Financial analysis of the natural forest management sector of Mozambique

Mozambique Forest Investment Project

UNIQUE forestry and land use

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Client

World Bank

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AAC	Annual allowable cut
AQUA	Agency for environmental quality and control
BS	Backstopper
cbm	Cubic meters
CBO	Community-based organization
CCP	Company community partnerships
ESG	Environmental and social governance
DBH	Diameter at breast height (1,30 m)
DINAF	Directorate of Forests
FIP	Forest investment program
FMP	Forest management plan
GoM	Government of Mozambique
ha	Hectare
IRR	Internal rate of return
MITADER	Ministry of Land, Environment and Rural Development
Moz	Mozambique
NFM	Natural forest management
NPV	Net present value
PPP	Public private partnerships
SDAE	District Services of Economic Activities
SNFM	Sustainable natural forest management
SPF	Provincial Forest Services
t	Ton
VC	Value chain

SUMMARY

Executive summary

This study clearly indicates that whilst current forestry practices in natural production forests in Mozambique can be highly profitable, they are completely unsustainable in the long-run. The resource is being depleted with the prized, high value species being over-harvested. The analysis carried out as part of this study, however, shows that whilst there is no 'quick fix' solution, it is possible to reverse the current downward spiral. The recommendations presented are a combination of measures referring to policy, legislation, market development and particularly to improved silviculture and forest operations. The current licensing system needs changing to encourage investment in more efficient harvesting and added value processing. Silvicultural practices must also become standard, to encourage growth of selected species whilst the use of lesser-known species also needs promoting. Integrating charcoal production into the harvesting operations helps to utilize more reasonable and efficiently the forest resource and allows the cooperation with communities and the formalizations of this value chain. In conclusion, a long-term view needs to be taken if Mozambique's natural production forests are going to survive. The changes recommended, however, will need to be introduced, monitored and enforced soon in order for the forests to recover and be sustainable for future generations to also benefit from.

Background

Mozambique has an estimated 40 million ha of natural forests, of which some 27 million ha (mostly Miombo) are classed as production forests. These forests provide nationally and internationally demanded high value timber, and a variety of other goods and services. However, the utilization of the natural forest is in most cases unsustainable leading to forest degradation and devaluation. Mozambique's Forest Investment Program (MozFIP) identified a shift towards sustainable management of Miombo production forests as a key deliverable for achieving its mitigation targets (REDD) as well as sustainable rural development. The natural forest management component of the MozFIP will be implemented with support from the World Bank in Zambezia and Cabo Delgado provinces and has components on a national level.

The study at hand was commissioned by the World Bank as a background study contributing to the design of MozFIP, with the aim to identify the conditions under which natural forest management businesses could be sustainable from a financial, economic and social perspective.

Approach

The study was divided into three phases. In the first phase a comprehensive desk review of data sets and literature on natural forest management in Mozambique was conducted. During the second phase, nine forest businesses (three simple licenses and six forest concessions) operating in Zambezia and Cabo Delgado were assessed on site. The assessment combined with the desk study lead to conclusions on financial viability and on (non-)sustainability of current forest management practices. The outcomes of this phase were discussed in a validation workshop in Maputo in Oct. 2016. In the third and last study phase, different scenarios towards sustainable Miombo management have been analyzed and recommendations for MozFIP derived.

Current state of Miombo forest management

Forest management businesses vary considerably with respect to the area licensed to forest operators. The actual productive area can range from 50% to 90%s of the whole concession area. Likewise, the allowable cut varies substantially but is generally very low (<0.2 m^3/ha/yr) across the nine forest operators interviewed. Investments into assets and infrastructure vary between the two license types, with forest concessionaires usually investing into substantially more heavy machinery to harvest and transport logs, as well as processing facilities (required by regulation for forest concessionaires only).

The **management practices** observed in previous surveys (e.g. MITADER, 2016) and during field work show that forest utilization is entirely market driven. Current practices focus only on a few species and volumes harvested of these selected species are not sustainable. The resource degrades and devaluates gradually. Furthermore, investments into silviculture are virtually absent and efficiency of operations is low. Most businesses do not employ forest technicians, and use outdated techniques and technology; with the exception of few operators making serious efforts to improve efficiency, recovery and value addition. Timber and charcoal production are currently not integrated. Forest management plans are provided for compliance rather than for actual planning and guiding the operations.

Mozambique's forestry sector benefits from high acceptance of some of its premium and first class timber species in overseas **markets** and has relatively easy access to these markets. The export market is dominated by Chinese companies and is highly selective, i.e. takes few species only – namely, *Dalbergia melanoxylon* (local name Pau preto); *Pterocarpus angolensis* (Umbila); *Afzelia quanzensis* (Chanfuta) and *Millettia stuhlmannii* (Jambirre). In the national market a slightly wider range of species is accepted, although preference is clearly given to the same species. Little effort is made by the forest operators to develop new markets which would allow them to utilize a wider range of species. Illegal timber harvest and trade has very negative implications competitiveness of operators complying with the regulations.

The major timber **value chains** range from sale of logs at the forest road or at customer gate to trading sawn timber nationally or overseas. Timber businesses are profitable regardless of the point of sale and degree of value addition. This holds true under the current management practices, which are not sustainable. When regarding sustainability of operations, then the picture changes substantially. Value adding by saw milling vs. selling logs can be very low to non-existent if the recovery rate at saw mill is low. Hence, forest concessionaires often prefer to sale logs rather than sawn timber. Charcoal is always produced using basic means in the forest and traded either at the forest road or in urban centers. The charcoal business in Mozambique is highly informal and generates only small profit margins. However, when integrating it intelligently in an overall the forest management approach, charcoal can become an important produce to utilize also the large volumes of secondary and non-commercial tree species.

Scenarios

Scenarios were developed for a timeframe of 51 years, and assume a model company with 50,000 ha net-production area implementing harvesting cycles of 10 years. The **baseline scenario** assumes use of the currently harvested species only. The harvesting of commercial species exceeds the growth rate leading to a gradual degradation and devaluation of the forest. Hand in

hand with the degradation, also the revenues of forest utilization decrease gradually. After 50 years the resource is completely exhausted and the business has to be closed.

The **sustainable forest management scenarios** assume *introducing silviculture*[1] as a basic that always has to be conducted, combined with different options: i) *introducing silviculture with integrated charcoal management*, i) *introducing silviculture with use of secondary species* for timber products, iii) *introducing silviculture with improved technology and economy of scale*, and iv) *introducing silviculture with forest certification*.

All of the improved scenarios show a positive impact on resource development from the beginning. However, the initially much lower rate of extraction when *introducing silviculture* means a substantial loss of revenues in comparison to the baseline scenario. Revenues start to increase after 30 years when stocks have recovered and larger volumes can be harvested sustainably. The combination of *Introducing silviculture* with any of the above-mentioned options results in only slightly improved economic performance. The economic performance can only be enhanced substantially when combining all options, i.e. when improving technologies and using a wider range of species.

To consider the impact of time the net-present value (NPV) of the different scenarios have been calculated by applying different discount rates. Only with very small discount rates below 3% the univariate sustainability scenarios have higher NPV than the baseline scenario of current unsustainable utilization practices. At higher, more realistic discount rates for Mozambique (>10%), only the combination of the different management options can match the NPV of the baseline scenario. The demonstrates the importance to integrate use of secondary species, charcoal production and leveraging economy of scale effects to make sustainable management of Miombo forests happen.

Recommendations

To ensure the long term sustainability of natural forest management in Mozambique while maintaining the economic viability of forest operators, requires interventions in different key areas as summarized in continuation:

- **Enabling environment**
  - **Secure long term access to the forest resource** is pre-condition for any investments into sustainable forest management. Forest administration, concessionaires and communities must work out arrangements that clearly define user rights, location and management practices.
  - The current **forest licensing system** is not conducive to sustainable natural forest management. It enables illegal harvest and trade of wood products, and controls wood product movement rather than sustainable production. Issuance of short term licenses creates an incentive to ruthlessly exploit rather than sustainably manage forests. The possibility of setting the value of a concession based on current/future timber stocks and variable

[1] Sustainable forest management includes prevention/management of forest fires, tending of natural regeneration, liberation thinning of future crop trees and gradual elimination of over-mature trees, reduced impact logging, and reducing the harvesting volume of premium and first class species until recovery of forest stocks.

license fees according to the state of the forest resource should be explored. Simple licenses should be phased out if at all feasible.

- **Applied forestry research** in partnership with research institutions and forest concessionaires on forests dynamics, timber properties (making use of secondary species), and efficient application of best management practices can substantially support the competitiveness of sustainable forest management.

- **Forest management practices**
  - Sound **forest management planning and monitoring** of resource development is pre-condition for sustainable utilization of forests. The starting point for SFNM planning and monitoring is a reliable inventory of the resource base for each concession. Based on this, the best fitting silviculture and harvesting plans can be developed. The interaction between the forest expert conducting the inventory and management planning with the forest concessionaire is essential. At the same time forest authorities have to be trained in sustainable forest management, and management planning and monitoring to guide and approve the implementation of forest management standards.
  - **Appropriate silvicultural measures** must be defined on a case by case basis, including the regulation of species composition and stand quality, and fire management. The need for change of current practices and support to and enforcement of sustainable forest management must be addressed by policy makers and implementing authorities alike.
  - **Efficient utilization of forests** will reduce cost per cubic meter wood extracted, reduce damage to the remaining trees (conserving the forest value) and, over time, increase the commercial volume available. Measures include using a wider range of (secondary) species, utilization of residues for e.g. charcoal, and better technologies in order to reduce operational cost and damage to the remaining forest.
  - **Forest certification** with international standards such as FSC or PEFC can be beneficial to forest enterprises, allowing access to different (export) markets and funding sources. However, in many cases forest certification does not have a significant impact on the overall economic performance of a company. Forest concessionaires must explore the potential for and likely gains before committing to certification.

- **Market development value chain**
  - A wider range of marketable species is deemed crucial for the long term survival of the NFM industry in Mozambique. Accordingly **market development** should be actively promoted by the forest enterprises with aid from government and research institutions, and in partnership with national industries (in particular the construction sector).
  - Investment into **value addition** can be an important means to sustain and/or raise profitability despite additional cost from e.g. higher forest management standards or lower (sustainable) harvesting volumes. Interested investors are likely to need assistance in terms of access to technology and finance, technical advice and market development.
  - However, most important is the integrated forest management approach. This means to make use of all mature trees in the forest. In terms of species and quality, different products and different markets have to be served. This finally, is precondition for reasonable and responsible forest management and is as such applied all over world by companies that in fact manage the forest resources sustainably.

The report ends with specific recommendations on the planned activities in the framework of the Mozambican Forest Investment Program (MozFIP).

1 BACKGROUND

An estimated 40 million ha or 50% of Mozambique are covered with natural forests (mainly Miombo). Of these, circa 27 million ha are categorized as production forests. Besides containing nationally and internationally demanded high value timber species, the forests provide a variety of other goods and services such as non-timber forest products, fuelwood and construction material, water regulation, and biodiversity. However, the utilization of the natural forest is in most cases unsustainable leading to forest degradation and devaluation. Mozambique's Forest Investment Program (FIP) identified a shift towards sustainable management of Miombo production forests as a key deliverable for achieving its mitigation targets (REDD) as well as sustainable rural development.

The Mozambique Forest Investment Project (MozFIP, module 1 of FIP) will be supported by the World Bank. The project will be implemented in two provinces (Zambezia and Cabo Delgado) and has a national component. The design will build on the identified opportunities for and potential benefits of promoting sustainable natural forest management (SNFM):

- Very large natural forest area with the potential to deliver large-scale impacts and the opportunity to upscale successful business models to other provinces
- Existence of high value timber species in Mozambican Miombo forests as a basis for private sector involvement
- Implementation of a land management system which is very close to natural forest dynamics, resulting in continued provision of environmental services.

To realize the potential of sustainable management of the Miombo forests, a variety of challenges have to be addressed:

- Due to biophysical conditions the natural forests in Mozambique are of relatively low productivity, and related, low sustainable harvesting levels.
- Like in many other natural forests, the share of non-commercial tree species and of low quality trees is high. The common practice is to harvest only commercial species, leaving the non-commercial species in the forests. As a consequence, the species composition gradually shifts to non-commercial species resulting in gradual devaluation of the resource.
- The natural forest sector in Mozambique is, similar to other countries in the region, plagued by illegal harvesting and trade of timber, threating sustainability. Reducing illegality and increasing formalization requires years to decades. NFM concepts have to consider and address this restriction.
- Forest operators currently focus on few species and products and there is little investment into strategic market development.
- In addition to the challenges specific to SNFM, the development of the sector is limited by other constraints such as weak infrastructure, land tenure/resource insecurity, and complicated land use regulations.

This study was commissioned by the World Bank as a background study contributing to the design of the MozFIP. The study's objective is to identify under which conditions natural forest management businesses will be sustainable from a financial, economic and social perspective. To that end the economic performance of natural forest management businesses in the two

project regions was assessed under current conditions, followed by the development of potential future scenarios including business as usual and sustainable forest management.

In the following the approach and results are presented follows:

- Chapter 2: Description of the methodology used.
- Chapter 3: Summary of background information for the NFM sector in Mozambique and presentation of current Miombo value chains and their economic performance.
- Chapter 4: Description of possible future scenarios and their impact on financial performance of Miombo forest management and resource development.
- Chapter 5: Recommendations for improving sustainability of the sub-sector in general and for MozFIP interventions specifically.

It should be stressed that this study focused on timber products from the Miombo forests and did not address the environmental services that such forest provide (or could provide) - for example, in carbon sequestration.

2 METHODOLOGY

The methodology of the study combines different methods, implemented in three distinctive phases as shown in Figure 1 and described in the following sections.

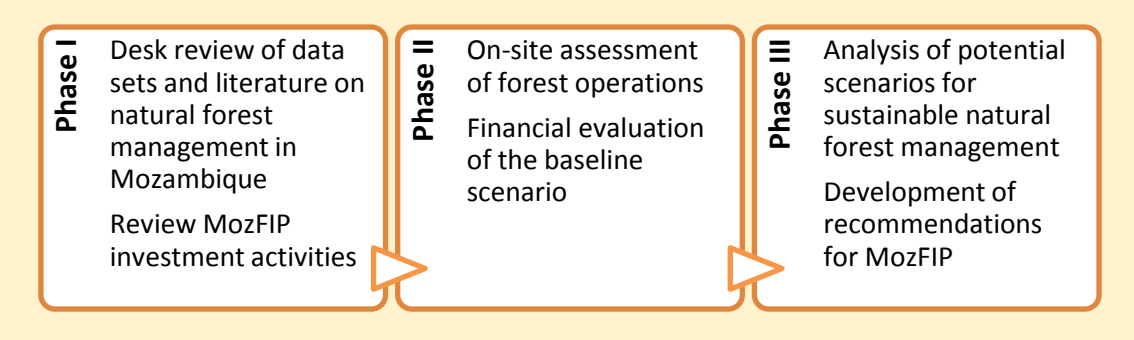


Figure 1: Work flow of the study

Phase I: Desk review

The desk review included literature and data on Miombo growth and yield, regulatory framework for NFM in Mozambique, technical forest management, and marketing of - or trade with - Miombo timber species as well as charcoal. The review of the available literature specific to Mozambique and /or Miombo forest management in the region was complemented with global data sets on natural forest management in similar forest ecosystems (e.g. Chaco region in South America). The thus compiled data set provided the necessary context for field work and the design of the interview questions. Furthermore, the results were partly used as entry values for the development of the baseline and potential SNFM scenarios and provided benchmarks for the validation of the interview results.

Phase II: On-site assessment of forest operators and baseline scenario

The utilization and management of production forests in Mozambique is done by entrepreneurs and companies which are licensed to harvest, transport and trade timber. Two types of licenses exist: Simple License for a duration of five years and Forest Concessions for a duration of 50 years. The latter is issued only to companies able to process logs.

For the empirical part of the study, the Ministry of Land, Environment and Rural Development (MITADER) and World Bank selected a small group of Simple Licenses (3) and Forest Concessionaires (6) operating in the provinces targeted by MozFIP. The table and map below show basic information on and the districts where the selected forest operators work.

The selected simple licensees have production areas between 750 and 6,550 ha, basic business structures, few assets and produce logs for onward trade. The Forest Concessionaires interviewed have production areas between 26,200 and 93,700 ha, and are more diverse: managing only one or several concession areas, and selling logs and sawn timber to varying degrees. In two cases further value addition was practiced at a small scale but with the interest to scale up such business ventures. Further information for Simple Licenses and Forest Concessions in the

two provinces and the interviewed businesses are provide in section 3.2, “Licensed forests in Cabo Delgado and Zambezia”.

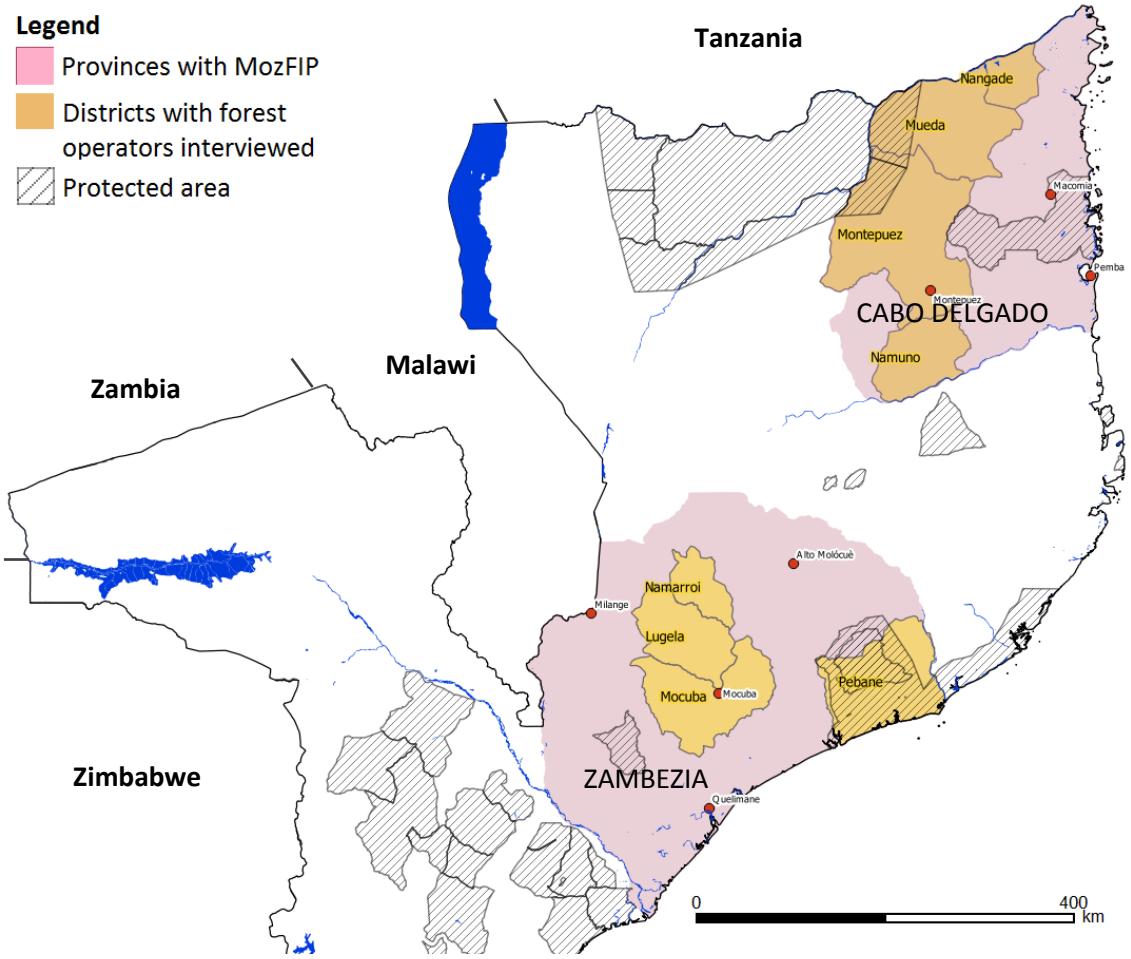


Figure 2: Location of field work in the MozFIP intervention areas in central and northern Mozambique

On-site qualitative and quantitative data has been assessed through a structured questionnaire[2] requesting information on:

- Cost of operations, transport, administration and corporate social responsibility
- Forest productivity
- Forest and technical management
- Processing facilities and utilization thereof
- Products, market location and sales prices
- Knowledge of and interest in forest certification and
- Challenges and barriers for conducting and developing their businesses.

[2] The full questionnaire is provided in Annex 1.

Field work included the visit of processing and forest production sites to the extent possible. MITADER provided the forest management plans for the interviewed operators, providing basic data sets on production area, availability of commercial species and estimated annual harvest volume.

The collected data on current state of the art of Miombo forest management was presented to stakeholders operating in and with knowledge of the NFM sector in Mozambique for validation before continuing with phase III, the development of scenarios for SNFM.

Limitations of the empirical part of the study

- The (intentionally) small and heterogeneous sample of forest operators gives insights in the finance of forest operations and allows the description of value chains but cannot be considered as a representative survey.
- To protect the confidentiality of the businesses the individual data sets from interviews and FMPs are not provided.
- The quality of responses to questions related to yield, cost and prices varied greatly, due to (i) different frame work conditions for the management (state of resources, distance to market, capacity of the operator); (ii) level of aggregation of costs and revenues (reference unit cubic meter log or cubic meter sawn timber or ha, considering only variable costs or also depreciation of equipment); (iii) lack of proper cost and revenue documentation by the forest operators; and (iv) political responses given by some interviewed persons on some issues.

In consequence, implausible data and extreme data were not considered to derive realistic average cost and revenue flows along the different value chains. In a validation workshop the range, the plausible average and international benchmarks of the main cost and revenue drivers were discussed with competent sector stakeholders. This resulted in agreed values for the description of the current value chains and for the baseline scenario.

Phase III: Analysis of baseline & SNFM scenarios and development of recommendations

The **baseline scenario** assumes the continued implementation of the current forest utilization, management and marketing practices as described in detail chapter 3, i.e. use of a few species only and overharvesting, and use of inefficient technologies for forest utilization and processing.

For the analysis of **sustainable natural forest management scenarios** a set of univariate and multivariate scenarios were developed. These were evaluated in regard to the likely impact on sustainability and economic viability of the businesses. Scenarios include changes to:

- Improved forest management (silviculture)
- The species and product portfolio of forest operators
- Technologies used in forest operations and processing
- Forest certification.

The individual scenarios are described in detail in chapter 5.

The results of the scenario analysis are reflected in two sets of recommendations addressing the following questions:

1. Which activities can improve the sustainability of NFM while maintaining or even enhancing the economic viability of NFM and the businesses involved?
2. How can the planned MozFIP interventions related to NFM be adjusted to achieve the best possible impact?

Limitations of the analytical part of the study

The analyzed scenarios are based on the empirical data collected in phase II and a range of assumptions. These, and modelling parameters are described in section 4.3. The financial performance of the different scenarios are highly sensitive with respect to forest growth rates, recovery rates at saw mill, distance to market, technology and economy of scale gains, etc. Nonetheless, we believe that the scenarios show trends and provide the technical justification for our recommendations. Absolute values, for example cash flow or net present value, provide an orientation of the average situation only and should not be used for specific business plans. When developing a concrete business plan the particular circumstances (status of the forest resource, distance to market, technology applied, etc.) have to be considered.

3 CURRENT STATE OF MIOMBO FOREST MANAGEMENT

3.1 Framework for natural forest management

The implementation of sustainable natural forest management policies is hindered by several barriers, chiefly institutional capacity gaps, insecure long-term resource access further exaggerated by poor track record of sharing forest benefits with resident communities, and a complicated licensing system which does not cater to multiple purpose forestry.

Institutions

The institution carrying the overall responsibility for forests is the recently created Ministry of Land, Environment and Rural Development (MITADER). The Ministry's Directorate of Forests (DINAF) is responsible for the management of natural forests outside protected areas. At provincial level the Provincial Forest Service (SPF)[3] is in charge for issuing licenses for harvesting, law enforcement and afforestation. At district level the District Services of Economic Activities (SDAE) are responsible for natural resources management. However, significant capacity gaps exist at all levels (MITADER, 2016).

Forest harvesting licenses

Two forms of commercial harvesting licenses exist for natural forests: simple license and forest concession which can include timber, non-timber, charcoal and building materials. Licensees for timber have the right to harvest and transport timber according to the annual allowable cut (AAC) specified in the approved management plan. Concession size, duration and requirements for the two timber harvesting license types differ substantially (Table 1) and as a result provide different (dis-)incentives for sustainable forest management. License fees and taxes are based on the round wood volume or charcoal extracted, i.e. are in essence transport licenses. Charcoal production licenses are issued for relatively small areas and have an annual production limit of 1,000 bags of charcoal. Timber harvesting and charcoal production rights are not issued together. Both simple license and forest concession only include the forest user rights but not the land use right. Regardless of the forest license resident communities retain the right to subsistence uses such as agriculture, charcoal, firewood and hunting etc. As a result forest land can be converted to e.g. agriculture as needed by resident communities (Figure 3).[4] This of course impacts the productivity of the concession forests and in consequence the annual allowable cut (see also section 5.1.1). Furthermore, the current licensing structure and process provides opportunity to legalize timber or charcoal sourced illegally, i.e. by producers without license or produced outside the license area[5] (Baumert et al, 2016, Ekman et al, 2014).

[3] SPF is one department under the Provincial Directorate of Land, Environment and Rural Development (DPTADR).
[4] Conversion of forest land to small-scale agriculture is the biggest driver of deforestation in Mozambique (MITADER, 2016).
[5] Compliance is controlled outside the forest, i.e. is based on logs pasing through check points along major roads. As a result everyone with a license can legally transport timber or charcoal regardless of the actual source of the products transported.

Figure 3: Forest conversion

Village within a concession area. The tree stumps indicate recent conversion.

Table 1: Forest harvesting licenses

License type	Number of licenses	Details
Simple license	883	Duration: 5 years Area: ≤ 10,000 ha Requirements: ▪ Mozambican nationals only ▪ Simple forest management plan (based on a preliminary inventory) approved by the provincial governor Maximum production: ▪ Timber: 500m³/yr ▪ Charcoal: 1,000 bags/yr (regardless of size) Cost: ▪ License fee based on products (roundwood, charcoal bags) extracted ▪ Reforestation tax* of 15% based on license fee
Forest concession	198	Duration: 25-50 years, renewable Area: > 10,000 ha Requirements: ▪ Management plan approved by the provincial governor (≤ 20,000ha) or DINAF (> 20,000) and periodically renewed ▪ Proof of processing capacity (sawmill) Maximum production: ▪ Timber as per FMP ▪ Charcoal not foreseen for forest concessions Cost: ▪ License fee based on round wood volume extracted ▪ Reforestation tax of 15% based on license fee ▪ CSR costs (concessionaire is expected to provide social support to communities)

* Commonly used term for the "sobretaxa de repovoamento florestal e faunístico" (over-tax for restoration of forests and wildlife)

Source: GoM (2002): Forest regulation, GDS (2016), Luz et al (2015), MITADER (2016)

Regulations and sustainable forest management

All (potential) licensees must comply with a minimum set of standards (Forest Regulation, 2002) geared towards sustainable resource management – but often don't, or do so only nominally (Table 2).

Table 2: Basic standards for sustainable forest management

Requirement	Compliance by the interviewed operators
Approved forest management plan[1] based on a forest inventory	All operators interviewed had approved management plans, however: ▪ Little detail on the forest inventory conducted is provided ▪ Inventory designs are unsuitable to provide useful entry data for management planning ▪ Annual allowable cut is calculated based on documented harvested volume over long periods of time (> 10 years) ▪ Figures stated are clearly not supported by the basic data (e.g. area per vegetation type)
Demarcation of the concession area	None of the operators had demarcated the area
Reforest in harvested areas[2] (enrichment planting)	All but one operator claimed to reforest. Operators: ▪ Were doubtful about the effectiveness of the activity given the frequent and often intensive fires reducing survival of seedlings, and capacity of Miombo to naturally regenerate ▪ Already pay for reforestation as part of the reforestation tax
Forest concessions: have the capacity to process round wood to sawn timber	All forest concessionaires had sawmills. These were: ▪ Used well below capacity ▪ In one case not functional

[1] A guideline for forest management planning for forest concessions exists (Sitoe et al 2008)
[2] Not a regulatory requirement but included in the forest management planning guideline.

Source: GoM Forest regulation 2002

Benefit sharing mechanism

A benefit sharing mechanism to communities residing within the license area is in place. Communities are to receive 20% of the logging taxes paid to the GoM by the forest operators. Furthermore 50 % of the value of the fines collected for not following the legislation is to be given to community members participating in law enforcement activities.

However, in reality communities may receive little to no benefit either due to unlicensed wood harvesting, the cumbersome process and due to weak enforcement of the benefit sharing mechanism (e.g. Baumert et al, 2016 and MoA, 2012). Operators do at least partially compensate by providing assistance to community projects (e.g. construction of a school or festivities).

3.2 Forest resource

Forest area and forest growth

According to the most recent statistics compiled in Mozambique's Forest Investment Program (MITADER, 2016) forests cover approx. 40 million ha of the total land area, of this ca. 27 million ha are considered production forests with Miombo being the pre-dominant forest ecosystem. In Cabo Delgado province production forest was estimated to be 3.1 million ha and in Zambezia province 4.1 million ha (Marzoli, 2007). A forest cover map for the two provinces is provided in the figure below.

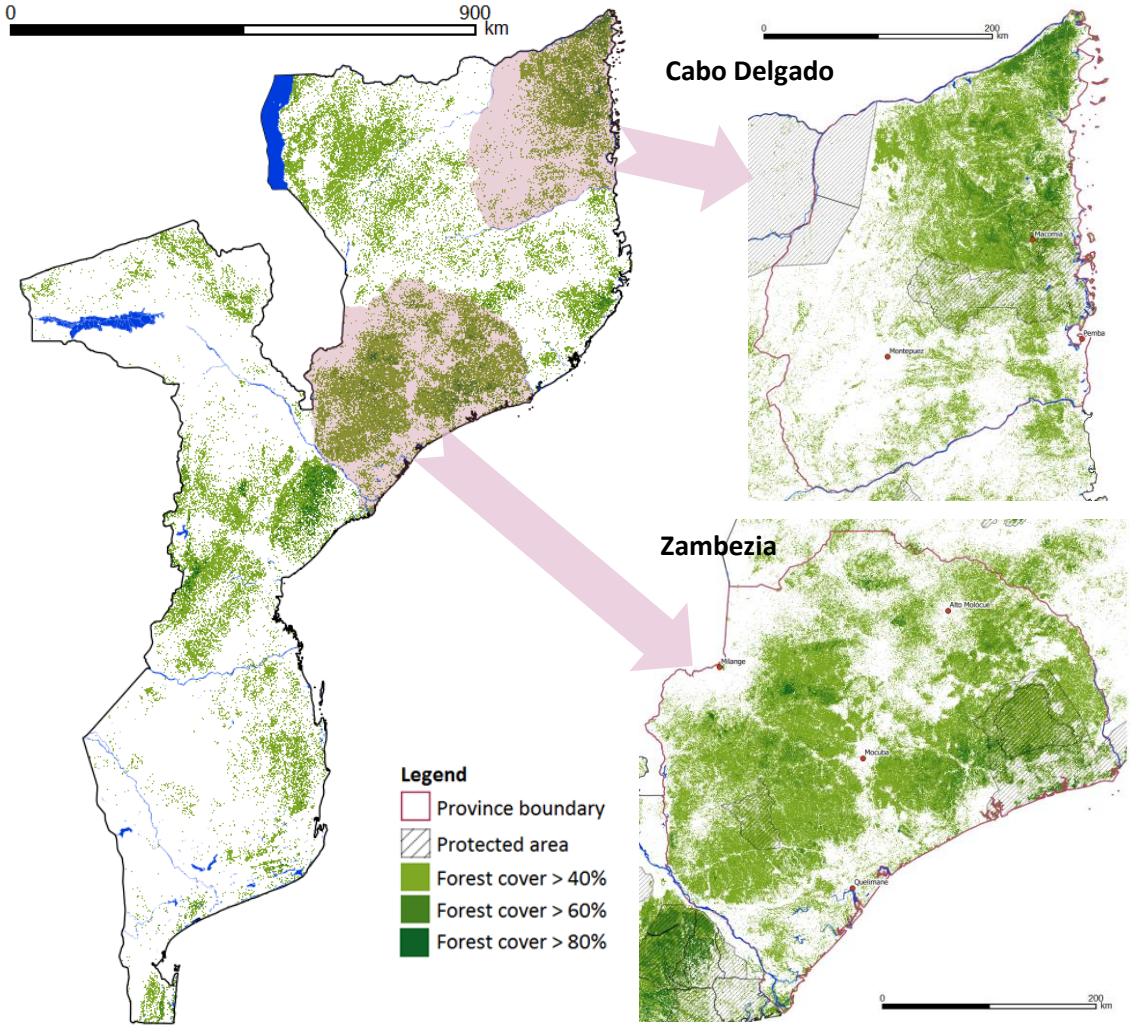


Figure 4: Forest cover

Source: Earth Engine Partners

Annual growth of Miombo forest in Mozambique and in the region is estimated to be in the range of 0.5-1.5 m³/ha/yr (Saket, 1994; Saket, 1999). The last national forest inventory was conducted from 2004 to 2007 (Marzoli, 2007). According to the inventory results commercial species constitute ca. 7% of the standing volume and Saket (1994) states that commercial timber

species account for only 4% of biological growth. According to Marzoli (2007) the annual allowable cut for commercial species is estimated to be 2.1 million cubic meters. However, only very few species were actually harvested, in particular Jambirre, Chanfuta and Umbila (refer Fig. 5 for species' scientific names): a situation that remains unchanged today.

The given data on increment and annual harvest refer to stem volume. The wooden biomass of branches, which can be used for fuel wood, charcoal and partly as construction timber (house-building, fencing) is not considered. As a rough number the total woody biomass volume of natural forest trees can be divided in 50% logs and 50% branches.

Licensed forests in Cabo Delgado and Zambezia

The total area licensed to operators in Cabo Delgado and Zambezia is 1.9 million ha and 2.9 million ha respectively. In Cabo Delgado ca. 20% of the total area is managed by simple licensees whereas in Zambezia the share is much higher with 40%. The share of the actual productive area of the operators visited varied between 45 and 90% of the total licensed area.[6] Further details are provided in the table below.

Table 3: Production forests in Cabo Delgado and Zambezia

		Cabo Delgado	Zambezia
Forest area	ha		
Areas with license	ha	1.933.148	2.897.200
of which:			
Simple license	no.	40	116
Total area	ha	399.881	1.160.000
Average area	ha	10.000	10.000
Forest concession	no.	43	53
Total area	ha	1.533.267	1.737.200
Minimum area	ha	15.000	20.000
Average area	ha	35.657	33.408
Maximum area*	ha	103.927	94.000

*In some cases companies hold more than one forest concession, raising their total concession area beyond the values stated here.

Source: MITADER (2016)

The annual allowable cut for all commercial species (as per regulation) stated in the forest management plans (FMP) of the interviewed forest operators ranges between 0.1 and 0.5 m³/ha*yr. However, at the time of the survey operators were harvesting only very few species (see Figure 5): Pau preto, Umbila, Chanfuta and Jambirre (Panga-Panga) in Cabo Delgado, and Umbila in Zambezia. The annual allowable cut for the species actually harvested is much lower ranging

[6] According to the forest management plans of the operators visited. Only the forest types LF1, LF2 and LF3 (or similar) were considered. In one case the forested area was only 7% of the total area.

between 0.01 and 0.12 m³/ha*yr. As per the National Forest Inventory (Marzoli, 2007) the share of premium (Pau preto) and first class species (Umbila, Chanfuta, Jambirre) is 25% out of the total volume of commercial species.

Most operators stated that the actually licensed and harvested volume is lower than the annual allowable cut per FMP. The data collected indicates a significant difference in abundance of marketable species and harvestable volume between Cabo Delgado (higher) and Zambezia.

Pau preto	**Umbila**	**Chanfuta**	**Jambirre**
Dalbergia melanoxylon	*Pterocarpus angolensis*	*Afzelia quanzensis*	*Millettia stuhlmannii*
			

Figure 5: Species harvested in Cabo Delgado and Zambezia

Source: Pictures from Google Images.

While the low number of species with an assured market is a concern, natural forest management in the two provinces benefits from the relatively flat terrain and long dry season allowing easy access to forests.

3.3 Current forest management and utilization practices

The current approach to forest management and utilization is entirely market driven, i.e. species and volume harvested are determined by the buyer of a certain species rather than sustainable yield. As a result the function of forest management plans is compliance rather than actual planning, periods between re-entry to the same areas tends to be short (2-3 years) when the market asks for another (first class) species that the one harvested in the intervention before, and volume harvested for the selected species (not in absolute!) is not sustainable. Investments into silviculture are virtually absent with the exception of enrichment planting – the effectiveness of which is doubtful. Forest fires are frequent and can be very intensive, severally limiting natural regeneration. The level of mechanization of forest operations, and investments into processing and further value addition vary, with some forest concession companies making serious efforts to improve efficiency, recovery and value addition. However, the majority of operators does not employ forest technicians, and uses outdated techniques and technology.

Forest management planning and monitoring

A forest management plan is required for both simple licenses and forest concessions. These management plans have to be developed by specialist service providers, and must be based on a forest inventory. The survey of forest operators conducted for MITADER in 2015 (2016) shows that almost all operators are compliant. However, the standard of the management plans (interviewed companies only) is low:

- The inventory design and data does not allow detailed spatial planning
- Harvesting blocks (3-5) are identified but do not reflect the distribution of the resource, nor the often verbally stated rotation length of 10-20 years (i.e. the number of blocks should be at least equal)
- Annual allowable cut in updated management plans is calculated based the original AAC on harvesting statistics (no spatial component).

The survey (MITADER, 2016) also shows that concession and block boundaries are often not demarcated, that the collection / availability of statistics is poor (in particular for simple licensees), and that qualified personal[7] needed to implement forest management is frequently lacking.

Adherence to the management plan (other than AAC which is the basis for transport license) is low. All but one of the operators explained that harvesting does not follow a prescribed regime, nor are FMPs translated into annual operational plans. Rather, re-entry logging at unspecified intervals regardless of post-logging growth is conducted when market demand (national or international) for certain species pops up. Pre-harvest and post-harvest inventories are likewise not conducted.

A report by Fath (2001) analyzing the standard and efficiency of forest management in detail stated that equipment and personnel are used inefficiently due to a lack in planning, inadequate preparation and logistical problems. A situation that seems to have changed very little if at all.

Box: Calculation of annual allowable cut (AAC)

A fact-based and reliable derivation of the AAC is of outstanding importance for the implementation of sustainable forest resource management. The AAC must reflect the current state of the resource (inventory), the history of the resource utilization (e.g. overexploitation of some species in the past) and the silvicultural regime to be applied in future and has to be calculated at concession level, taking into account productive area only. Information from national and regional inventories can only give an orientation, rather than being the basis for forest management planning and AAC calculation. Taking this in account, each forest concession or simple license requires a forest inventory. The AAC has to be calculated across all species and should be adhered to, including the removal of non-commercial tree volume to stop the unbalanced extraction of premium and first class species only as currently practiced (resulting in gradual resource degradation, see also section 4.3 and 5.1.2).

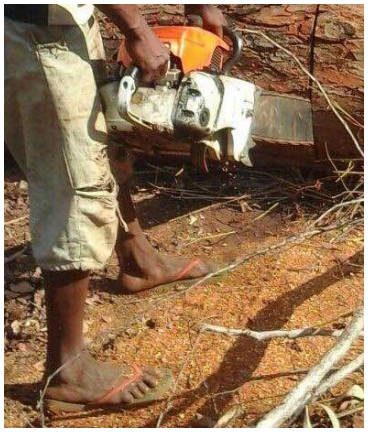
Forest utilization

Current forest utilization practice is to log the most accessible areas first, before moving on to more difficult sites (e.g. those requiring the construction of bridges and roads). In addition, forest operators also set up operations in different areas of the concession as a means to control concession boundaries and prevent illegal logging. Frequently operators fill their annual quota of commercial species by looking for and harvesting these trees anywhere within the concession area (in contrary to a planned block by block approach).

Forest utilization includes the identification of trees suitable for harvest immediately prior to harvesting (required species and minimum diameter), felling and sectioning, skidding and loading. In some cases logs are transported with small trucks to a concentration point within the

[7] While not described in the report, it is assumed that qualified personnel refers to persons with a formal education e.g. certified forest technicians.

forest (usually <50 km). All operators interviewed work with their own felling team(s) in seasonal employment rather than hiring service providers.



Clockwise from upper left:

- Parts of the stem and big branches are not utilized. The production of log lengths below conventional standards requires vertically integrated processing and/or a dynamic marketing approach.
- Basic health and safety measures are lacking in many forest operations.
- Manual loading is common. While providing local employment, it is also very dangerous and highly inefficient. The loading process takes hours binding the truck. Mechanized loading would be more cost-efficient, but requires an investment that may overrun the capacity of most forest operators.

Figure 6: Common practices in forest utilization

According to MITADER (2016) the technical capacity[8] to execute these activities is low in Zambezia (with only ca. 20% of simple licensees and 70% of forest concessions complying with the survey standard) but much better in Cabo Delgado (with over 90% of all operators being compliant). Our own observations and studies by Ekman et al (2014) and Fath (2001) indicate that harvesting operations:

- Do not apply reduced impact logging (RIL) practices such as directional felling or low impact skidding;
- Are often highly inefficient in utilization of stem volume;

[8] While not described in the report it is assumed that technical capacity refers to the availability of equipment and machinery rather than human resources.

- Have high costs per harvested m³ due to low harvesting volumes per ha, inadequate setting with machines (e.g. using small agricultural tractor instead of forest skidder), low density and bad conditions of forest roads, and not counting with skilled forest labor force;
- Do not include basic health and safety standards such as protective equipment for the work crews.

While only one forest operation could be actually visited in the framework of this assignment, interviewee's responses suggest that this holds true to date for most operators.

Transport

Transport refers to the movement of logs from the forest to a log yard and/or sawmill outside the forest usually 50-100km away. In very few cases logs are moved directly from the forest to the client (very often Chinese timber exporting companies) several hundred km. From the log yard/mill logs or sawn timber are transported to the client or harbor for export. Transport costs include offloading / loading.[9]

Clockwise from upper left:

- Transport of Pau preto logs to the client in-country
- Transport to the harbor for export
- Transport of Chanfuta logs to the saw mill

Figure 7: Transporting logs

[9] Loading in the forest is included in forest utilization.

Silviculture

The implementation of silvicultural measures is restricted to enrichment planting. While all but one operators interviewed claim to do this, the MITADER (2016) survey indicates that few operators actually do so in Zambezia. In the interviews, operators stated that their efforts are rendered useless by frequent forest fires causing high seedling mortality, and perceive it as an undue financial burden.[10] According to Putz et al (2015), successful enrichment planting in tropical forests requires dedicated staff, is costly and the economics questionable in comparison to protecting and liberating existing natural regeneration.

The impact of implementing silvicultural measures such as tending natural regeneration, promoting future crop trees (positive selection) or eliminating overmature non-commercial trees (negative selection) aiming to enhance the more valuable timber species / trees with high potential for producing good logs in Miombo forests is not well understood. However, the general perception of the scientific community is that to do so would help to avoid a gradual shift of the species composition to non-commercial species. Protection from and management of fire (e.g. timing and intensity) seems to have a significant impact on regeneration, development of saplings into trees (rather than bushes), and species composition. According to Gambiza et al (2000) long disturbance-free intervals are needed. Gambiza et al also noted the positive effect of coppice management on forest development while at the same time pointing out that the additional cost may likely offset the economic benefits.

3.4 Markets, timber value chains and forest product prices

Mozambique's forestry sector benefits from high acceptance of some of its premium and first class timber species in overseas markets and relatively easy access to these markets through ports in Pemba, Nacala and Beira. However, the export market is dominated by China[11] and is highly selective, i.e. takes few species only (Pau preto, Pau ferro, Umbila, Chanfuta and Jambirre). Non-Chinese forest operators rarely, if at all, export directly to China. Rather, operators sell logs to Chinese owned companies who mill (in case of 1st class species) and export. Other export markets mentioned in interviews as being directly accessible to operators are Mauritius and South Africa. In the national market a slightly wider range of species is accepted. Nonetheless, market preference is clearly on the same 1st class species as for the export market with others such as Metonha, Metil, Messassa, Missanda and Messinge contributing only 15% of market volume (FAEF, 2013). Maputo is by far the biggest market.

Decisions by producers on what and when to harvest are driven solely by the customer requirements (Chinese traders, wholesale timber buyers in urban centers, construction firms) and do

[10] The current situation is that forest operators have to pay the overtax and do the reforestation as well. The 15% overtax paid by forest operators for reforestation is in practice used by the Government to produce seedlings in nurseries only. The work and the costs of transporting, planting and maintenance of the seedlings has to be covered by the forest operators. Our understanding is that there is a misinterpretation of the regulation. Although in the past there were suggestions to waive the reforestation overtax for those companies that can demonstrate a successful reforestation/regeneration, there were no consensus.

[11] Export to China is usually done by Chinese traders, not the forest operators/producers.

not take into account the actual production capacity of their forests (i.e. the wide variety of species available). Little effort is made by the forest operators to develop new markets which would allow them a more balanced approach to forest utilization.

Furthermore, illegal timber harvest and trade has very negative implications for revenue collection and competitiveness of operators complying with the regulations. FAEF (2013) reports that annually harvested timber (comprising formal and informal production for national consumption and export) exceeds the annual allowable cut by approx. 40% and that ca. 60% of timber was harvested without license. It can be assumed, that the situation with respect to overexploitation only considering the premium and first class species is even worse. According to EIA (2014) the majority of illegally harvested and traded timber is for the export market. The same report indicates that illegal harvests were as high as 93% of the total harvested volume in 2013.

Box: Broaden the portfolio of species utilized

The situation of harvesting only few species out of a wide range is very common for natural forest utilization in the tropics. In the long run doing so will harm the sustainability of utilization as the resource gradually but invariably degrades in terms of species composition and harvesting costs increase (with valuable trees reduced and more dispersed, and extracted volume/ha reduced). To broaden the portfolio of harvestable species is key for the implementation of SNFM. How-ever, it is very challenging to enter the market with new, unknown species. This requires time and effort forest companies and public institutions alike. (See also sections 4.3.2 and 5.1.3).

Value addition by the forest concessionaires is largely limited to conversion of logs to sawn timber; and often the quality of the sawn timber is not suitable for the export market. In very few cases companies engage in further value addition such as carpentry or production of veneer. Simple licensees usually trade unprocessed logs. Pau preto is not traded in the domestic market and can be exported as round wood. The principle value chains are illustrated in Figure 8.

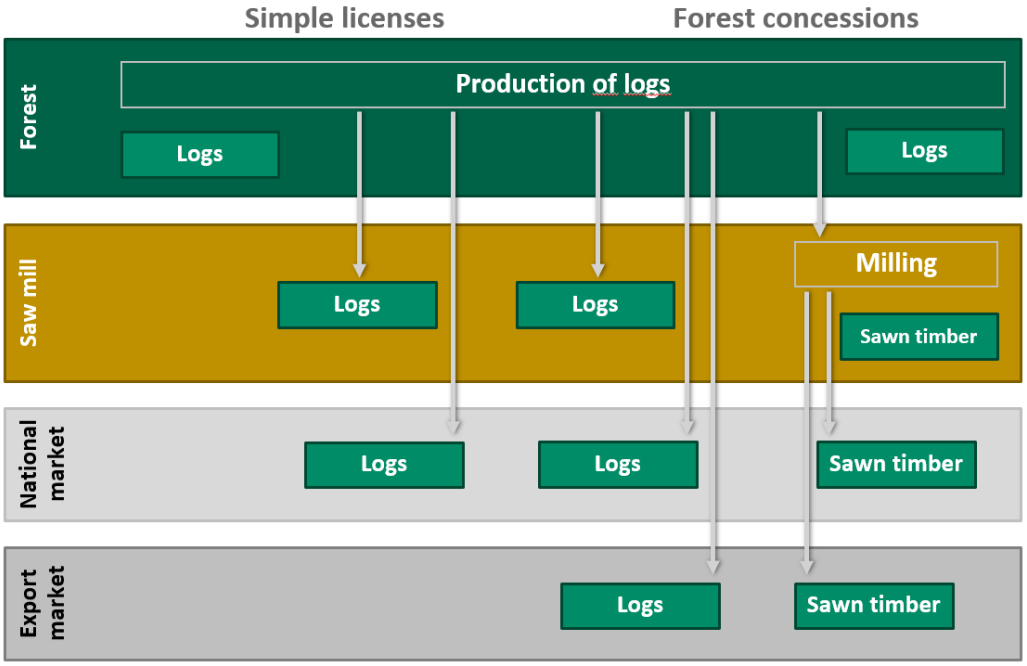


Figure 8: Current timber value chains

Predictably, timber prices vary according to the product and point of sale. However, the price range is also very wide for similar products and selling points (Table 4). These differences are likely related to the quality required by the customer (less vs. more selective) and marketing skill of the operator.

Table 4: Log and sawn timber prices

Product		**Selling point**	**Price range observed** (USD/m³ commercial)	**Most plausible value[3]** (USD/m³ commercial)
Logs	1st class[1]	Forest road	110	110
	Premium class[2]	Customer gate	325-600	535
	1st class		140-300	220
Sawn timber	1st class	Export (FOB)	900-1,300	900
	1st class	National market	345-900	500

[1] Chanfuta, Jambirre, Umbila

[2] Pau preto

[3] Value used for economic calculations and scenario modelling

Production of timber and charcoal by the same forest operator is currently not happening. However, licensees/concessionaires can apply for charcoal production. Two principal charcoal value chains exist:

1. Small scale production by communities/individuals and transport to the next road or urban center.
2. Large scale production and transport with trucks to big towns such as Pemba, Quelimane, Nampula or Beira and wholesale.[12]

A combination of the two value chains is common, i.e. small scale production, which is then bought and transported to urban centers by wholesalers.

Table 5: Charcoal prices

Selling point	**Price range observed** (USD/t charcoal)	**Value used for economic model** (USD/t charcoal)
Road side	63-87	85
Wholesale in large urban centers	125-190	150

Source : ICEM (2016), Egas et al (2016), UNIQUE data collection

[12] The Maputo market is not considered here as it is rather far away from the two provinces included in the study.

3.5 Production costs

The interviewed operators stated similar values for the individual cost items as found in the literature. Table 6 shows the range of values observed, including efficiency rates and provides a comparison with the literature (for Mozambique or Miombo) and global benchmarks. Values for the charcoal value chains are provided further below.

Table 6: Cost along the timber value chain

Item		Unit[1]	Value			
			Observed range[2]	Literature for Miombo forest	Literature for tropical forests[3]	Most plausible value[4]
Forest operations						
Forest operations[5]		USD/m³ roundwood over bark	15-68	10-51	13-69	26
Silviculture		USD/m³ roundwood over bark	0.4-1.2[6]	N/A	3	0.8
Ratio commercial / harvested volume[1]		%	75-85	N/A	N/A	80
Industrial operations						
Milling		USD/m³ roundwood commercial	13-50	32-77	30	24
Recovery rate		Output m³ of sawn timber / input m³ roundwood commercial (%)	20-50	35	30-70[7]	40-50[8]
Transport						
Transport to mill or log yard outside the forest	Cost	USD/m³ roundwood per km	0.1-0.3	0.15	0.2	0.2
	Average distance	km	100	N/A	N/A	100
Transport to the customer[9]		USD/m³ roundwood	37-48	N/A	0.05 to 0.15 per km	45
Administration						
Forest administration[10]		USD/m³ roundwood over bark	1-5	N/A	20	5
Forest management planning (FMP)		USD/ha every 10 years	1	N/A	2	1

Item		Unit[1]	Value			
			Observed range[2]	Literature for Miombo forest	Literature for tropical forests[3]	Most plausible value[4]
Taxes and fees						
License fee for logs	Premium	USD/m³ roundwood over bark	-	40	-	40
	First class			20		20
	Other[11]			10		10
Reforestation tax		% of license fee	-	15	-	15
Export tax		% of FOB	-	15	-	15

[1] An example calculation for the different volumes along the value chain is provided in Annex 2.
[2] Extreme outliers, or clearly false values are excluded. Scale of operations vary widely between operators with productive areas between 746 ha (Simple License) and 93,713 ha (Forest Concessionaire) and annual allowed cut for actually harvested species (premium: Pau preto; 1st class: Chantufa, Umbila, Jambirre) between 0.01 and 0.12 m³/ha/year.
[3] Grulke et al (2016)
[4] Value used for economic calculations and scenario modelling
[5] Includes: Tree identification, felling and sectioning, concentration and loading of logs.
[6] Values were provided in total USD per year. Benchmarks per m³ were estimated based on forest area and harvested volume figures. The only silvicultural intervention at the moment is enrichment planting.
[7] The range covers processing of natural forest species with mobile mills to milling of conifers in high tech large scale mills in Europe.
[8] 40% for sawn timber for export markets and 50% for national markets
[9] Long distance transport to the customer or port is not directly related to distance. The cost stated includes transport distances between ca. 300 and up to 1,500km. Includes loading.
[10] Values were provided in total USD per year. Benchmarks per m³ were estimated based on forest area and harvested volume figures
[11] Average value of class 3 and 4 species. These species are currently not traded in significant amounts.

Since forest operators interviewed within this study do not produce charcoal, it was not possible to obtain primary data on charcoal production costs. Instead, information was obtained from the literature and experiences in other countries. It was observed that available sources rarely provide comprehensive economic data or a breakdown of costs, and the few data available show high variability. For costs of producing one ton of charcoal, data ranged from 55 USD in Tanzania, 74 USD in Mozambique (van der Plas et al, 2012) and 100 USD in Paraguay. Most often average values were used for calculations. Table 7 provides values for the charcoal value chain.

Table 7: Cost along the charcoal value chain

Item		Unit[1]	Value			
			Observed range	Literature for Miombo forest	Literature for tropical forests	Most plausible value[2]
Charcoal						
Conversion efficiency		t charcoal / t stacked timber (%)	N/A	14-19	N/A	20
Production and transport to road		USD/t charcoal	N/A	55-100	N/A	80
Transport to urban center	Cost	USD/t charcoal * km^{-1}	N/A	0.33	N/A	0.33
	Average distance	km	N/A	100-300	N/A	150
Taxes and fees						
License fee for charcoal		USD/t charcoal	-	16	-	16
Reforestation tax		% of license fee	-	15	-	15

[1] An example calculation for the different volumes along the value chain is provided in Annex 2.
[2] Value used for economic calculations and scenario modelling

3.6 Profitability of timber and charcoal value chains

The profitability was analyzed for the following Miombo forest value chains (VC, see also Figure 8 above):

- VC 1: Selling logs at the forest road
- VC 2: Selling logs at the customer gate
- VC 3: Selling sawn timber in the national market
- VC 4: Selling sawn timber in the export market (FOB)
- VC 5: Selling charcoal at the forest road
- VC 6: Selling charcoal in urban centers

Log and sawn timber value chains

The first two value chains apply to both simple licenses and forest concessions, whereas the latter two apply to forest concessions only.

The values presented in the tables above (Table 4 - Table 6) were used to assess the profitability of these value chains, expressed per cubic meter of harvested roundwood (Table 8). This allows to compare the profitability of the different value chains.

This exercise corresponds to a static economic analysis, accounting for costs and revenues linked to harvesting and adding further value to one m^3 of roundwood. Value chains have not been analyzed over time, and hence values have not been discounted (such an analysis is presented in the next chapter). In fact this approach matches well with business models applied today by forest operators. Operators do not make significant investments or apply any silvicultural treatments in the forest between interventions, meaning that they do not assume costs of timber

growth. Operators only have costs related to harvesting roundwood, processing and transport and in turn get immediately the revenues of their activities through the sale of the product.

Table 8: Costs and revenues along timber value chains*

VC1: Logs at forest road	VC 2: Logs at customer gate	VC 3: Sawn timber national market	VC 4: Sawn timber export market
Costs			
Production of logs ▪ Forest operations ▪ Silviculture ▪ Administration and FMP ▪ License fee and other tax	**Production of logs** ▪ Forest operations ▪ Silviculture ▪ Administration and FMP ▪ License fee and other tax **Transport of logs** ▪ To log yard ▪ To customer	**Production of logs** ▪ Forest operations ▪ Silviculture ▪ Administration and FMP ▪ License fee and other tax **Transport of logs** ▪ To mill **Milling** ▪ Milling ▪ Add. administration **Sale of sawn timber** ▪ Transport customer	**Production of logs** ▪ Forest operations ▪ Silviculture ▪ Administration and FMP ▪ License fee and other tax **Transport of logs** ▪ To mill **Milling** ▪ Milling ▪ Add. administration **Sale of sawn timber** ▪ Transport customer ▪ Export taxes
Revenues			
Sale commercial logs	Sale commercial logs	Sale sawn timber	Sale sawn timber
Net revenues per m³ of roundwood harvested			
32 USD / m³	**55 USD / m³**	**44 - 81 USD / m³** (in function of recovery rate 40-50% of commercial log volume)	**61 - 115 USD / m³** (in function of recovery rate 30-40% of commercial log volume)

*First class species only

Note: Costs and revenues for each value chain are based on data from previous sections. Since these might refer to different volume units in each case, conversion and recovery rates have been applied as necessary to obtain results in USD per m³ of roundwood harvested. Values are not discounted.

The analysis shows that the log businesses is profitable regardless of the value chain under the current, unsustainable management practices. When regarding sustainability of operations, then the picture changes substantially (see chapter 4).

If the integration of saw milling adds value depends mainly on the recovery rates of the transformation process log to lumber. If the recovery is at the lower end, then no value adding can be achieved. In practice, this situation is evidently very common: many of the interviewed concessionaires with milling facilities reported that they prefer the sale of logs instead of processing them.

Figure 9 below shows the high variability amongst operators. When considering the overall range, results for VC 2 and VC 3 are comparable. As long as the sale of logs yields a higher than

or equal price to sawn timber, operators have little incentive to engage in value addition by saw milling.

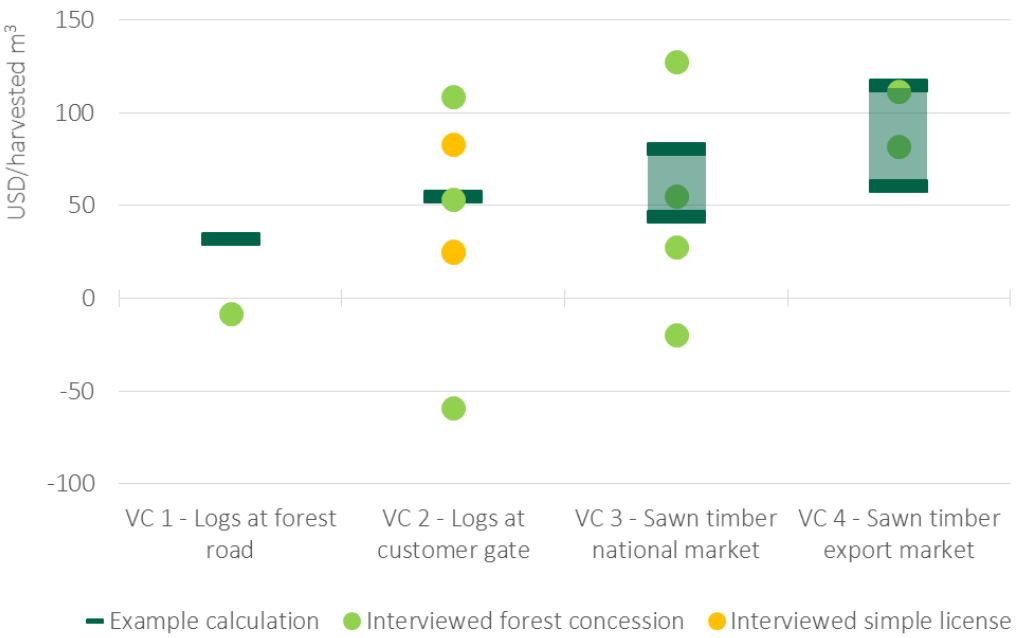


Figure 9: Comparison of net revenues by value chain*

*First class species only

Net revenues were calculated based on the cost and revenue values provided by the operators. In cases of missing or extreme values the most plausible value was applied. Forest concessionaires interviewed likely sell the majority of their timber as logs. The share of sawn timber on total volume sold could not be assessed.

Charcoal value chain

In terms of utilized wood volume charcoal is by far the most important product of Mozambique's Miombo forests. Charcoal production is not yet part of the business model of forest operators harvesting logs. However, when analyzing integrated and sustainable approaches for a sustainable Miombo forest management, charcoal production plays an important role.

The value chains of current charcoal utilization in the two study regions can be described in a simplified manner as follows (see also Table 9):

1. Production of charcoal and sale at a nearby road (common business model of small scale producers).
2. Production of charcoal and transport to big urban centers such as Pemba, Quelimane, Beira or Nampula for wholesale.

While the net revenue per cubic meter wood harvested is low it may be enough to cover the cost of removing trees without timber value as part of silvicultural interventions.

Table 9: Costs and revenues along charcoal value chains

VC5: Charcoal at forest road	VC 6: Charcoal in urban centers
Costs	
Production of charcoal ▪ Production and transport to road ▪ (License fee and reforestation tax)	**Production of charcoal** ▪ Production and transport to road ▪ (License fee and reforestations tax) **Transport of charcoal** ▪ To urban center
Revenues	
Sale of charcoal	Sale of charcoal
Net revenues per m³ of roundwood harvested	
1 USD / m³ roundwood harvested (with fees & taxes: -3 USD / m³ roundwood*)	**4 USD / m³ roundwood harvested** (with fees & taxes: <1 USD / m³ roundwood*)
Net revenues per t of charcoal	
5 USD / t charcoal (with fees & taxes: -13 USD / t charcoal*)	**21 USD / t charcoal** (with fees & taxes: 2 USD / t charcoal*)

* Small scale producers – usually community members do not have to pay the license fee or reforestation tax.

Note: Costs and revenues for each value chain are based on data from previous sections. Since these might refer to different volume units in each case, conversion and recovery rates have been applied as necessary to obtain results in USD per m³ of roundwood harvested.

If license fees and other taxes were paid, the sale of charcoal would generate a loss when sold at forest road and a very small net revenue when sold in urban centers. In practice, however, charcoal production is an informal business and fees and taxes are not part of the actual costs. Excluding fees and taxes, businesses can generate a small net revenue, estimated at 1 USD and 4 USD per m³ roundwood depending on the place of sale. These small margins reflect perfectly the actual situation of the charcoal value chain (maybe better called *charcoal misery chain*): only the poorest of the poor, who do not have any alternatives, nor opportunity costs, engage in this business. Charcoal production, as currently practiced destroys the natural resources and exploits charcoal producers.

While the direct economic profits achievable with charcoal production appear small, the integration of sustainable charcoal production into the overall resource management can bring other important benefits. It can help to (i) formalize the production of charcoal, and to ii) utilize the large volumes of non-commercial tree species in a planned and sustainable manner. A more detailed analysis is provided in the next chapter.

4 SCENARIOS FOR MIOMBO FOREST MANAGEMENT

4.1 Introduction

Based on the results of our analysis, the management and utilization of Miombo forests implemented today in Mozambique can be briefly described as follows:

- Forest operations are extremely market driven, focusing only on a few premium and first class species.
- Forest operations have the characteristics of a mining business, rather than those of a long-term natural resource management system, having no silvicultural strategies to enhance productivity and value creation.
- Forest operators are often in the business because they can realize attractive gross margins without taking significant entrepreneur risks, but have little interest in forestry as a long-term business.
- Harvesting technologies used are often outdated, resulting in low operational efficiency, damages to the forest and valuable timber wasted.
- The development of the natural forest management (NFM) sector in Mozambique towards a sustainable industry is constrained by non-transparent and often illegal practices and processes.
- The current forest operations lead to continuous resource degradation. The business is not sustainable and will have substantially reduced revenues over the time (see section 4.2). Long-term sustainable Miombo forest management requires a turn-around of current utilization practices.

For the NFM sector to become sustainable, current forest practices must be fundamentally changed. Sustainable natural forest management (SNFM) will secure a long-term viable business and will enhance future profitability. However, the change towards sustainability comes at a cost and entails trade-offs, which means forsaking some of the (short-term) economic benefits to secure the viability of NFM businesses in the long run. To get a better understanding of the trade-offs and potential impacts of switching from current to sustainable practices, we analyzed several Miombo forest management scenarios:

- Baseline scenario (section 4.2): Current management practices continue without major changes.
- Scenarios for sustainable forest management (section 4.3): Improved practices towards SNFM are implemented. The analysis is performed first in a univariate manner, secondly by combining several options.

In order to understand and compare the economic performance of these scenarios, we did an estimation of future cashflows over a period of 51 years. We assumed a harvesting cycle of 10 years, meaning 6 interventions along the considered period. Often much longer cycles (20 to 30 years) are promoted by NFM experts, the argument being that forests require substantial time to recover and grow before the next harvest takes place. However, given the need to actively manage forests by applying silvicultural measures, more frequent but less intensive interventions will be necessary to achieve the targeted positive impacts on productivity and species com-

position. The timeframe of 51 years allows analysis of the long-term impact that applied management practices will have on timber stocks, forest quality and company economics. Also, in order to evaluate the likely impact at company level we assumed a model company with 50,000 ha net-production area, equaling an annual intervention area of 5,000 ha.

The detailed modelling approach for the individual scenarios is described below together with a list of parameters used for forest growth, yield and stock of different timber categories. The financial data presented in chapter 3 have been used for the economic forecasts.

Please note that the models presented in the following show trends for resource development and company economics. The magnitude of results for real, individual forest concessions might differ from the scenarios presented here, depending on their particular circumstances. An in-depth assessment according to specific circumstances will be necessary in all cases to evaluate any potential improvements.

4.2 Baseline scenario: Continuation of current utilization practices

4.2.1 Scenario description

Value chains

For modelling the baseline scenario, we selected the most plausible and representative combination of value chains currently pursued by forest operators:

- Only premium and first class species have secured market; hence these are the only species harvested.
- Premium species are sold as logs at customer gate.
- First class species are 50% processed and 50% sold as logs at customer gate. Obtained sawn timber is sold in equal parts in national and export markets.
- There is no integration of fuelwood or charcoal production.

Forest operations and related costs and revenues

Forest operations are implemented as described in the previous chapter. This means, for instance, that no silvicultural treatments other than enrichment planting are applied (requested by forest legislation). Efficiency and recovery rates, operational costs and prices of timber products are based on the results of the combined data collection and literature review presented in the previous chapter. The table below presents an overview of input values used for modeling the baseline scenario.

Table 10: Input values for economic modelling of the baseline scenario

Parameter	Unit	Input value
Conversion factors		
Ratio commercial / harvested volume	%	80%
Recovery rate in milling for national markets[1]	Output vol. sawn timber / input vol. roundwood commercial (%)	50%
Recovery rate in milling for export markets[1]	Output vol. sawn timber / input vol. roundwood commercial (%)	40%
Costs of forest operations		
Silviculture (enrichment planting)	USD/m³ roundwood over bark	0.75
Forest operations[2]	USD/m³ roundwood over bark	26
Costs of industrial operations		
Milling	USD/m³ roundwood commercial	24
Costs of transport		
Transport to mill or log yard outside the forest	USD/m³ roundwood	20
Transport to customer gate	USD/m³ roundwood	45
Costs of administration		
Forest administration and FMP	USD/m³ roundwood over bark	6
Industry administration	USD/m³ roundwood over bark	6
Taxes and fees		
License fee premium sp.	USD/m³ roundwood over bark	40
License fee first class sp.	USD/m³ roundwood over bark	20
License fee second class sp.	USD/m³ roundwood over bark	13
License fee other sp.	USD/m³ roundwood over bark	5
Reforestation tax	% of license fee	15%
Export tax	% of sales value	15%
Timber revenues		
Sale of premium logs at customer gate	USD/m³ roundwood commercial	535
Sale of first class logs at customer gate	USD/m³ roundwood commercial	220
Sale of first class sawn timber in national market	USD/m³ sawn timber	500
Sale of first class sawn timber in export market	USD/m³ sawn timber	900

[1] For milling recovery rates, we assume the highest value of most plausible ranges presented in chapter 3. In case of lower rates, processing activities would not make sense for an operator, from an economic point of view.

[2] Includes: Tree identification, felling and sectioning, concentration and loading of logs.

Forest resources and harvesting rates

The starting point of forest resources is assumed the same for all scenarios. It is based on the results of National Forest Inventory (Marzoli, 2007) with a focus on the Provinces of Zambezia and Cabo Delgado. Main assumptions are:

- The initial timber stock is 53 m³/ha. This value refers to total volume, only 50% of this corresponds to log volume.
- The share of species categories in the initial stock and growth rate is 7% for premium and first class species, 30% for other commercial species (second, third and fourth class species), and the rest for non-commercial species. Besides, for the first category we differentiated between premium and first class species, since these follow different value chains and achieve different economic results. Only 4% of the volume corresponds to premium species and 96% to first class species.
- The initial growth rate is 1.5 m³/ha/year in terms of total volume.
- Natural mortality: 1.5% per annum over all species (Maitre, 1987; Wöll, 1989; Grulke, 1998).
- Harvesting damage: 15% of standing volume is damaged by harvesting operations (Prabhu et al, 1993; Hampel, 1997; Grulke, 1998).

During the analyzed period of 51 years, we assume that harvesting operations focus exclusively on premium and first class species. In initial years, harvesting rates of these species (estimated in 0.16 m³/ha/year) exceed their growth rates (estimated in 0.11 m³/ha/year). This practice leads to the degradation of forest resources over time. Growth rates of premium and first class species decrease progressively until 0.01 m³ per ha and year. Likewise, their share in timber stocks decreases from 7% to less than 1% at the end of the assessment period. As a result the availability of harvestable volumes in the forest decreases over time and tends to 0 towards the end of the assessment period (see Table 11)[13].

Table 11: Harvesting rates in the baseline scenario

Period	Harvesting rate* in m³/ha/year		
	Premium and first	Other commercial sp.	Non-commercial sp.
Years 1-10	0.16	-	-
Years 11-20	0.10	-	-
Years 21-30	0.08	-	-
Years 31-40	0.06	-	-
Years 41-50	0.04	-	-
Years 51	0.03	-	-

* 50% corresponds to log volume and 50% to branches

[13] In the framework of this assignment we did not come across studies on Miombo that confirm our assumption scientifically by long term research projects investigating forest dynamics under concession management. Our modelling does not claim predicting the exact numbers of this degradation process provoked by unstainable utilization of the forests. However, the impact of current forest utilization (extracting only a few species) on future species composition is clear and evidenced by many degraded natural forests around the world that have undergone these unsustainable harvesting practices in the past. Even though we do not know the precise magnitude of this degradation process, we exactly know the direction.

Figure 10 shows the development of timber stocks and harvested volumes along the assessment period according to forest dynamics and harvesting patterns described above.

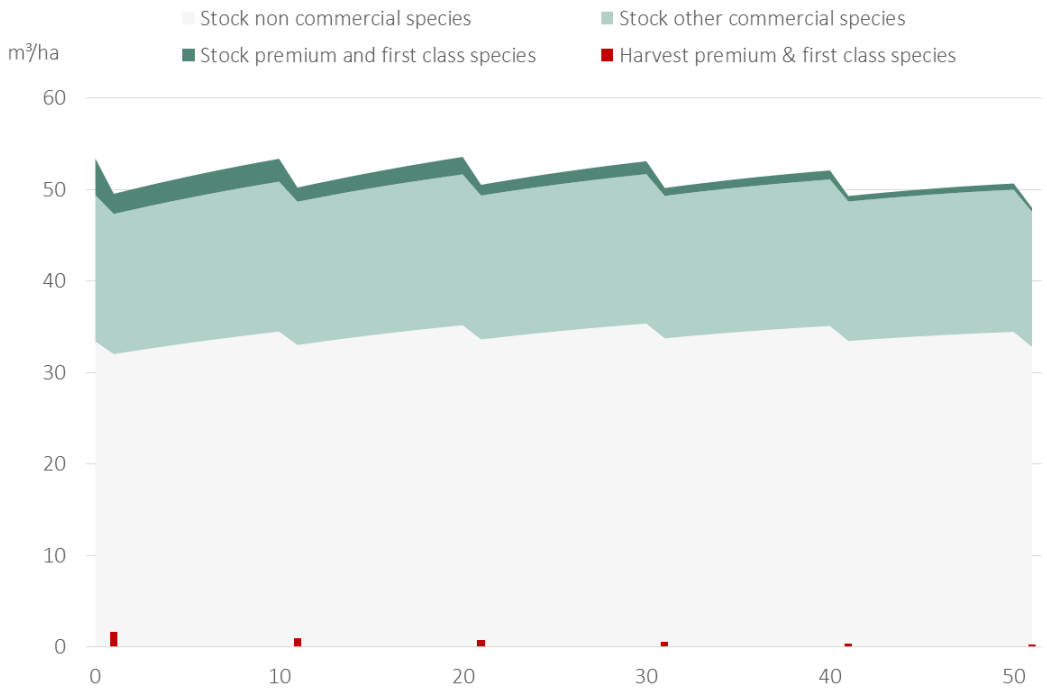


Figure 10: Timber stocks and harvest volumes in the baseline scenario

The figure above shows that over a period of 50 years, both the stock and harvestable volume of premium and first class species decrease drastically. The stock of other commercial and non-commercial species is also dynamic: on the one hand it decreases due to natural mortality and harvesting damages, on the other hand it increases through biological growth. Even if the total forest stock does not change overall, the share of premium and first class species decreases progressively over time, reflecting the gradual degradation process provoked by current forest utilization practices. Moreover, in this simplified model (see also footnote before) of stock development and species composition, we did not account for certain events that actually happen in many cases. Many concession areas suffer from loss of productive areas due to conversion to agriculture. Likewise, many forests are degraded not only by extraction of valuable logs, but also by uncontrolled extraction of fuel wood for charcoal production and frequent forest fires. If these factors were considered in the model, the situation would become even more critical.

4.2.2 Economic assessment

Assessment of cashflows

Based on economic input values and forest dynamics defined for the baseline scenario, we did a forecast of costs and revenues over 51 years for a forest company managing 50,000 ha of net production area, as stated in the introduction. The results are presented in Table 12. In order to appraise the development of net revenues over time, values have not been discounted (this will

be addressed in section 4.4). In the table and chart below, equivalent net revenue values in USD per ha have been included to facilitate the interpretation of the results.

Forecasts for the baseline scenario shows a net revenue of 7 USD/ha in the initial years of forest utilization. As a result of the degradation of forest resources and subsequent decrease of harvested volumes per ha, net revenues decrease progressively over time.

Table 12: Costs and revenues in the baseline scenario (values not discounted)

Period	Costs USD/year	Revenues USD/year	Net revenues	
			USD/year	USD/ha/year
Years 1-10	535,581	892,000	356,419	7.1
Years 11-20	334,706	557,447	222,741	4.5
Years 21-30	256,193	426,685	170,492	3.4
Years 31-40	188,529	313,991	125,462	2.5
Years 41-50	132,745	221,084	88,339	1.8
Year 51	90,361	150,495	60,134	1.2

The chart below (Figure 11) gives a good overview of the progressive decrease in the economic performance under this scenario, and how net revenues tends towards zero in later years.

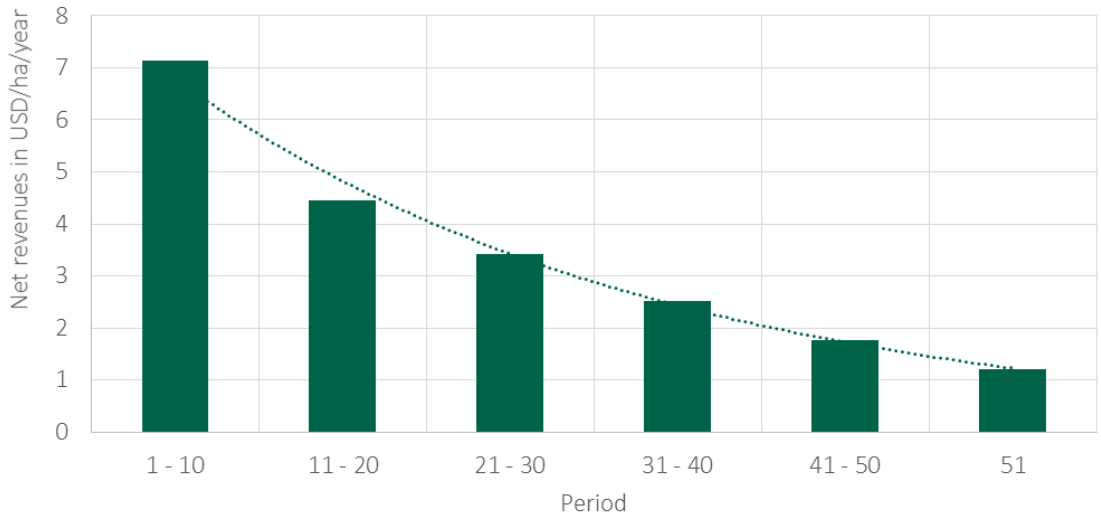


Figure 11: Net revenues per ha and year in the baseline scenario (values not discounted)

Sensitivity analysis

In addition to harvesting volumes, profitability can be extremely sensitive to variations in the economic parameters. The impact of factors influencing the profitability of the business is presented in Figure 12. Of particular influence are recovery rates and timber prices, where we also observed a wide spread during interviews with operators (see Table 4 in section 3.4). Recovery rates refer to the

combination of the ratio commercial / harvested volume[14] and recovery rates in milling processes. The first is influenced by species and tree diameter (i.e. thicker trees tend to have a higher share of heartwood vs sapwood and bark); the second is additionally influenced by the milling equipment and the skills of operators. Another relevant factor is the operational cost efficiency.

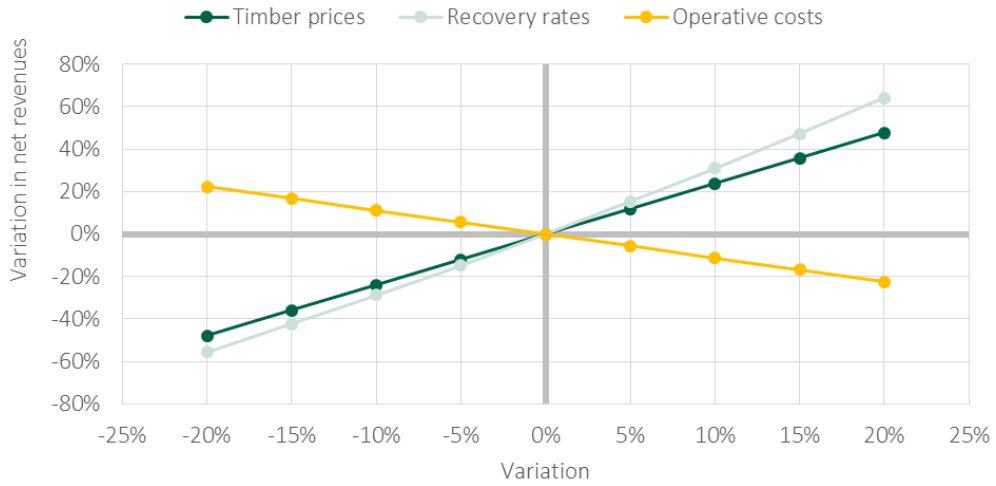


Figure 12: Sensitivity of average annual net revenues per ha of forest to changes in timber prices, operative costs and recovery rate

NB. Variation is applied as baseline value * (1 + x). The value for x = 0 corresponds to assumptions used for the baseline scenario.

4.3 Scenarios for sustainable forest management

4.3.1 Analyzed scenarios

The introduction of sustainable management practices was analyzed in three steps:

1. **Introducing silviculture** to enhance productivity and rebuild forest stocks in degraded forests. This step is crucial for all SNFM scenarios. Therefore, it was included in all other scenarios as an inherent element of sustainable forestry.
2. Assessment of univariate scenarios corresponding to improvements in:
   - Use of a wider range of species available in the forest:
     - **Integration of charcoal production** with all available species, including both other commercial and non-commercial species.
     - **Use of secondary species** (other commercial species) to produce sawn timber for national markets.
   - **Technology and leveraging economy of scale effects**
   - **Forest certification**
3. Assessment of two **multivariate scenarios**, combining different SNFM options outlined above.

[14] Harvested volume = over bark; commercial volume = without bark and ½ of the sapwood.

In the following we describe the selected scenarios, in terms of changes in forest and harvesting dynamics, as a results of introducing silviculture, and in terms of additional / adjusted costs and revenues compared to the baseline scenario, resulting from changes in management practices.

4.3.2 Description of univariate scenarios

Introducing silviculture

The objective of introducing silviculture is to improve forest quality, stocking of premium and first class species and the economic value of forests. It encompasses the activities presented in the table below:

Table 13: Basic silvicultural activities and expected impacts

Activities	Expected impacts
▪ Enabling natural regeneration by preventing / managing forest fires ▪ Tending of natural regeneration ▪ Liberation thinning of future crop trees (positive selection) ▪ Gradual elimination of over-mature trees (negative selection) ▪ Consequent application of reduced impact logging ▪ Reducing the harvesting volume of currently used premium and first class timber species	▪ Enhanced productivity ▪ Increased share of valuable species ▪ Degraded forests restored

Under this scenario, harvested volumes for premium and first class species will be adjusted downwards initially, reflecting the need to increase their stocking. Later on, they will increase progressively until reaching values equal to growth rates. Assumed changes in harvested volumes over time are as shown in Table 14. The commercial utilization focusses mainly on premium and first class species, while other species are removed for silvicultural reasons.

Table 14: Harvesting rates in the silviculture scenario

Period	Harvesting rate* in m³/ha/year			
	Premium and first	Other commercial	Non-commercial	Total
Years 1-10	0.10	0.40	1.17	**1.67**
Years 11-20	0.11	0.40	0.96	**1.47**
Years 21-30	0.15	0.41	0.85	**1.41**
Years 31-40	0.20	0.43	0.79	**1.42**
Years 41-50	0.28	0.45	0.76	**1.49**
Years 51-60	0.37	0.48	0.73	**1.58**

* 50% corresponds to log volume and 50% to branches

For modeling forest dynamics under this scenario, the starting point is assumed the same as in the baseline scenario. However, the development over time of forest growth rates and the share of species categories were adjusted to reflect the positive impact of silvicultural treatments and reduced harvesting rates:

- Forest growth rates increase progressively up to 2.25 m³/ha total tree volume. This corresponds to a growth rate of 1.13 m³/ha log volume[15].
- The share of stocks of premium and first class species increase gradually over time from 7% to 25% of total standing volume.

Figure 13 illustrates the relationship of forest growth, silviculture and adjusted harvesting rates.

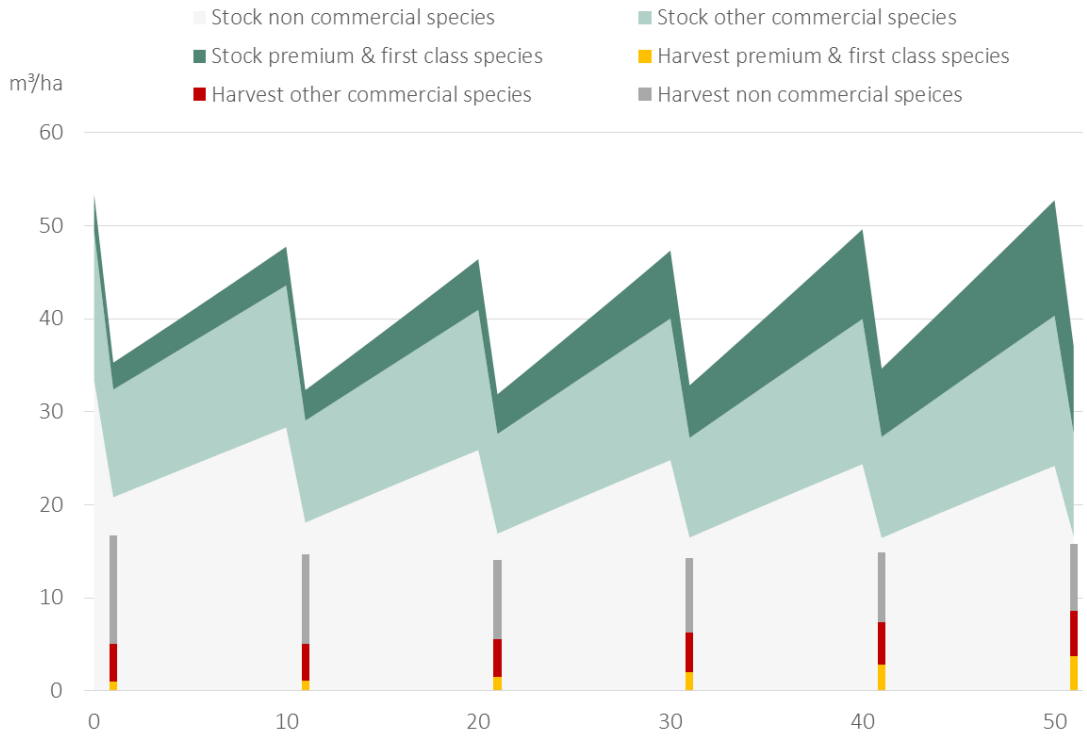


Figure 13: Timber stocks and harvest volumes through silviculture

Silvicultural interventions result in additional costs in comparison to the baseline, presented in the table below.

Table 15: Additional / different input values for introducing silviculture

Parameter	Unit	Baseline value	Input value
Cost of additional silvicultural treatments	USD/ha/intervention	0	40

Note: The availability of cost benchmarks for silvicultural treatments in Miombo forests is scarce. The value of 40 USD/ha/intervention was obtained from a forest company operating in Paraguay for which UNIQUE has access to realized costs. This cost includes liana cutting and thinnings. Natural forests in Paraguay are different to Miombo forests in Mozambique. On the one hand, silviculture treatments in Miombo will be less intensive, given the lower number of trees, meaning lower costs. On the other hand, Miombo forests require additional costs for fire prevention. For this exercise we assumed that lower costs of silviculture compensate additional costs for fire prevention.

[15] Log volume growth of 0.5 to 1.5 is reported for Miombo forests (see section 3.2).

Integration of charcoal production

The objective of this scenario is to increase the efficiency of forest utilization and management by using a wider range of species and harvesting residues, and to contribute to transforming the charcoal sector in a legal and sustainable business activity. Related activities are presented in the table below.

Table 16: Activities and expected impact of integration of charcoal production

Activities	Expected impact
▪ Utilization of all trees removed for silvicultural reasons to produce charcoal ▪ Utilization of harvesting residues of trees harvested for commercial purposes	▪ Legal and transparent charcoal production from forest concessions ▪ Reduced impact from forest fires due to reduced fuel load ▪ Income opportunities for resident communities

The use of removed trees and harvesting residues is complementary to the scenario *Introducing silviculture*. In addition, important potential co-benefits are legal and sustainable production of charcoal, the potential of off-setting silvicultural costs from the charcoal income, reduction of fuel load and resulting lower impact of forest fires; and last but not least the additional income opportunities for communities in charcoal production.

For modelling this scenario, we assumed that 100% of the log volume of trees removed (from silvicultural interventions) and 75% of the harvesting residues (volume from branches) will be converted to charcoal. Produced charcoal will be sold in urban centers. Table 17 shows related costs and revenues.

Table 17: Additional / different input values for integration of charcoal production

Parameter	Unit	Baseline value	Input value*
Charcoal tons per m³	t/m³	0	0.20
Cost of charcoal production	USD/t charcoal	0	80
Cost of transport of charcoal	USD/t charcoal	0	50
License fee charcoal	USD/t charcoal	0	16
Reforestation tax	% license fee	15%	15%
Sale of charcoal in urban markets	USD/t charcoal	0	150

* Please note that most assumptions are based on secondary sources, since primary information on charcoal production was not collected within this study, given that interviewed forest operators are not involved in this value chain.

Use of secondary species

Like in the previous case, the objective of this scenario is to increase the efficiency of forest utilization and management by using a wider range of species. Activities and expected impact are listed in the table below.

Table 18: Activities and expected impact of use of secondary species

Activities	Expected impacts
▪ Utilization of second class timber species, catering to the rural timber markets and the national market for products similar to those from pine or sleepers amongst others	▪ Extended product portfolio

The implementation of this scenario would require a complete turnaround from today's market driven operations to resource driven operations. This approach would be highly complementary to the scenario *Introducing silviculture*.

For modelling this scenario, we assumed that all trees removed of other commercial species are suitable for commercial purposes. Trees will be harvested and logs processed to sawn timber for sale in the national market. Assumed operative costs are the same as for premium and first class species. Sawn timber will be sold in national timber markets at pine price levels. Table 19 shows concrete costs and revenues related to this scenario.

Table 19: Additional / different input values for use of secondary species

Parameter	Unit	Baseline value	Input value
Sale of second class sawn timber in national market	USD/m³ sawn timber	0	250

We are aware that larger utilized volumes can have a positive impact on the costs efficiency of forest and processing operations (economy of scale effects). However, in this section we focus on univariate analysis. Upscaling and upgrading impacts addressed in the next scenario *Technology and leveraging economy of scale effects*). The impact of combing different scenarios (e.g. using secondary species and leveraging economy of scale effects) is discussed in section 4.3.3.

Technology and leveraging economy of scale effects

Improved technology aims to maintain, even increase the profitability of NFM businesses while reducing harvested volume to sustainable levels, by improving cost efficiency of operations. To achieve this, the activities listed in the table below have to be implemented.

Table 20: Activities and expected impact of introducing technology

Activities	Expected impacts
▪ Improve forestry technologies ▪ Improve saw milling technologies ▪ Leveraging economy of scale effects	▪ Reduced operational cost per cubic meter wood harvested ▪ Improved recovery and value addition

With the introduction of adequate technology, operational costs can be reduced and recovery rates of downstream activities enhanced. However, while operational efficiency can be increased to some extent at low cost, investments in machinery for harvesting operations,

transport and processing require a minimum economy of scale. Thus, the required minimum annual production required to enable such investments needs to be considered.

Options to improve technologies are plentiful and diverse: e.g. investments in infrastructure, acquisition of machines, strengthening technical skills or management processes. Most suitable options only can be assessed on a case-by-case basis according to specific needs and weakness of the forest company, condition of the forest resources, particular market situation and production environment. For modelling this scenario, we focused on those challenges that we identified as frequent for Mozambican forest operators. So, we assumed an initial investment in roads construction, distributed over the first 10 years, the acquisition of machinery for forest operations (skidder), and minor investments in upgrading industrial facilities and skills, distributed over the first two years. We estimate that the implementation of such changes alone will result in higher efficiency and lower costs for related operations, equivalent to a 33% decrease. Furthermore, recovery rates of sawmilling are expected to improve. Table 21 shows adjusted parameters for this scenario:

Table 21: Additional / different input values for introduction of technology

Parameter	Unit	Baseline value	Input value
Roads construction (over 10 years)	USD/ha/year	0	25
Acquisition of machinery	USD	0	150,000
Upgrades in industry (over 2 years)	USD/year	0	50,000
Cost of forest operations	USD/m³ round-wood over bark	26	17
Cost of transport of logs outside the forest to sawmill	USD/m³ round-wood over bark	20	13
Cost of milling	USD/m³ round-wood commercial	24	16
Recovery rate sawmilling for national market*	%	50	55
Recovery rate sawmilling for export market*	%	40	45

*based on commercial volume that is only 80% of harvested volume

Forest certification

Main activities to be developed to become certifiable and the expected impact of certification are presented in the table below.

Table 22: Activities and expected impact of certification

Activities	Expected impact
▪ Change of forest management operations to become compliant with international certification standards ▪ Introduce sound monitoring and documentation system ▪ Introduce an responsible person for environmental and social governance (ESG) ▪ Enter into the certification process	▪ Best practice SNFM ▪ Access to high-end export markets ▪ Priced premium for products ▪ Access to investors

Forest certification can open the door to new export markets. Several market studies show that with certification a price premium can be reached. However, the price premium is relatively low (in all cases < 10% of the price without certification) and only applies for the highest quality export products. The largest share of the product portfolio will still be sold for the same price as without certification. In consequence, averaged price premium for all products sold by certified forest company remains below 3%.

In addition, certification can have additional benefits for forest operators such as attracting international investors, addressing reputational risks or creating unique selling points and therefore gaining competitiveness. In addition, forest certification involves regular audits on forest operators, offering synergies to efforts done by institutions to strengthen their control over forest management practices. These co-benefits were not considered in the financial analysis of this scenario.

For modelling this scenario, our approach was to only consider direct certification costs and those indirect costs that can be clearly associated to additional certification requirements, such as adjusted documentation and specific environmental and social monitoring systems. Further indirect costs were excluded because they cannot be clearly differentiated from costs related to implementing a legal, responsible management (e.g. forest management plan) and because they are highly dependent on the specific situation of a forest operator. Based on this, we assumed additional costs of 4 USD per m³ of harvested log volume, resulting in annual costs 10,000 to 37,000 USD for our model company, depending on annual harvesting rates[17]. This value is in line with WWF results (see box). To mention a particular case, with realized values by the company FORCERPA operating in Paraguay: The company harvests between 8,000 and 10,000 m³ logs per

Box: Costs of forest certification

Forest certification entails direct and indirect costs. Direct certification costs include preparation for audit and audit fees, as well as costs related to logo use. These costs can be easily identified and are often well documented by forest companies. On the other hand, indirect costs are costs related to adjustments in operations, contracts, management and documentation, incurred by companies to become compliant with the social and environmental requirements of the certification standard. The farther away the current forest management is from certification standards, the more relevant the indirect certification costs are. Compared to direct costs, indirect costs are complicated to appraise. This relates mainly to the difficulty to clearly distinguish and different perceptions on which costs relate to certification and which costs relate to regular management.

A study conducted by WWF (2015) analyzed the economic implications of FSC certification on 11 forest companies. In addition to direct certification costs, this study took into account a wide range of indirect costs. The study concluded that on average direct and indirect costs[16] for achieving and subsequently maintaining FSC certification amount to 3.74 and 3.71 USD per m³ of certified roundwood equivalent respectively. The study highlighted the high variability of indirect costs among companies.

As per the study some products can achieve up to 10% price premium with certification. However, on average the premium is 2-3% of the whole turnover realized by timber sales.

[16] Indirect costs considered related to: forest inventories, management planning and operations; procedures; new machinery and labor facilities; safety equipment and benefit sharing with workers; E&S impact assessment and subsequent monitoring and mitigation, HCV management; trainings and staff for certification.

[17] Under this scenario the model company harvests 2,500 to 9,000 m³ (increase over time, see Table 14) of premium and first class logs per year.

year and has annual certification costs of 15,000 to 20,000 USD, including auditing fees, preparation for audits and social and environmental monitoring.

Also, we assumed an increase of 10% in prices of timber products sold in export markets from year five onwards, i.e. after successful certification. This is equivalent to a 3% increase on the total annual income of the model company. While the achievement of premium prices cannot be expected in all cases, since this will depend on target markets, this value seems reasonable when compared to results obtained by WWF, in which premiums represented on average 2% of the companies´ turnover.

Table 23 summarizes related costs and revenues.

Table 23: Additional / different input values for certification

Parameter	Unit	Baseline value	Input value
Indirect and direct costs of FSC certification (refer to the total harvested volume)	USD/m³	0	4
Price of premium sawn timber in export market	USD/m³	900	990

4.3.3 Economic assessment

As in the baseline, we estimated costs and revenues for all analyzed scenarios, considering an assessment period of 51 years and assuming a forest company managing 50,000 ha, and using economic values and forest dynamics defined above. The results presented in the following are expressed in USD per ha, with the objective to facilitate a better understanding of the impact of related practices and comparisons between scenarios. For the assessment of the development of net revenues over time, values have initially not been discounted. The impact of time, by applying discount rates, will be addressed in the next section 4.4.

Introducing silviculture

Figure 14 shows the development of net revenues over time compared to the baseline scenario. In initial years, as a result of lower harvesting rates and additional costs, net revenues are estimated to be less than 1 USD/ha. This is 15 times less than net revenues in the baseline scenario. However, the situation changes as forest degradation is gradually reverted. Towards the end of the assessment period the economic performance is expected to achieve performance levels comparable, or even superior to those obtained in the early years of the baseline scenario. More importantly, harvesting levels and returns can thereafter be maintained at equally high level.

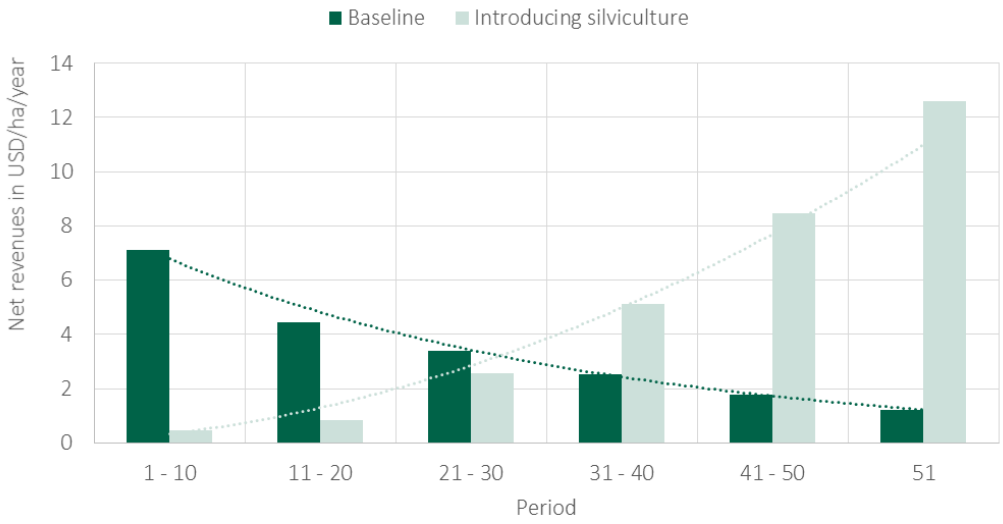


Figure 14: Net revenues resulting from silvicultural management compared to the baseline (values not discounted)

Introducing silviculture as a stand-alone measure is financial un-attractiveness. How results are influenced in combination with other measures is presented in the following sections.

Performance of univariate scenarios

Figure 15 presents the net revenues of all other univariate scenarios, compared to the baseline and *Introducing silviculture* scenarios. In the charts the dark green series corresponds to the baseline scenario, the light green series to the *Introducing silviculture* scenario, and the orange series to the univariate scenario assessed in each case, in all cases combined with *Introducing silviculture*. The results are without discounting future costs and revenues (for the impact of time see section 4.4).

The analysis shows that only *Technology and leveraging economy of scale effects* has a significant positive impact on the economic performance of operations, on top of *Introducing silviculture.* The scenarios *Integration of charcoal production* and *Forest certification* have a minor impact on the economic performance. They show however slightly different behaviors over time: while the production of charcoal represents an additional source of revenues throughout the assessment period, pursuing forest certification comes at a cost in initial years. In these two scenarios, further non-economic benefits are to be considered: the production of charcoal contributes to formalizing the charcoal value chain and to a better use of available resources; certification can improve the market position and access to funding of operators. Finally, the *Use of secondary species* as an isolated measure has a negative impact on net revenues.

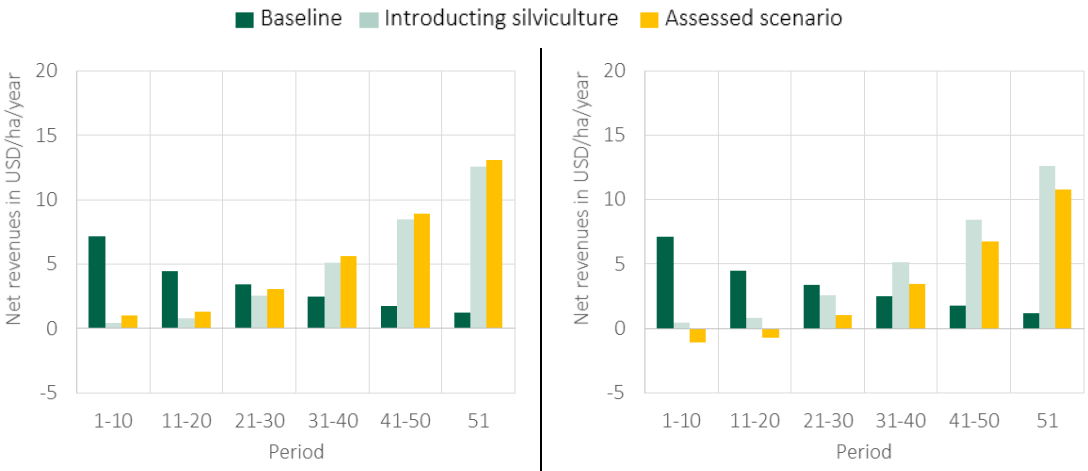
For the scenario *Technology and leveraging economy of scale effects* the magnitude of annual production in terms of volume harvested will be a key factor for sound decision making. When improvements involve the investment in machinery and equipment, a certain economy of scale will be necessary to make cost efficiency really happen. This will need proper case-by-case assessment and business planning on company level. As per our experience, the annual harvesting volume in natural forests should be minimum 5,000 to 10,000 m³ to leverage economy of scale effects.

Introducing silviculture + Integration of charcoal production

- Charcoal integration has very little impact on the economic performance.
- It represents a source of additional income on top of logs and sawn timber, by utilizing a large share of wood that is not suited for other uses.
- In particular, in early years it contributes to compensate lower net revenues obtained from premium and first class species.

Introducing silviculture + Use of secondary species

- Use of secondary species has a negative impact on the economic performance.
- This relates to expected sale prices of sawn timber not compensating production costs.
- This scenario can only make sense when combined with improvements in technology resulting in more cost efficient operations.



Introducing silviculture + Technology and leveraging economy of scale effects

- Investments in technology / adequate equipment have a significant positive impact on the economic performance.
- This requires however some time and upfront investments, that only make sense when large volumes of timber are harvested.

Introducing silviculture + Forest certification

- Forest certification has very little impact on economic performance.
- Premium prices achieved in export markets compensate additional costs of certification, but not beyond that.
- From an economic point of view, certification might be an interesting option for companies planning to increase their presence or enter export markets. A cost revenue assessment will be important to assess each case.

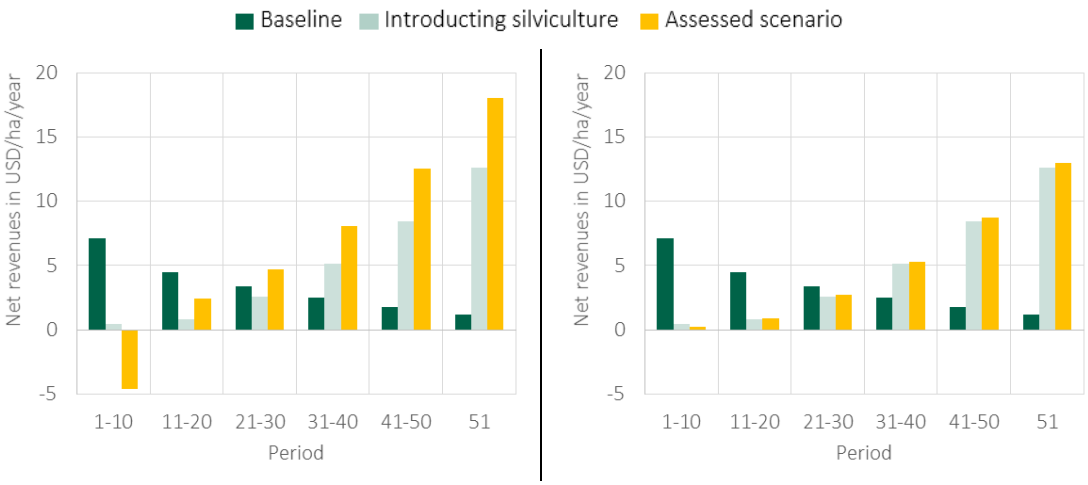


Figure 15: Net revenues resulting from other univariate scenarios (values not discounted)

Performance of the multivariate scenario

The combination of several sustainable management options can involve tradeoffs or synergies. For instance, when secondary species are used to produce sawn timber, the equivalent volume will not be available to produce charcoal. On the other side, the positive effect of investments in technology improvements will be multiplied when larger volumes of timber benefit from more efficient costs, i.e. when using a wider range of species.

Based on the results obtained from the analysis of univariate scenarios presented above, we defined a multivariate scenario aimed at exploring synergies between improving technology and leveraging economy of scale effects, and the use of a wider range of species available in the forest. The *Multivariate* scenario combines *Introducing silviculture*, *Integration of charcoal production*, *Use of secondary species* and *Technology and leveraging economy of scale effects. Forest certification* was excluded, given its little impact on the economic performance. On the contrary, we decided to include *Integration of charcoal production* because of its great importance in achieving sustainable management through a more efficient use of available forest resources.

For modelling this scenario we assumed that total log volume of other commercial species is used for producing sawn timber for national markets, while log volume of non-commercial species and 75% of forest residues are used for charcoal production. As a result of improved technology we further assumed that charcoal production also benefits from lower production costs (assuming in this case a more moderate decrease than in other operations, equivalent to 17% decrease i.e. 67 instead of 80 USD/t charcoal).

Figure 16 shows the net revenues resulting from modelling the multivariate scenario. This has been done without applying discount rates for future costs and revenues (for the impact of time see section 4.4). Results show a great impact on net revenues, indicating that combining several SNFM practices can bring important synergies. Utilizing a wider range of species helps to overcome upfront investments in improved technologies. At the same time, higher benefits from improved technologies and more efficient costs are achieved when larger timber volumes are used. Results indicate that using other commercial species turns into an attractive option when this is accompanied by more efficient operations. Net revenues in the multivariate scenario are at least twice those of *Introducing silviculture* alone.

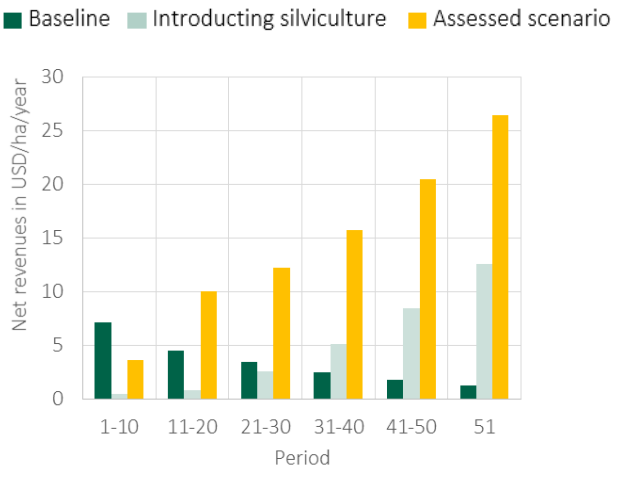


Figure 16: Net revenues resulting from the multivariate scenario (values not discounted)

On the basis of these results, the remaining question is why forest operators are not already applying the proposed measures to enhance future economic results. The analysis shows that

the net reduction in revenues in the first decade is small and from the second decade onwards the sustainability scenario turns superior compared to the baseline. The reasons for not applying SFNM are manifold (no access to finance, uncertainty of ownership, lack of information and expertise) but one factor is outstanding: **time**. The impact of time by discounting future cashflows is discussed in the following section.

4.4 The impact of time

One general observation on the analysis of cashflows is that whenever SNFM scenarios have a positive impact on net revenues, realization of such impacts requires time, meaning that in initial years, implementation of practices towards SNFM will result in lower net revenues than the baseline scenario, and even in losses in the case of some scenarios. The impact of time needs to be considered in the assessment since from the perspective of forest operators (and investors in forestry) revenues in the short term are more valuable than revenues in the future.

In order to address this and compare the different scenarios, we assessed the Net Present Value (NPV) for the 51 year period by using different discount rates. For this analysis, only scenarios identified as having a positive impact have been included. The results are presented in Figure 17.

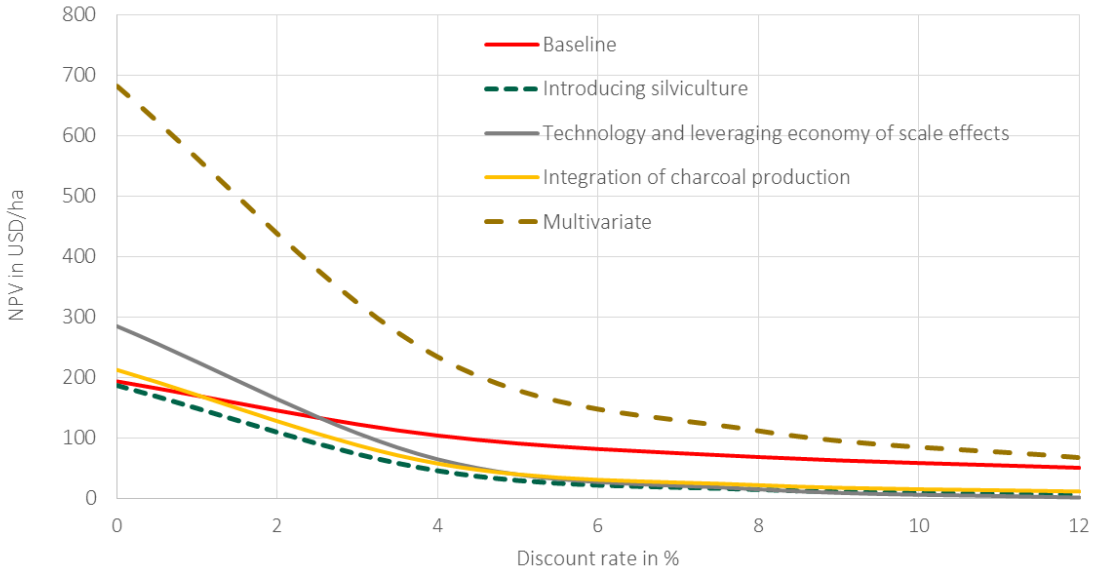


Figure 17: Net present value over 51 years of assessed scenarios by applying different discount rates

The NPV shows how the advantage of SNFM scenarios over the baseline scenario decreases quickly when the time factor is considered. Discounting costs and revenues makes future returns smaller and thus investments less attractive. Furthermore, the baseline scenario is something that the operator knows and is happy with, it is "business as usual" and therefore predictable. Any change (new technologies, new practices) involves risks and brings uncertainty. The more risk-averse a forest operator is, the higher discount rate he will consider.

In our analysis, for discount rates above 3% only the multivariate scenario is able to compete against the baseline scenario. The NPV of the multivariate scenario still keeps above the baseline

scenario when applying a realistic commercial discount rate for Mozambique of around 12%. In other words: When starting an integrated SNFM (= using also secondary and non-commercial species) and leveraging economy of scale effects, Miombo forest management can turn into an attractive long-term business. This is a motivating result, hence it shows that sustainable Miombo forest management can compete financially with the destructive mining practices currently applied. However, how to motivate and incentivize forest operators to change their "business as usual" with the consequence of lower net revenues during the first decade will be a huge challenge. Some ideas for achieving this are discussed in the following chapter.

5 RECOMMENDATIONS

5.1 Improving sustainability and economic viability

To ensure the long term sustainability of natural forest management in Mozambique while maintaining the economic viability of forest operations requires interventions in three key areas to:

- Improve the **enabling environment**, particularly with respect to the legal framework for forest licensing systems.
- Improve **forest management practices** in terms of introducing silviculture to enhance productivity and seeking for cost efficiency by applying technology and leveraging economy of scale effects.
- Develop **value chains** and markets for a broader range of products.

5.1.1 Enabling environment

The improvement of the enabling environment for the implementation of sustainable management of the Miombo forests is the responsibility of the GoM and requires pubic investments. In the following the most important and urgent aspects of (non-)enabling environment with respect to SNFM are addressed.

Resource security

Secure long term access to the forest resource is pre-condition for any investments into sustainable forest management by the forest operators. This is nominally guaranteed through the 50 year renewable license agreements. However, license agreements are restricted to timber only and resident communities have the de-facto right to farm and hunt (often with fire) in the same areas, significantly compromising the productivity and, ultimately, the existence of forests.

Forest administration, concessionaires and communities must work out arrangements that clearly define user rights, location and management practices. In particular fire has to be controlled to allow natural regeneration of Miombo forests. The often found “hall forests” with (few) old trees in the upper strata and lacking young and therefore less fire resistant trees in the lower strata are man-made by frequent fire events. The arrangements of user rights requires a sound regional land use planning and may be best done on a case by case basis, but must be anchored in the relevant regulations providing structures and processes to reach and enforce agreements.

Concession types, forest resource and concession size

The current forest licensing system is not conducive to SNFM. In combination with weak institutional capacity it enables illegal harvest and trade of wood products, controls wood product movement rather than sustainable production and short term licensing creates an incentive to ruthlessly exploit rather than sustainably manage forests. Furthermore, economically viable SNFM requires a minimum annual harvest (corresponding concession area depending on species

composition and stocks) neither of which is adequately reflected in the current licensing system and control of annual allowable cut as per FMP.

To enable economically viable SNFM, concession size and duration must reflect minimum sustainable yield required / available (based on inventories) to achieve economies of scale. The possibility of setting the value of a concession based on current/future timber stocks should be explored. To incentivize the concessionaire to preserve and enhance timber stocks, the option of variable license fees according to the state of the forest resource at the end of the concession period should be explored.

Simple licenses are too small in terms of area and produced volumes to implement proper and sustainable forest management. If simple licenses are political wanted, then forest associations should be promoted to enable simple licensees to benefit from economy of scale effects and implementation of sustainable forestry.

Regulations

Improvements in forest management by concessionaires and investments in value chain and market development must be closely matched by adjustments of forest related policies, regulations and guidelines. Such adjustments may include but are not limited to:

- Incentivize the application of sustainable silviculture (e.g. reduce license fees or pay-back of license fees in case forest stock is enhanced over the duration of the concession agreement).
- Permit to use thinnings and harvesting residues from premium and first class species for charcoal.
- Establish sustainable forest management standards / guidelines emphasizing regular and technically sound forest inventories and forest management plans, operational planning, forest monitoring, and basic health and safety standards.
- Combined issuance of licenses for timber, charcoal and potentially even reforestation with exotic species in bare land patches of the concession area.
- Processing of logs to timber in the forest using mobile saw mills (requiring an adjustment in control mechanisms to prevent harvest of trees below minimum diameter).
- Put in place mechanism to reduce illegal timber harvest (and trade), for example:
  - Change license types from transport to harvesting license;
  - Upgrade the current licensing system to a GIS based chain of custody system allowing to trace timber from the stump to the buyer (only recommendable in case of high value species);
  - Enforce sound FMP (inventories) and operational planning and implementation thereof;
  - Enable the local forest authorities to execute on the ground checks of the proper implementation of the FMP.

Ideally, these regulative measures should be accompanied by concrete measures providing further incentives, e.g. by encouraging procurement of wood products from sustainably managed forests (starting, for example, with government procurement policies).

Institutional capacity

MITADER and other relevant government institutions must be able to provide technical advisory services, monitor and control the implementation of forest management standards and regulations. The MozFIP has already identified the need for institutional capacity building.

Applied research on forest growth and yield

Sustainable forest management relies on the ability of forestry experts to make reasonably accurate predictions on forest growth and yield, considering the silvicultural options on productivity improvements. Ideally such predictions allow forecasting of the effect of harvesting regime and silvicultural activities as well. However, at the moment detailed information on forest composition, growth and yield in the various Miombo forest types in Mozambique is not existent and/or not easily accessible[18]. Even less is known about the effect of silvicultural interventions such as liberation thinning, enrichment planting and management of regeneration. Accordingly, some funding should be channeled into applied research, e.g. in partnership with research institutions and forest concessionaires. Research could, for example, be linked to periodic inventories for forest management planning as well as pre- and post-harvest inventories.

The lack of scientifically based information on Miombo forest dynamics shouldn't prevent starting immediately with the implementation of responsible silviculture. This can be done based on general experience with respect to natural forest management and step by step optimized (adaptive forest management) according to particular research outcomes on Miombo forest management.

5.1.2 Forest management practices

To improve forest management practices mainly private investments are required. However, some public investments (e.g. extension service or better information base on resource condition) has to accompany this process. In continuation the most important aspects to improve the sustainability of today's management practices are presented.

[18] An example of this is the development cooperation project Forest Research Capacity Strengthening in Mozambique 2012-2014 (FORECAS), implemented by the Finnish Forest Research Institute (Metla), the Agrarian Research Institute of Mozambique (IIAM) and the Faculty of Agronomy and Forest Engineering in Eduardo Mondlane University (FAEF-UEM). FORECAS promoted research on Mozambican native forests and wildlife species, their growth and their utilization (see: https://wiki.metla.fi/display/forecas/FORECAS+wiki). Likewise, the project PAIMO (Private Agricultural Investments and Land Use Change Impact on The Adaptive Capacity of Local Communities to Climate Change in Mozambique) developed in 2013-2014 by the University of Helsinki, the Pellervo Economic Research and the Eduardo Mondlane University, conducted research on biomass and carbon stocks, in the context of adaptation capacity of communities to land use changes linked to private agricultural investments and climate change (see: http://www.helsinki.fi/vitri/research/Research_Projects/paimo.html). However, the dissemination of results of these studies has been limited.

Planning and monitoring

Efficient and sustainable forestry production starts with sound management planning and monitoring of resource development. The starting point for SFNM planning and monitoring is a reliable inventory of the resource base for each concession. Based on this, the best fitting silviculture and harvesting plans can be developed. The interaction between the forest expert conducting the inventory and management planning with the forest concessionaire is essential. The forest concessionaires should be made aware of the benefits of regular forest inventories as a basis for forest management and business planning. The concessionaire also should have access to corresponding guidance and technical advice from the forest administration or forest service providers. Forest concessionaires should be obligated to participate regularly in training on sustainable forest management. On the other hand, forest authorities have to be trained in sustainable forest management, in management planning and monitoring. The local foresters must be able to prove the proper implementation of the required management standards at any given time.

Silvicultural basics

To date forest operators do not apply silvicultural measures in their concession areas. Together with the current unsustainable harvesting levels this result in degradation and devaluation of the resource, as discussed in chapter 4. It is a question of time: the Miombo forest will run out of the precious timber they still have. Whether this happens in 30, 50 or 70 years depends on many factors and cannot be predicted. But it will happen if there isn't be a turnaround of current forest management practices. This needs to be recognized on a political level, and correspondingly addressed.

Silvicultural measures must be defined on a case by case basis and include as a basic package:

- Regulation of species composition and stand quality:
  - Removal of mature trees belonging to non-commercial or non-marketable species. Best is to utilize the removed trees (e.g. for rural construction and/or charcoal). If this for any reason cannot be done, then the standing tree should be killed by girdling or poisoning.
  - Selective thinning favoring high quality trees of commercial value.
  - Management of regeneration, especially to promote high value trees species.
  - Only in cases of no natural regeneration enrichment planting may be necessary.

  Without applying these silvicultural basics step by step the share of non-commercial trees species increases.
- Fire management:
  - Agreements with communities when and where to use fire.
  - Reduction of fuel load by e.g. utilizing harvest residues for charcoal.
  - Preventive burning, that means controlled, low intensity fires.

  Without adequate fire management many species of the Miombo forests cannot regenerate. In consequence there will be loss of value and of biodiversity.

Forest utilization

Efficient utilization of forests will reduce cost per cubic meter wood extracted, reduce damage to the remaining trees (conserving the forest value) and increase the commercial volume without a corresponding increase in trees harvested.

Basic measures include:

- Harvesting the trees not too early to increasing the ratio of harvested to commercial volume (the ratio sap / heart wood is related to diameter).
- Use of state-of-the-art technology (skidder with cable winch and hydraulic log grapple) for harvesting, loading and transport (such investments require minimum scale of operations to be viable).
- Value adding to shorter stem lengths and large dimensioned branches.
- Utilization of residues of primary species and secondary species for timber (whenever possible), fuel wood or charcoal. An integrated utilization of forest products is key to sustainable resource management.
- Saw-milling in the forest to reduce transport cost (in particular important for secondary species and smaller pieces; the current legislation does not provide the option to do so).
- The introduction of basic health and safety standards.

In particular the production of charcoal can offset an important part of the additional cost of silvicultural management (as observed in section 4.3.3) and provides additional employment and/or direct income for communities[19].

Forest certification

As pointed out above, forest certification with international standards such as FSC or PEFC can be beneficial to forest enterprises by allowing access to different (export) markets and funding sources. In some cases a price premium can be achieved. However, certification comes at a price with direct cost for preparation and audit fees and indirect ones related to ensuring compliance with the social and environmental regulations of the selected standard. In many cases forest certification does not have a significant impact on the overall economic performance (see section 4.3.3). Forest concessionaires must explore the potential for and likely gains before committing to certification.

5.1.3 Market development and improved value chains

As discussed below, market development and improved value chains require both, public and private investments.

Market development

The current range of commercially used timber species from Miombo forest is very narrow. Experiences from other tropical forests show that additional species will enter the market over

[19] The forest concessionaire can either fully incorporate charcoal production, employing community members or give the business to communities altogether.

time. However, the process tends to be slow and is usually based on decreasing availability of the currently preferred timber species.

A wider range of marketable species is deemed crucial for the long term survival of the NFM industry in Mozambique. Accordingly market development should be actively promoted by the forest enterprises with aid from government and research institutions, and in partnership with national industries (in particular the construction sector). A survey of such enterprises in Tanzania (UNIQUE, 2014) showed that they are willing to experiment with lesser known species provided the species exist in sufficient quantities for later commercial supply. However, it must be noted that the economic feasibility of harvesting lesser known species at scale must be well researched as prices are usually much lower than for well-established timber species[20]. As shown by the findings of our economic assessment (see section 4.3.3), efficient harvesting, primary processing (see "Forest utilization" above) and vertical integration of processing to (semi-)finished products (see below) will help bring these species to market.

Investments in value addition

Investment into value addition can be an important means to sustain and/or raise profitability despite additional cost from e.g. higher forest management standards or lower (sustainable) harvesting volumes. For such investments to be successful, specific technical know-how along the complex value chain[21] of precious timbers, marketing skills and often substantial funding are required. In case of export, semi-finished products such as dimensioned and kiln dried timber (S4S) for parquet flooring or furniture manufacturing maybe the appropriate vertical integration. Investments into processing of finished products will likely be of smaller scale and cater mainly to the national market.

Interested investors are likely to need assistance in terms of access to technology and finance, technical advice and market development.

However, we believe that the forest business as such has to be financially viable and generate sustainable net revenues to the forest operator. Options to leverage upside potentials by value chain integration of course should be analyzed and implemented to the best fit of the company. However, if financial viability only can be achieved by the integration of downstream activities, then the framework conditions for sustainable forest management are not in place.

[20] The reasons for less appreciation of secondary species are manifold: Timber properties, esthetic parameters (color and pattern), machinability, silvicultural behavior. However, sometimes the commercial potential of secondary species is just unknown.

[21] The value chain from the tree to the end product of precious tropical timber is long, complex. E.g. for a furniture we have minimum 7 steps: Harvesting – transporting logs – saw milling – dimensioning – drying – planning and polishing – manufacturing. Specific knowhow and experience at each level is required to add value. If these specific capacities cannot be guaranteed, the risk to destroy value instead of adding is high.

5.2 Planned MozFIP activities related to NFM

The design of the Mozambique Forest Investment Project includes the following group of activities related to NFM:[22]

1. Strengthening forest governance.
2. Strengthening inspection, detection and control in the forest sector.
3. Promoting the sustainable management of natural forests.
4. Supporting sustainable production and use of charcoal.

Recommendations on the planned activities are provided in the table below.

Table 24: Recommendations on planned MozFIP activities

Planned activity	Comments and recommendation
1. Strengthening forest governance	
Establish a forest information system to tackle illegal logging: georeferenced data on forest licensing, management plans and annual harvesting allowance, inspection, enforcement and control of contracts.	Very important activity as a basis for investments in SNFM. Can be implemented as the precursor to a full chain of custody system. However, it's a high hanging fruit. To implement an FIS very well skilled professionals are required as well as a high level of commitment and integrity and a regional administration that really works and can do the work on the ground. The implementation of a running FIS is a long-term project (minimum 10 years) that requires intensive follow up. Even a budget of US$ 3million might be insufficient.
Multi-stakeholder forest governance assessments and regular evaluations of the performance of forest operators	Very relevant. There are not so many forest operators. A control visit once a year to check the management plan against the management implementation is useful. Capacity and integrity of the local forest administration staff is a precondition. Starting point for the "reality check" is the availability of sound management plans based on reliable forest inventories data. It cannot be assumed that this is given. Therefore an action is required to increase the quality and reliability of the management plans. The activity should be closely linked to the national forest certification standard. Also it should be specified what happens in case of non-compliance by the forest operator.
Promote national forest dialogue through the establishment of the National Forest Forum	Important to facilitate policy dialogue amongst the key stakeholders. Can be the platform for the high level consensus on key issues concerning Miombo forest management as for example content of forest management plans, contractual base for concessions, eligibility criteria for forest concessionaires or monitoring of proper management implementation. However, the risk that the Forum develops to a "debate club" has to be taken seriously and addressed from beginning (e.g. by formulating road map and milestones for the Forum).
Implement the national forest certification standard currently being developed by MITADER	The national forest certification standard can be understood as regulative guidance on minimum NFM standards forest operators have to comply with in order to continue qualifying as concession holders. However, a national certification standard is unlikely to take the role

[22] From „Natural Forests in PAD.doc" version from 26.10.2016

Planned activity	Comments and recommendation
	of an international market based certification standard similar to FSC or PEFC and their benefits (see 5.1.2). When developing a national certification standard it should be appreciated that there are plenty existing standards for responsible and sustainable forest management. These can be used as starting point to make a reality check with existing practices and the regulative framework. Based on the outcomes of the reality check a roadmap for the standard development can be developed. An important aspect is the compliance of the standard, albeit it is voluntary, with national forest legislation. An adjustment of the regulatory framework may be necessary, for example the inclusion of sustainability criteria such as persistence of forest area, rational timber utilization, maintenance of forest productivity and forest service provision.
Strengthen forest operator associations to consolidate and convey the demands and opinions of private sector players in NFM	Important action company-company dialogue and company-research dialogue is very important to enter in a learning and adaptive management process. Some countries (e.g. Paraguay, Germany) have had very good experiences with benchmark circles (learning from the best).
2. Strengthening inspection, detection and control in the forest sector	
Strengthen Mozambique's forest law enforcement institutions, so as to improve forest areas patrolling and inspecting, infractions prevention, detection and prosecution	Extremely important. As mentioned before: Starting point for sustainable forest management is a sound planning, on macro level (land use planning) and on concession level (forest management plan). The planning must be based on reliable data and information and properly documented to allow plan/actual comparisons. To do this assessment, inspections on the ground with strong regional staff is a prerequisite.
Strengthening enforcement within conservation areas: Gilé National Reserve and Quirimbas National Park	
Training of forest law enforcement officers working under AQUA	
Implementation of technologies for information, communication, and timber tracking incl. real-time internal communications and reporting	The natural forest timber supply is not complex, it is informal. This only partly can be resolved by technical solutions. It is important to check the lessons learned with respect to in intended implementation of digital GPS based timber tracking systems. There was a project financed by the Inter-American Development Bank in the Chaco Province in Argentina (Chaco forest is very similar to Miombo forest). It appears that a lot of money was spent but the system never worked.
Strategic partnerships and inter-agency coordination with key institutions in forest supply chain tracking to increase efficiency and reduce corruption	In a first and very long step addressing informality and disposition for corruption is key. This requires positive incentive systems for the stakeholders that go for sustainable resource management and act with a high degree of integrity, e.g. companies that can bring the evidence of legal and sustainable concession management have to pay less license fees.

Planned activity	Comments and recommendation
3. Promoting the sustainable management of natural forests	
Strengthening government capacity in forest management at the National Forest Directorate and the Provincial Forest Services to systematically verify legal operators, inventories and management plans	This is clearly an important activity. Additionally, improvements in forest management planning and documentation are needed. The quality of the management plans (prepared by independent forestry expert) has to be enhanced in terms of: i) based on reliable inventory data; ii) giving guidance to best silvicultural practices to be applied under given conditions of the natural resource; and iii) defining KPIs to make the supervision of proper plan implementation operational. A corresponding guideline and clear definition of content, reflected in forest regulations must be provided, and operators and service providers for FMPs given training on improved management planning. The forest authorities need a silvicultural understanding of natural forest management to judge if management plans are appropriate or and to do the inspection of proper implementation on the ground.
Piloting of public concessions in Zambezia and Cabo Delgado to test a more competitive forest concession model	Maybe the most important action. The sector urgently needs success stories and showcases. That is prove of concept through companies implementing sustainable Miombo management and being profitable. If possible MozFIP should support companies when they are willed to implement more sustainable management, e.g. by offering trainings for managers and operators or helping to get access to finance. Piloting best practice management with private concession holders should be considered as well. This would without doubt send a much stronger signal to other forest operators. One of the pilots should include the joint management of concessions by forest operators and communities. Instead of community members making charcoal by clear-cutting forests, this activity could be integrated in the forest management plan of concessions. That helps the forests to remove the far too high share of non-commercial trees and helps the charcoal producers to legalize and formalize their business. One big challenge is that the positive effects of sustainable management in terms of resource quality and long-term financial viability will only be visible in some decades, well beyond the duration of the initial MozFIP.
Creation of a Technological Center for Excellence for the Forest Industry as a training hub for the natural forest sector, including commercial timber production and processing	Makes perfectly sense but is also risky that the center after support from the MozFIP decays (several examples around the world). From the beginning it should be structured as a PPP with a real private contribution and first focusing on the very low hanging fruits, such as improvements in recovery rates (in the forest and in the mills), decreasing operational costs by introducing suited technologies, enhancement of “doing together” to leverage economy of scale effects. Another question mark is whether the sector is ready to employ professionals? For example, none of the enterprises interviewed employed forestry professionals. Understaffing (in terms of professionalism) can be addressed with eligibility criteria for forest concessions.
Supporting partnerships between communities and the private sector: development of models for mutually beneficial partnerships	Charcoal production within the forest concession is key for an integrated forest utilization and sustainable forest management. Company community partnerships on charcoal production should be supported with priority (see also comment above).

Planned activity	Comments and recommendation
Applied research in sustainable forest management: provision of locally relevant, evidence-based guidance; knowledge management and dissemination	To the extent possible research should be done in conjunction with/supported by private sector.
4. Supporting sustainable production and use of charcoal	
Training and knowledge transfer on FMP for charcoal production, business plans, efficient technologies for charcoal production and sustainable forest management	Charcoal is the most important product of the Miombo forests, in terms of market volume, in terms of forest destruction and in terms of potential for shifting to sustainable forest management. How to integrate charcoal production into the management planning and management implementation, how to set-up partnerships between forest concessionaires and communities, how to optimize charcoal production in regard to recovery rates, costs and working health and safety should be analyzed in-depth. The inclusion of charcoal production is key to overcome "forest mining" and introduce sustainable management according to resource requirements (potentials and limitations). Testing and introducing optimized technology of charcoal production is relevant and important. However, projects and pilots for improved charcoal production have failed quite spectacularly in East Africa. Stationary or hard to transport kilns often lead to over-exploitation of the surrounding forest, followed by abandoning the new technology in favor of traditional earth kilns. Such lessons learnt should be taken into account in project design.

In a nutshell: Most of the planned actions make perfect sense. Some are high hanging fruits (e.g. FIS implementation), others lower hanging (e.g. improving the quality of forest management plans); some are of first priority (e.g. integration of charcoal production), others are of second (e.g. charcoal kiln technology).

To get the actions grouped and prioritized, it may help to classify them with the help of a two dimensional matrix:

- Relevance for sustainable and financial viable resource management (priority)
- Probability and velocity of successful implementation (high / low hanging)

Doing this exercise together with the relevant stakeholders enhances ownership of the MozFIP and reduces the risk allocating the scarce resources to actions of less importance.

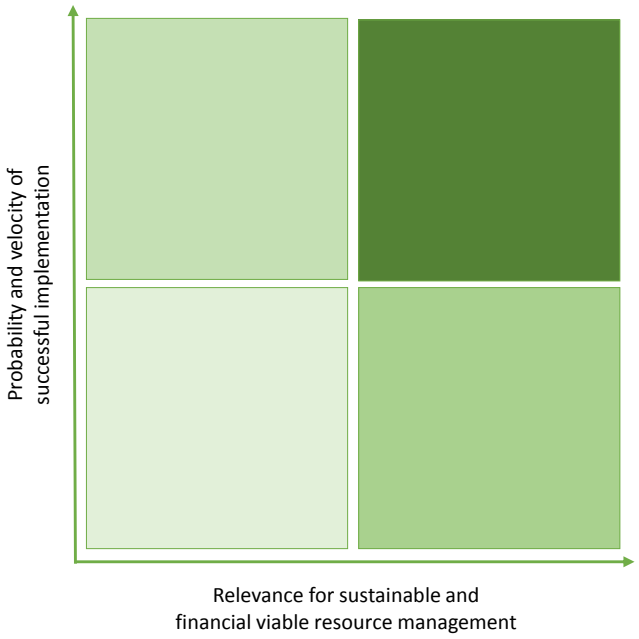


Figure 18: Classification of SNFM related MozFIP actions

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ANNEX

Annex 1: Questionnaire

Basic information

Forest operator name	
Contact details	
Persons interviewed and role	▪ ▪ ▪
Interviewer	
Date and location of the interview	

Concession and areas

Forest location (province, district)	
Total concession area in ha (gross/productive)	
Forest types and areas distribution in ha	▪ ▪ ▪
Total productive area in ha	
Year of start and end of concession	

Forest productivity

Have you done forest inventories? Yes / No

If yes. Indicate differences between strata when required:

Species groups	Number species identified	Standing volume in m^3/ha	Basal area in m^2/ha	Assumed MAI in m^3/ha/a
All species				
Premium species (excellent market)				
First class species (with good market)				
Second, third and fourth class species (restricted market)				
Non-commercial (no market except energy)				

What are the most important species for your economic performance?

Is the number of marketable species a challenge? Do you believe the number of marketable species could increase? Have you tested the marketing of secondary (lower class) species?

Silvicultural management

Intervention interval in years	
Harvested volume per intervention in m^3 per ha	Total: Premium species: First class species: Second, third and fourth class species:

What has been the development of harvested volumes since the start of the management (in case you have harvested several times a same forest area)? Increase / Decrease / Steady

Do you believe that intervention interval could be shortened and why? Yes / No

Do you believe that yields could improve and how? Yes / No

Do you apply treatments for improving growth and quality of forests? What is the impact?

How do you manage regeneration? Is it an contractual requirement? Replanting / tending of natural regeneration

Other comments / observations

Description of operations

Preharvesting inventories (such as inventory and marking trees to be harvested / potential crop trees)	▪ ▪ ▪
Harvesting operations (felling and skidding techniques)	▪ ▪ ▪
Silvicultural measures (as thinnings, elimination of over mature trees, tending regeneration)	▪ ▪ ▪
Postharvest assessment (impacts assessment)	▪ ▪ ▪

Costs of operations, infrastructure, overheads and social responsibility

Note: Costs in monetary terms are necessary for financial modelling. However, during interviews with operators, data on time productivity might be easier to obtain (and converted afterwards into monetary units later) and might facilitate the discussion on cost efficiency improvements.

X	Item	Productivity e.g. in ha or m³ per day	Costs e.g. in USD per ha or m³
	Forest operations		
	Preharvesting inventories		
	Felling and hauling		
	Silvicultural measures, including reforestation; name it _____ _____ _____		
	Postharvest assessment of logging impacts		
	Transport to selling point / industry		
	Land, infrastructure and overheads		
	Land / concession		
	Harvesting fees, if any		
	Infrastructure construction (mainly roads)		
	Infrastructure maintenance (mainly roads)		
	Management and admin		
	Income taxes		
	CSR		
	Social development plan		
	Others, name it _____ _____		

How do you assess the efficiency of your operations?

Do you think there is room for improvement? What would be the cost of such improvements and its impact on efficiency? Such as modern machines, skills of workers

Timber sales and markets

What timber products do you produce? Indicate units. Add groups as necessary:

X	Product	Sold volume per year	Target market	Place of sale and distance	Prices per unit
	Logs premium species (excellent market)				
	Logs first class species (good market)				
	Second, third and fourth class species (restricted market)				
	Logs non-commercial species (no market except energy)				
	Fuelwood				
	Charcoal				
	Processed timber (specify product)				

How is commercial volume determined? (how measured, deductions sap wood, bark, defects etc)

What has been the development of prices over the last years? Increase / Decrease / Steady

Is competition with other operators a challenge?

Is competition with illegal timber a challenge?

Is distance to markets a challenge?

Processing facilities

Do you have processing facilities? Describe briefly and explain the reason.

If yes:

Intake/output; share of logs processed/sold; processing of logs from third parties?

What are the main products you are processing?

What is your recovery rate log / commercialized product?

What are processing costs?

What is its impact on your economic performance?

How do you assess you facilities? Do you think efficiency could be improved?

If no:
Do you plan including processing to improve your economic performance?
Assessment of charcoal production:

Economic results

What is your current performance? It might be expressed in net profit per year

Do you see options to improve your performance?

Do you believe your company/concession is long-term sustainable or can be sustainable? How?

Certification schemes

Voluntary national standards or FSC certification?

Why one or the other?

Do you believe certification would benefit your company and how?

What are the barriers to entry?

What improvements should you implement to achieve certification?

Finance requirements

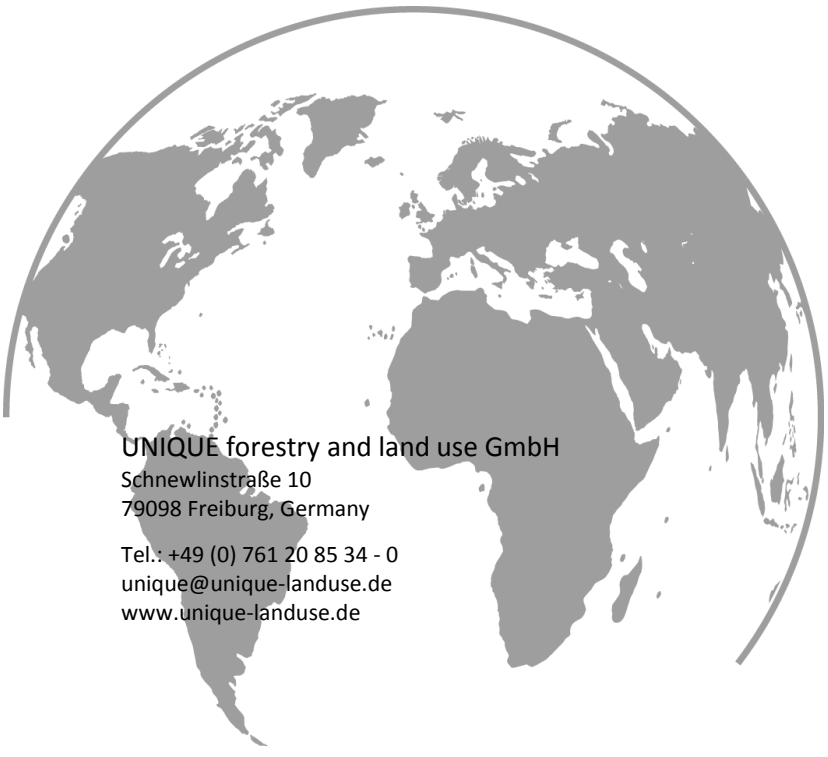
Could you improve (economic feasibility and/or impact) your natural forest management with access to finance?

Describe the required investment (type, volume, timing, pay-back).

Other observations

Annex 2: Different volumes along the value chain

	Tree volume	Real log volume	Commercial log volume	Sawn timber
Volume calculation	$V=(DBH/4)^2*Pi*H*0.6$ DBH: 43 cm Tree H: 12 m Log: 4.5 m Coefficient: 0.6 **= 1 m³** 	$V=(D/4)^2*Pi*L$ D: 0.4m Log L: 4m **= 0.5 m³** 	▪ Under bark + ▪ 50% of sapwood D: 0.36 cm; Log L: 4m **= 0.4 m³** 	▪ 1st quality (no sap wood) + ▪ 2nd quality (with some sap wood) ▪ High efficiency milling: 60% recovery **= 0.24m³** 
Relevant for:	▪ Biological production	▪ License fee ▪ Log production costs	▪ Log sale prices Input volume saw mill	▪ Milling cost ▪ Sawn timber price
Proportions recovery rate	200%	100% (baseline)	80%	48%



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