be found in the Kafa Biosphere Reserve to varying degrees (EWNHS, 2008).

3.2 Forest structure at Kafa

Afromontane rainforests in the south-western part of Ethiopia occur at altitudes between 1,500 – 2,600 m.a.s.l., with mean temperature between 18 – 20 °C, and mean annual rainfall ranging between 700 and 1,500 mm per year. Kafa falls perfectly within this environmental condition where the warmer and wetter type of Afromontane forest is found (Friis, 1992). Based on forest vegetation structure, we can see two types of forest (disturbed and undisturbed forest). A study by Schmitt (2006) illustrates that typical **undisturbed forests** are characterised by an upper canopy (height: > 15 m) and a lower canopy (height: 5 to 15 m) covering completely the understory (Figure 2). Hence, the ground layer receives very little sunlight. Due to this environmental condition, the tree trunks are covered with dense moss and fern. The **disturbed forests**, on the other hand, are typically characterised by disturbances such as natural fall of trees, or by people who depend for their daily lives on wood and timber.

Figure 2. Transect of a typical Afromontane forest structure. The left side indicating undisturbed forest with dense upper and lower canopy with little ground cover. In contrast, the right side indicates a disturbed forest with reduced canopy cover and dense shrub layer with dense ground cover (Source: Schmitt, 2006)

3.3 Status and trends of forests in Kafa

Between 2001 to 2010, Devris et al. (2014) estimated around 26,000 ha (or 7.2%) of forest cover loss within the Kafa Biosphere Reserve. Averaging over the 9-year period, **annual deforestation was approximately 2,900 ha per year**. This deforestation or loss was largely occurring in the BR's candidate core and buffer zone edges, underscoring the need of establishing these zones in order to protect the core zone. Not surprisingly, much of the forest lost during this period was located near the urban centre Bonga. Moreover, the remaining losses were detected in remote places that were targeted for resettlement. However, after the establishment of the Kafa Biosphere Reserve, the **deforestation rate declined significantly to 1,000 ha per year**, and the rate was very negligible in the core zone (Devris et al., 2014). Before the BR establishment in 2010 it was 0.15%, while the rate declined to 0.07% and 0.01% in the two consecutive NABU projects, respectively. Overall, the deforestation rate has been declining over the years (Figure 3), except for 2012, which is largely attributed to agriculture expansion and large-scale forest clearance along the forest edges and large-scale urban development constructions (Decuyper et al., 2017).

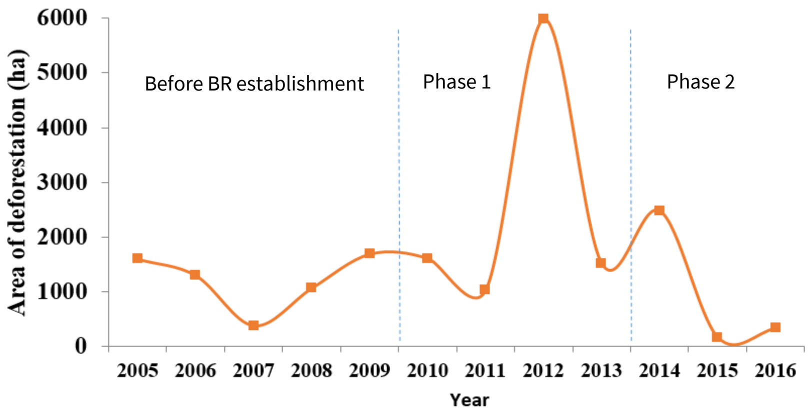

Figure 3. Forest area change (ha) before and after Kafa Biosphere Reserve establishment (Decuyper et al., 2017). Phase 1 and 2 are two consecutive projects that were implemented by NABU

While much emphasis is given to deforestation and its drivers, **forest loss due to fragmentation** does not get enough attention. During the period of 2002 to 2010, the overall area of contiguous **forest at Kafa declined by 500 ha annually, while forest islands increased by 300 ha annually**. This indicates that fragmentation can lead to forest reduction, or even complete loss, even under a low deforestation rate (Decuyper et al., 2017). The Kafa Biosphere Reserve experienced a growing fragmentation of the forest (Table 2), which is amplified by the emergence of isolated forest areas (patches), and the decline of large core forests that are fragmented into small and medium-sized core zones.

Table 2. Forest cover change at the Kafa Biosphere Reserve based on various fragmentation classes (Dresen, 2011)

Forest fragmentation class	Cover (ha)			Change (%)
	2002	2010	Change	
Patch	4,489	6,993	2,503.53	55.77
Edge	77,819	75,335	- 2,483.82	-3.19
Perforated	14,427	9,204	- 5,223.22	-36.2

Small core	7,455	8,497	1,042.09	13.98
Medium core	3,597	4,093	495.47	13.77
Large core	29,831	24,320	-5,511.58	-18.48
Total core	40,883	36,909	-3,974.02	-9.72
Total Forest Area	137,619	128,442		-6.67
Net Change			-9,178	

The study by Dresen (2011) revealed that forest edges and patch forests are highly susceptible to forest loss. With the help of landscape fragmentation tool analyses types of fragmentation were categorised into patch, edge, and perforation. **Patch forest** comprises coherent forest regions that are too small to contain a core forest. Non-forest land cover that occurs with a small woodlot in an urbanised or agricultural area surrounds this type of forest. **Perforated forest** defines the boundaries between core forest and relatively small perforations that would occur around a small clearing. **Edge forest** includes interior boundaries with relatively large perforations, as well as the exterior boundaries of core forest regions that would occur along a large agricultural field or settlement area (Table 2). The fragmentation analysis classified 57 % of the forest as forest edge for the year 2002.

Figure 4. Pictures showing forest loss in Kafa (photos: NABU/Abdurazak Sahile)

3.4 Drivers of forest loss at the Kafa Biosphere Reserve

The drivers or processes influencing forest cover loss can be divided into **direct and indirect drivers**. The direct ones are those activities which immediately cause deforestation or degradation, while the indirect ones are typically connected to socio-economic aspects supporting the direct drivers. Not surprisingly, the drivers responsible for deforestation and degradation in Kafa are similar to the national level drivers. Based on the studies conducted by Dresen (2011) and Devris et al. (2014) at Kafa Biosphere Reserve, there are six main drivers: **agriculture expansion, population pressure, resettlement, concessions (for coffee), land property rights, and unsustainable use of forest resources**.

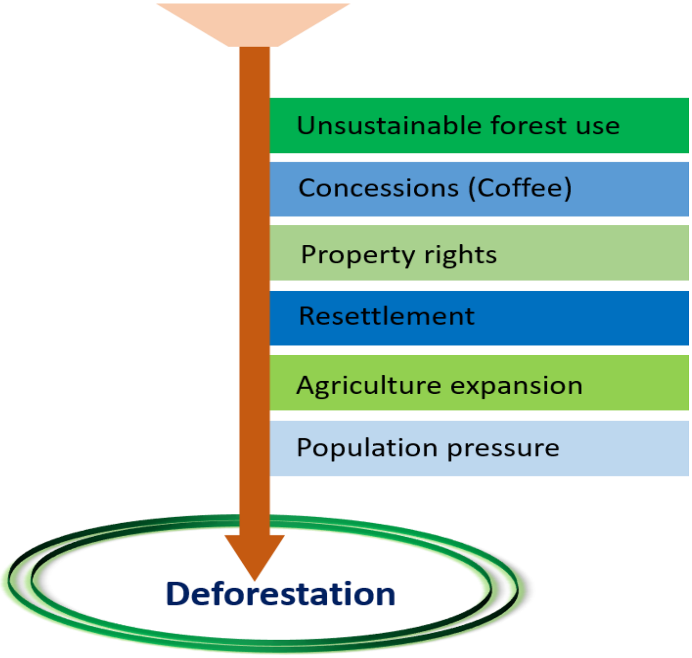

Figure 5. The six main drivers of deforestation and degradation at the Kafa Biosphere Reserve

- **Agricultural expansion**: Farmers in the BR convert forest to agricultural land by systematically clearing the understory, especially near forest borders, followed by slash and burn activities. Agricultural expansion is typically coupled with fuel wood collection, since the expansion by smallholder farmers exposes new forest edges, which are then subject to intensive fuel wood collection.

- **Population pressure**: Although population pressure in Kafa is not directly affecting the forest area, many drivers such as resettlement, agricultural expansion, and unsustainable use of forest resources are interrelated (Figure 5).

- **Resettlement**: People from outside of the region settling into previously unoccupied lands, which is largely forested land, have been responsible for rapid changes in the BR. This activity usually results into large clearance of forest areas, rather than the gradual growth of agricultural land expected in a typical subsistence agricultural system. The areas that are targeted for resettlement are usually areas that exhibit low population pressure. It is a common policy in the region to resettle people in virgin forests.

- **Concessions (coffee)**: Coffee plantation expansions are common in Kafa, although these expansions have been declining over the years. Nevertheless, these activities have been responsible for a decreasing biodiversity of the forest in the region, by thinning the upper story and systematically removing the understory of the forest. As the expansions are normally restrictive and local communities are banned from them, there are no incentives or motivation for forest dwellers and rural communities to manage the forest resources in a sustainable way.

- **Property rights**: The frequent redistribution of land has led to a high degree of insecurity among farmers, concerning the tenure rights of their holdings and use rights over the forest. This advocated an 'open access' mentality and prevented forest dwellers from supporting a sustainable forest management. Accordingly, it appears to be more attractive to invest in agriculture than in forestry, in terms of ease in securing land user rights.

- **Unsustainable use of forest resources**: Lack of sustainable silviculture practices leads to illegal and unmanaged use of wood resources, especially near or adjacent to the state forest or plantations. Hence, forest regeneration is hampered and lack of investment in natural forests, to replenish the stock, leads to severe forest degradation. Furthermore, the increasing livestock population and practice of using forests for grazing, is responsible for major forest degradation.

4. Step-by-step guide for reforestation

NABU's experience on successful reforestation has developed into a number of steps. The procedures are both intermingled and indispensable for securing proactive participation of pertinent actors including local communities who are the ultimate insurance for a long-term impact. The project, in collaboration with local partners, has carried out the following steps (Figure 6):

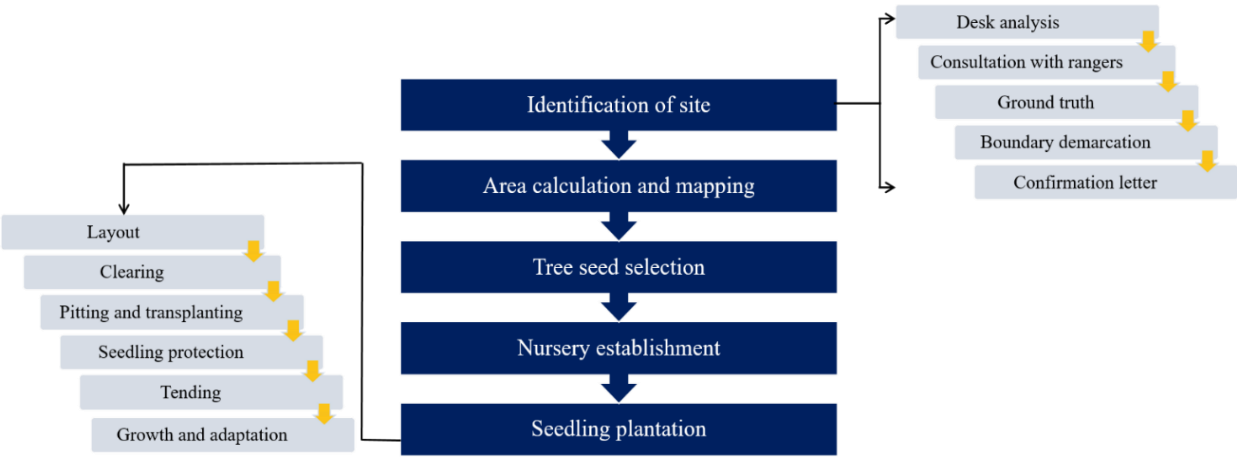

Figure 6. Step-by-step reforestation procedures

4.1 Identification of the site

Forest degradation differs very much in different places due to variations in the size of forests affected, intensity of structural change, dynamics of change, and the consequential impact.

Reforestation sites shall be selected based on:

- Sites that are **spatially suitable**.
- Sites that have **local communities' consent** to be considered as priority for interventions.

In order to reach a mutually agreed site with the local community, the following steps shall be taken.

4.1.1 Desk analysis

For identifying the site that is suitable for reforestation, a desk analysis at office level is essential.

- The main **drivers of forest change** in relation to population dynamics need to be identified in advance.
- Sites that exhibit **active degradation and severity of degradation** should be known:
  - Ground level information and experience about the sites from experts and local community members help during analysis.

Figure 7. Degraded area suitable for reforestation at the Kafa Biosphere Reserve (photos: NABU)

Info
NABU conducted an extensive assessment across the BR to identify sites that are suitable for reforestation, identifying fragmentation, perforation, and shrinkage of forest lands, which made the desk analysis more effective and easier.

4.1.2 Consultation with field experts

Consultation with field experts on the selected or proposed (based on desk analysis) sites shall focus on:

1. Reaching a consensus on a set of criteria that shall be used for site seeing, as well as for consultation with stakeholders (local community, officials and experts) for screening potential sites.
2. Incorporate key elements and information that would make individual sites worthy of intervention.

Figure 8. Discussion with field experts (photo: NABU/Abdurazak Sahile)

4.1.3 Ground truthing

Ground truthing refers to receiving or verifying data by observing the site on the ground. A proper ground truthing shall be done with the support of field experts involving local officials, community members, development workers, and experts who have knowledge about the selected sites.

Figure 9. Ground truthing with field experts and community members (photos: NABU)

4.1.4 External boundary demarcation

Once ground truthing is completed, ground level boundary demarcation of sites must be conducted.

Below are appropriate steps for demarcation:

- Debrief the relevant community members about the outcome of the ground truthing.
- Consult and nominate community representatives for demarcation task.
- Conduct negotiations with various stakeholders and reach an agreement.
- Following consensuses on the sites, take geo-reference data using GPS and paint on trees.
- Finally, prepare minutes with specific details about the site with signature of the main negotiator.

Figure 10. Demarcation of reforestation sites (photos: NABU)

> **Info**
>
> **Negotiation processes at the Kafa Biosphere Reserve include:**
>
> 1) Boundary negotiation with individual landholders whose farmland is adjacent to the forest border subject for demarcation.
> 2) Boundary negotiation between Participatory Forest Management (PFM) and Non-PFM forest users, or Kebele[1] administration within the same Kebele administrative territory.
> 3) Boundary negotiation with adjacent Kebele administration within the same district.
> 4) Boundary negotiation with another district.

Note: At the Kafa Biosphere Reserve, community members are typically from PFM or Kebele level dwellers. The demarcation members are normally from various areas, such as former officials, officials from PFM groups, or Kebele administration and Kebele land administration officials. The role of the Kebele level land administration committee, PFM committee members, elders and knowledgeable people, Kebele administration and government experts, has been very essential during the negotiation to trace legitimate occupation and track records that are valuable for reaching an agreement.

4.1.5 Securing minute or confirmation letter

Once demarcation is successfully completed, it is advisable to **secure a confirmation letter or a stamped demarcation minute** from the local authority (typically Kebele administration gives confirmation stamps at Kafa Biosphere Reserve). This will help to guarantee the protection and management responsibility of the selected sites.

4.2 Area calculation and mapping

Collection of GPS data from demarcated sites and mapping of the selected sites shall be finalised in order to estimate seedling quantity and quality required for reforestation.

Figure 11. Field experts taking GPS readings (photos: NABU)

> **Info**
>
> In 2014 and 2015, NABU conducted two GPS reading events, including demarcation and mapping of 501 ha. Estimation of seedling quantity as well as quality was determined by using the geo-referenced data from 13 sites, and analysed by using GIS.

[1] A Kebele is the smallest administrative unit in Ethiopia, similar to neighborhood or a localised and delimited group of people.

4.3 Tree seedling selection

The appropriate selection of tree seeds results in a high quality of seedlings. Thus, seeds shall be selected based on the following criteria:

- Define the **source and amount** of seeds required for each site:
  - The total seed quantity should consider potential damage up to 20 % and potential beating (replanting or replacement of seedlings that have died) up to two times.
- Agroecology - information such as **altitude range** are the first parameters which must be considered to evaluate tree species survival:
  - Additional inputs from local people or knowledgeable experts on the history of tree population, dominance, and canopy change, together with the standing remnant trees, will help to determine tree species suitable for individual sites.
- Select seeds that are native to Ethiopia, available and know the **maturity period** in the nursery sites,
- Define the **composition and canopy structure** of future tree stands for the area:
  - Proportional comparison of weight for different trees will help to define the share in the reforestation plan.

Figure 12. Seeds of *Schefflera abyssinica* (photo: NABU)

Note: It is very crucial to calculate the number of seedlings required per ha for each site (NABU's experience shows: 500 seedlings per ha required). The proportion of share of each selected tree species over the whole area also needs to be considered to make excellent decisions on seed requirements.

Info

At the Kafa Biosphere Reserve, NABU trained field experts on **tree selection** and **seed collection** procedure. All the seeds were collected locally under close supervision of the field experts. The suppliers of the seeds were labourers, former forest technicians, and PFM institutions. Labourers were assisted by field experts in **determining healthy trees, seed maturity and collection methods**. There are few former forest technicians and forest guards working for the government, who have deep knowledge but left idle. NABU targeted these individuals in order to secure their extensive knowledge and expertise on sensitive tree seeds such as *Hagenia abyssinica* (Figure 13).

Some PFM institutions that are active, and have abundant native trees in their respective natural forests, were also encouraged to supply tree seeds as another source of income for their organisation. The exchange of seeds from one site or district to the other is another important experience that opened the opportunity of **seed collection and marketing**. Moreover, this seed importing was a very important element to practically evaluate the performance impact radius in bringing seeds and their adaptability in other parts of the BR.

Figure 13. *Hagenia abyssinica* (photos: NABU)

4.4 Nursery establishment and cultivation of native tree seedlings

1. Site selection:
   - Key technical requirements for nursery site selection: availability of suitable free land, permanent water source, labour, access to transport, distance from plantation site, soil fertility, and slope.

2. Preparation of bagged (plastic bag) seedlings: seedlings shall be cultivated using plastic bags anticipating low soil fertility, logistical reasons (long distance to plantation sites or transportation means):
   - Mix soil (preferably forest soil), sand, and soil from the selected nursery site
     → this improves water permeability, fertility, and moisture retention,
   - Seedlings prepared in plastic bags have a better chance of survival than bare root seedlings.

Figure 14. Nursery site at the Kafa Biosphere Reserve (photos: NABU/Abdurazak Sahile)

> **Info**
> Three types of sites for nursery establishment were used at the Kafa Biosphere Reserve: Private farmland, PFM areas, and existing government nurseries. Few communal lands at Kebele level served as nursery site.

Note:

- Ensure a **reliable and continuous water supply** throughout the year. Check the source during the dry season, when the need for water is greatest.
- **Avoid transporting seedlings to a temporary holding site**. This eliminates the need for additional handling, which is typically the main source of physical damage to seedlings.
- Seedlings, at any stage, should **not be lifted by holding their stem**. Care must be taken with the handling of seedlings at every step of the transporting process.

4.5 Seedling plantation

4.5.1 Layout

- The layout shall be based on a **grid system** where a line of seedling plantation gets first priority,
- **Avoid clearing vegetation** of the entire area; it saves money, energy and time (see 4.5.2),
- For planting native tree species, arrange the plantation space to be 5 x 5 m; the space between rows and between seedlings should be the same (5 m),
- Arrange the pegs in 5-meter distance intervals from each other along a row.

Note: Placing the pegs at 5-meter distance intervals helps the decision-making process of clearing and calculating seedling numbers along each row.

Figure 15. Field experts doing reforestation layouts (photos: NABU/Abdurazak Sahile)

4.5.2 Clearing

Clearing is required for two main reasons:

- To create an **accessible working space,** which otherwise would be a daunting task,
- To establish **better growing conditions** for newly transplanted tree seedlings until they adapt to the new place.

Info
The clearing in NABU projects is based on the information gained during layout work and pegging. The clearing covers a total of 2-meter width from the pegs as a centre, and extension of 1-meter distance to the left and right side of the peg. This clearing reduces the total area to be chopped down, reduces clearing costs, time, and energy by focusing on effective plantation sites. On the other side, natural regeneration and vegetation damage will be reduced.

Figure 16. Example of a typical cleared site (photos: NABU)

4.5.3 Pitting

Pitting is a process carried out to improve the physical environment into which a seedling is planted. Pitting shall be done for the following reasons:

- Improvement of the **water infiltration** rate.
- **Removal of weeds and competition** around the seedlings.
- Increasing the rate of **organic matter decomposition.**

Note: The use of smaller pits must be accompanied by good weed control and good planting practice. This means that weed control should be practised in the area around the pit and not just in the pit.

Figure 17. Example of pitting and pits arranged in a row (photos: NABU/Abdurazak Sahile)

4.5.4 Transplanting of young seedlings

Plantation starts with planting the tree seedlings, which indicate the beginning of the growth cycle. Following the correct planting operation with the correct method builds the foundation of the reforestation endeavour.

Note: Planting seedlings along the row makes it easier to transport seedlings following the row and minimises possible damage and waste of seedlings.

Figure 18. Seedling plantation (photos: NABU/Abdurazak Sahile)

4.5.5 Tree seedling protection

Several factors cause damage to planted seedlings. The most common ones are:

- Wild animals.
- Domestic animals (if plantation sites are established near villages).
- Excessive use of temporary shade.
- Late start of the hardening process or totally neglected.
- Bad storage of seedlings near planting site.

Proper measures to protect seedlings from damage include:

- The construction of a protective **fence around each seedling** (Figure 19).
- The construction of an **external fence or boundary** for plantations established near villages.
- **Preventing the seedlings from shade** once they are over the shock of transplanting; still, nursery staff will be tempted to keep them under shade, to reduce the amount of watering needed and to mask the effect of bad transplanting.
- **Preventing to wait** until the last week to start the hardening process, as seedlings will not have had sufficient time to adjust to the harsher environment in the field.
- Avoid leaving seedlings in the shade without **water** for long periods after they leave the nursery site.

4.5.6 Tending the seedlings

Tending is a critical activity that ensures the planted seedlings survival and growth.

- **Vegetation management**: Seedlings should be freed from creeping and climbing plants because:
  - It influences tree growth and ensures competing vegetation does not take resources such as water, nutrient, light, and growing space,
  - It minimises seedling mortality,
- **Weed control**: Weeds must be controlled before they set seed,
- **Heavy watering**: Especially during the afternoon and evening hours, watering encourages diseases and, therefore, must be controlled and reduced to morning hours only.

Note: Strong weed control is necessary, especially during critical periods such as water stress periods. No weed should be allowed to flower and fruit along paths and roadways or unused land in the nursery.

Figure 19. Fencing and protecting individual seedlings (photos: NABU)

4.5.7 Growth and adaptation (follow-up)

The ultimate success of a reforestation project is measured by the growth and survival of planted tree seedlings. Below are appropriate methods for follow-up:

- **Monthly monitoring** should be planned and implemented.
- **Periodic measurement of tree growth,** either with the help of field experts or development agents.

Note:

- Proper follow-up helps to record adaptation challenges, beating up, as well as estimate the survival rate of specific species. The details required vary according to the size of the nursery, but good records provide the information necessary for task allocation and for monitoring the efficiency of the day to day operations.
- Monitoring can include: health of seedlings (free of diseases or insect attacks, discoloration of leaves, etc.), injuries (mechanical injuries), or straight stems (must be able to stand firm without much support, curved stems signal abnormal rooting).

Figure 20. Field experts measuring planted seedling growth (photos: NABU)

5. Lessons learned

The reforestation of 1,009 ha and 570 ha of degraded forestland were completed during the two consecutive NABU projects, following the same step-by-step guidelines for reforestation (see 4). The project exclusively focused on using native tree species for which no reference manual, literature, or experience exist. Among the main species planted, few of them are endemic/indigenous to Ethiopia (e.g. *Hagenia abyssinica, Millettia ferruginea, Croton macrostachyus, Prunus africana,* and *Cordia africana*). For this, around 59 nurseries with different site conditions (e.g. soil substrate, altitude, slope, water supply, or solar radiation) were used to grow a large number of seedlings.

The first years of seed cultivation and seedling plantation activities are typically difficult due to high mortality/damage of seedlings. Therefore, the project worked on collecting a larger quantity of seeds, which ultimately resulted in a large number of seedlings being planted.

Table 3. Mortality rate for replanted tree species after one year (in %) (Decuyper et al., 2017)

Species	Altitude (m)	Plants per ha	Average size (cm)	Age (months)	Mortality (%)
Hagenia abyssinica	1,830 - 2,465	625	96	7 - 15	31
Millettia ferruginea	1,621 - 2,179	625	27	7 - 8	37
Croton macrostachyus	2,010 - 2,147	400	51	7 - 8	38
Prunus africana	1,774 - 2,229	1,089	33	7 - 8	57
Cordia africana	1,636 - 2,066	900	70	7 - 8	46
Cupressus lusitanica	1,763 - 2,237	2,500	52	7 - 8	41
others	1,680 - 2,300	3,000	87	7 - 10	20

Though several factors were considered, losses were expected during planting as neither the optimal time nor the effect of local site conditions and other factors (water requirements, protection from sunlight, insect infestation, etc.) were known. Table 3 shows the mortality rate of selected tree species, ranging from 31 % (*Hagenia abyssinica*) to 57 % (*Prunus africana*) during the first year. The high failure rate of some species, such as *Prunus africana,* were also confirmed by field observations with the help of NABU field experts, who are responsible for monitoring. Table 3 also indicates only the rate of mortality for one year, hence failure of seedlings or young trees may continue if we include more years into the analysis.

Figure 21. Cultivation and plantation of *Prunus africana* (photos: NABU)

Although more than **1000 ha where successfully reforested**, NABU's reforestation project faced the following major challenges:

- Difficulty to find a local authenticated **seed supply source** for native tree species. Within the BR, there are **no reliable seed suppliers**. Hence, two options were considered to mitigate this challenge:
    - Commission local community members to collect directly from possible mother trees.
    - Purchase seeds from other localities or other regions.

Info

Even though the two options have been relatively successful, several problems came along:

- **Bad seed quality** due to selection of undesirable or inappropriate mother trees by the locals.
- Collection of all **seeds from a single tree**.

- **Seed collection methods** which often cause damage to seeds: collecting seeds from the ground, which often have been damaged, and collecting non-viable seeds.
- **Unsuitable storage** facilities or methods for seeds: in some cases, due to climate change effects and flowering season variability of certain seeds, advanced collection of seeds and storing them for future use is required; unfortunately, due to a limited availability of standard storage facilities or options in the area, the majority of the seeds lost their viability and germination.
- Mismatch between **seed maturity and cultivation calendar**: reforestation measures are very much dependent on the availability or amount of rainfall, and the cultivation of tree seedlings is normally planned considering the planting period; this normally lasts 4 to 7 months in the nursery, in order to have them ready for planting in June to August; however, some trees flower and bear seeds later than the required period; this forces the project to plan a year ahead, which entails other issues such as **safe storage and risk viability** of seeds up to 40%.

- Due to **climate change,** rainfall patterns became more unpredictable, affecting the reforestation efforts:
  - Delay on the onset of rainfall in the area affected the **regular planting season** (June, July, August) for crops as well as for planting seedlings.
  - Seed collection also became challenging due to the **unpredictability of tree flowering period**.
  - Nursery sites that were established near small rivers and streams, suffered, as these water sources became dry.
  - Increased heat waves and temperature overburdened the NABU project financially due to an **increased amount of watering required in nursery sites**: for a successful reforestation measure, early periods of sufficient moisture are very crucial for the planted seedlings; in some cases, the NABU project lost significant numbers of seedlings due to shortage or complete lack of rainfall; hence, seedling adaptation to plantation sites was very challenging.
- **Lack of systematic control and monitoring of illegal land grabbing** caused a number of disputes regarding claims people had on degraded forestlands, affecting reforestation processes in two ways:
  - Due to the slow response or inability to solve the disputes quickly and effectively by local administrations, planting seasons were delayed, or even sometimes missed, causing further financial pressure in managing seedlings at nursery sites.
  - People damaging planted seedlings, expecting to occupy the area in the future; once more, NABU was forced to hire guards to protect the plantation sites.

Info

In response to these challenges, the NABU project took the following measures:

- Early identification of reforestation sites with community representatives and local administrations, conducting participatory demarcation and securing an official confirmation letter annexed with signed minutes of the demarcation crew.
- Prepare a hand over form that will be signed by the responsible institution, depending on land entitlement.

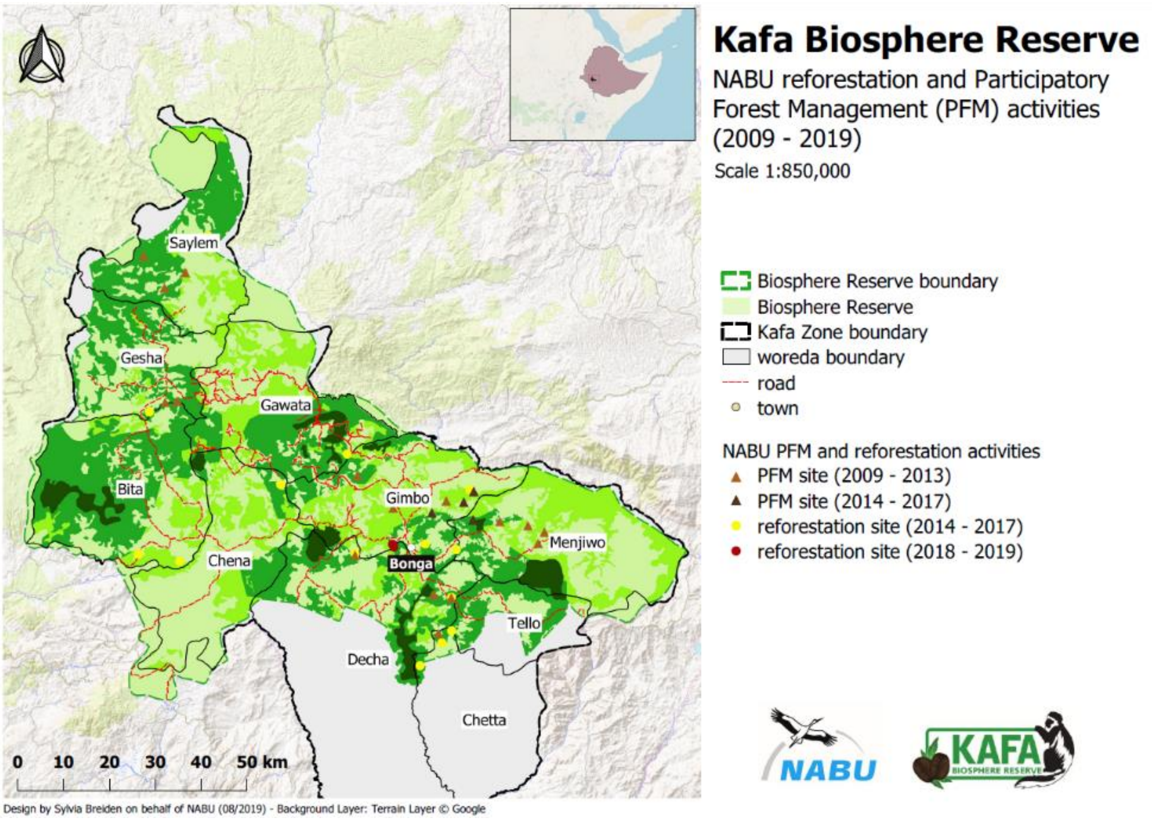

Figure 22. Map of reforestation and PFM sites at the Kafa Biosphere Reserve

6. Characteristics of selected tree species planted at the Ethiopian Kafa Biosphere Reserve

Table 4. Selected tree species (Latin name) used for reforestation activities at the Kafa BR and their characteristics; Endemism: indigenous (In), endemic (En), exotic (Ex) (Source: Azene & Tengnäs, 2007; NABU, 2018)

Species (Latin)	Ende-mism	Ecology and cultivation	Altitude range [m.a.s.l.]	Seed	Photo available at
Hagenia abyssinica	In	Upland rainforests, last tree before moorland, dominant tree of woodland zone above mountain bamboo.	2,300 – 3,300	Germination 40–60 % in 14–21 days. 200,000–500,000 seed per kg. Seed stores for 6–12 months.	NABU's Manual for the Medicinal Plant Garden at the Kafa BR (2018)
Millettia ferruginea	En	Found in upland forests, rain forests and forest remnants.	1,000–2,500	A productive tree with lots of seeds, up to 500kg. Can be stored for 2 months.	
Croton macro-stachyus	In	Pioneer species/light demanding, often dominates wooded grasslands; widespread on forest margins, along roadsides (volcanic soils).	1,100–2,500	16,000–27,000 seed per kg. Seeds usually damaged by insects while on the tree. Seeds store for a short period only since they are oily.	NABU's Manual for the Medicinal Plant Garden at the Kafa BR (2018)
Prunus africana	In	Upland rain-forests, montane and riverine forests, moist evergreen forest.	1,700-2,500	3,400–6,000 seed per kg. Seeds do not store well, therefore, fresh seeds should be used.	NABU's Manual for the Medicinal Plant Garden at the Kafa BR (2018)
Cordia africana	In	Common in Polyscias and Podocarpus forests, as a forest remnant in cultivated areas.	900–2,500	Germination rate is 50–80% in 40–60 days, slow and uneven germination. De-pulped fruit can be stored for some time.	NABU's Manual for the Medicinal Plant Garden at the Kafa BR (2018)
Cupressus lusitanica	Ex	A large evergreen conifer, up to 35 m, with a straight trunk.	1,200–3,000	Germination rate about 30-45% in 10-20 days. 160,000–290,000 seed per kg. Seeds can be stored for some months but the viability is gradually reduced.	

7. Conclusion and recommendations

Management actions to improve and reverse deforestation are unquestionably demanding. Particularly the global threat of climate change and the key role of forests have been well recognised and appreciated in unprecedented consensus by the global community. The issue of effective and permanent reforestation appears to be very essential to ensure the intended services from reforestation.

Based on NABU's extensive practical experience in reforestation projects, the following are critical points to consider for successful reforestation:

- **Planning**: Reforestation is a complex process that should be started with the proper planning of every step; all technical, social, environmental, and organisational issues need to be incorporated:
    - **Technical**: activities such as seed collection, minimising vegetation damage from land clearing, and trial of innovative seedling cultivation techniques, are very useful preparatory actions for success.
    - **Social**: gaining community consent and documentation of the agreement, awareness, willingness for management, and benefit from labour requires planning.
    - **Environmental**: awareness of agro-ecological suitability, tree species selection, possible climate change effects, and timing of the different activities with climate conscious measures.
    - **Organisational**: includes site identification, approval, and, most importantly, taking advanced planning on handover responsibility for future management and protection.

Providing balanced considerations for these issues helps to achieve the restoration of degraded forest habitats, species richness, and biodiversity.

Appendix

Table 5. Summary of planted tree species at various reforestation sites in different districts (Source: NABU, Project Terminal Report, 2017b)

	Species (Latin name)	Amount per woreda in number											Total
		Adiyo	Bita	Chena	Chetta	Decha	Gesha	Gewata	Meligawa (Gimbo)	Yeritechit (Gimbo)	Saylem	Tello	
1	***Cordia africana***	5,422	7,587	15,110	24,489	28,447	1,600	10,055	9,776	34,876	1,003	13,258	151,623
2	***Hagenia abyssinica***	10,674		8,406	6,317	14,069	9,796		9,100	11,427	7,454	19,761	97,004
3	***Aningeria adolfi-friedericii***				32				620			72	724
4	***Prunus africana***	569	565	3,169	922	1,032	14,911		1,018		30,489	100	52,775
5	***Albizia gummifera***	1,230	2,435	290	825								4,780
6	***Millettia ferruginea***	2,435	6,279		2,220	3,200	400	10,165	2,031	6,091	1,924	4,022	38,767
7	***Ekebergia capensis***		278			323	725		194				1,520
8	***Maytenus arbutifolia***					857							857
9	***Podocarpus falcatus***				3,850	120							3,970
10	***Schefflera abyssinica***										109		109
11	***Syzygium guineense***				1,446						2,113		3,559
12	***Croton macro-stachyus***	561									4,490	996	6,047
13	***Olea welwitschii***		311						2,657				2,968
14	***Juniperus procera***		117										117
15	***Terminalia brownii***		125										125
16	***Erythrina brucei***								942				942
17	***Grevillea robusta***	6,815	3,880	4,521	2,471	13,003	4,519	1,710	4,285	6,745	2,240	10,244	60,433
18	***Cupressus lusitanica***									2,331			2,331
19	***Ficus sur***					36							36
Total		**27,706**	**21,577**	**31,496**	**42,572**	**61,087**	**31,951**	**21,930**	**30,623**	**61,470**	**49,822**	**48,453**	**428,687**

Table 6. Monitoring and follow-up of selected tree species planted at Kafa Biosphere Reserve. Tree height measurement (Source: NABU monitoring report by field experts, 2017)

S.N	Tree species	Adiyo	Bita	Chena	Chetta	Decha	Gesha	Gewata	Gimbo	Saylem	Tello	Sum
1	*Cordia africana*	2.5	2.5	3.5	2.6	4.0	2.8	3.5	2.8	3.6	3.0	**3.4**
2	*Hagenia abyssinica*	2.8	3.2	3.0	3.5	4.0	3.5	3.0	4.0			**3.4**
3	*Aningeria adolfi-friedericii*	2.0	1.9	2.5	1.5	2.5		1.7	1.4	2.0		**1.9**
4	*Olea welwitschii*	2.0	1.8	2.8				1.5		2.0		**2.0**
5	*Podocarpus spp.*			2.3	2.0	2.3		1.8	2.8			**2.2**
6	*Albizia gummifera*	1.8	1.5			2.3	2.0	1.8	0.7			**1.7**
7	*Prunus africana*	1.8	1.9			2.3	2.0	2.2	1.8			**2.0**
8	*Millettia ferruginea*	1.8	1.9	2.0	2.0	2.2	2.0	1.8	1.7	2.0	2.0	**2.2**

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Since 2010, NABU is registered as international NGO in Ethiopia and has since gained a wide-ranging experience in the implementation of large-scale projects in the country. NABU's core topics cover planning and establishment of UNESCO biosphere reserves, biodiversity conservation, adaptation to climate change, reforestation and forest management incl. Participatory Forest Management, sustainable development incl. value chains and private sector cooperation for livelihood improvement as well as capacity building at government and community level.

For more information visit www.en.NABU.de.

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