'Promoting Sustainable Forest Management in the KAZA-Region in Namibia'

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Status quo of Sustainable Forest Management in Namibia

Baseline Study

April 2022

Sustainable Forest Management in Namibia – Baseline Study

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Authors: Vera De Cauwer and Lara Beer
Dr Vera De Cauwer is a forestry engineer trained in Belgium and France, with 20 years of experience in Namibia who started forest research in Namibia in 2005.
Dr Lara Beer is an agricultural economist trained in Germany, with 7 years of experience in energy wood and empirical research in Europe and Namibia.

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Delegation of the European Union to Namibia
P.O. Box 24443
Windhoek, Namibia
Tel: +264 61 202 6000
Email: delegation-namibia@eeas.europe.eu
Website: http://europe.eu

Hanns Seidel Foundation (HSF)
P.O. Box 90912
Klein Windhoek, Namibia
Tel: +264 61 237 373
Email: info@hsf.org.na
Website: www.hss.de/namibia/en, www.thinknamibia.org.na

Desert Research Foundation of Namibia (DRFN)
P.O. Box 20232
Windhoek, Namibia
Tel: +264 61 377 500
Email: drfn@drfn.org.na
Website: www.drfn.org.na

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Abbreviations

α-ESA	α-eleostearic acid
ABS	Access and Benefit Sharing
BIS	Bush Information System
BMZ	Geman Development Service
CBD	Convention on Biological Diversity
CBNRM	Community Based Natural Resource Management
CF	Community Forest
CFN	Community Forestry in Namibia Project
CLB	Communal Land Board
CO_2	Carbon dioxide
CRIAA SA-DC	Centre for Research Information and Action in Africa – Southern Africa Development and Consulting
DBH	Diameter at breast height
DEA	Department of Environmental Affairs
DoF	Directorate of Forestry
DRFN	Desert Research Foundation of Namibia
ECC	Environmental clearance certificate
EU	European Union
FAO	Food and Agriculture Organisation
FINNIDA	Finnish International Development Agency
FMC	Forest Management Committee
FRA	Forest Resources Assessment
FSC	Forest Stewardship Council
Gt	Giga tonnes
GTZ	German Agency for Technical Cooperation (Deutsche Gesellschaft für Technische Zusammenarbeit)
ha	Hectare
HSF	Hanns Seidel Foundation
IFTT	Indigenous Fruit Task Team
INPs	Indigenous natural products
IPTT	Indigenous Plant Task Team
IRDNC	Integrated Rural Development and Nature Conservation
ITTO	International Tropical Timber Organization
KAZA	Kavango-Zambezi area
KfW	German Development Bank (Kreditanstalt für Wiederaufbau)
Kg	Kilogram
LDC	Livestock Development Centre
m	Metre
m^3	Cubic metre
MAWF	Ministry of Agriculture, Water and Forestry
MEFT	Ministry of Environment, Forestry and Tourism
MLR	Ministry of Land Reform
N$	Namibia dollar
NACSO	Namibian Association of CBNRM Support Organisations
NBRI	National Botanical Research Institute
NCE	Namibian Chamber of Environment
NFI	National Forestry Inventory
NFFP	Namibia-Finland Forestry Programme
NFRC	National Forestry Research Centre

NGO	Non-government organisation
NILALEG	Namibia Integrated Landscape Approach for Enhancing Livelihoods and Environmental Governance to Eradicate Poverty
NNF	Namibia Nature Foundation
NRSC	National Remote Sensing Centre
NSFM	Namibia Sustainable Forest Management Project
NSI	Namibian Standards Institution
NTFP	Non-timber forest products
NUST	Namibian University of Science and Technology
NWFR	North West Forestry Region
PIC	Prior Informed Consent
PSP	Permanent sample plot
REDD	Reduction in Emissions from Deforestation and Forest Degradation
SADC	Southern African Development Community
SAR	Synthetic Aperture Radar
SFM	Sustainable Forest Management
TAO	Total Allowable Offtake
UAV	Unmanned aerial vehicle
UNAM	University of Namibia
UNFCCC	United Nations Framework Convention on Climate Change
WWF	World Wide Fund for Nature
ZAR	South African Rand

Abstract

The NSFM-Project seeks to support an active multi-stakeholder dialogue on Sustainable Forest Management (SFM) as a contribution to improved forest management in the KAZA-Region in Namibia's northeast. SFM aims to balance the various uses of forests while ensuring their ecological functioning and the provision of benefits and functions in the future. It supports multifunctional forests, which require a sound forest policy, committed stakeholders and forest managers and users with ecological knowledge and technical skills. This study gives an overview of the progress made in SFM since Namibia's Independence, the obstacles encountered and the challenges ahead. The main aim is to provide an information base against which to evaluate the impact, progress, and effectiveness of the NSFM-Project. The study is based on an in-depth desktop study, that includes the latest scientific research, and a baseline survey performed to assess the level of awareness, understanding and knowledge of SFM among the target groups in Namibia.

The study starts with an overview of Namibia's forests and woodland, the major timber trees and non-timber forest products, and the dynamics that regulate Namibian tree populations. Namibia has multifunctional forests and a detailed overview of its services and products is given. The first chapters show that there is still a lack of data required for SFM, which does create opportunities for forest and woodland researchers in Namibia. An overview of the legal framework illustrates that Namibia's laws and policies strongly support SFM. The main legal tool in Namibia is the Forest Act with its Regulations, which are currently under revision.

The baseline survey in the Community Forests (CFs) of north-eastern Namibia shows that many participants appear to know and understand SFM well, however, this knowledge is superficial and does not include silviculture. For example, very few of the respondents had ever planted a tree. There is a general perception that the Namibian forest is non-exhaustive and does not need assistance to regenerate. However, natural forest regeneration in Namibia is slow and erratic, while the continuous removal of the best droppers, poles and timber trees degrades the timber quality of Namibia's trees.

The application of SFM is currently limited in Namibia for a variety of reasons. One of the main problems is that the existence of forests in Namibia is not well recognised by laymen, policymakers, and ecologists. There are no forests in Namibia according to local classifications, only savanna. No updated forest map according to FAO classifications has been made for Namibia since Independence, nor has a national forestry inventory. The Namibian Directorate of Forestry is small and has limited resources, especially considering the vast areas of forested land to manage and the increasing pressure on forests for subsistence agriculture and tropical hardwoods. CFs provide opportunities for SFM, however, they need a lot of assistance to draft management plans and monitor annual allowable harvest guidelines.

There is no silviculture applied in Namibia; forest management in protected forests is restricted to the bare extraction of resources with a trend of overharvesting. Opportunities are hence manifold to improve SFM in Namibia and they are summarised in the last chapter.

1 Introduction

The Hanns Seidel Foundation (HSF) Namibia together with the Desert Research Foundation Namibia (DRFN) is implementing a project on the promotion of Sustainable Forest Management (SFM) in Namibia, here referred to as the NSFM-Project. The NSFM-Project is supported by the European Union (EU) and seeks to support an active multi-stakeholder dialogue on SFM with a focus on valuable hardwood as a contribution to an improved implementation of SFM in the KAZA-Region in Namibia's northeast.

SFM aims to balance the various uses of forests while ensuring their ecological functioning and the provision of benefits and functions into the future (ITTO 2015a). It is based on the principle of multifunctional forests, which requires a sound forest policy, committed stakeholders, and forest managers and users with ecological knowledge and technical skills. Forest policy and legislation are relatively recent in Namibia, while the extent and even existence of Namibia's forests are not always recognized, affecting SFM practices in the country. Despite this, a lot has happened in the forestry sector since Namibia's Independence, and since the book "Forestry in Namibia 1850 – 1990" (Erkkilä and Siiskonen 1992) was written. Hence, it was an opportune time to give an overview of the progress made, the obstacles encountered and the challenges ahead for SFM.

The purpose of this baseline study is to provide an information base against which to evaluate the impact, progress, and effectiveness of the NSFM-Project, including the information campaign. The baseline study consists of two components:

- Chapters 2 to 7: a desktop study, that includes the latest scientific research, to analyse the status quo of SFM in Namibia, including the legal framework, forest management plans at a local and regional level, community forests (CFs), certification systems, existing and potential value chains;

- Chapter 8: a baseline survey was performed to assess the level of awareness, understanding and knowledge of SFM among the project's target groups.

The desktop study is compiled by Dr Vera De Cauwer, a forestry engineer trained in Belgium and France, with 20 years of experience in Namibia who started forest research in Namibia in 2005. The baseline survey of Chapter 8 was designed and implemented by Dr Lara Beer, an agricultural economist trained in Germany, with 7 years of experience in energy wood and empirical research in Europe and Namibia.

Next to an overview of Namibia's forests and the use and status of SFM in Namibia, this baseline study also gives an introduction to basic concepts of SFM, such as silviculture, ecosystem services and sustainable timber harvest. Common names are mainly used for tree species, with an overview of all scientific and common names in Appendix 2.

2 Namibia's forests

2.1 Where are Namibia's forests?

Namibia is an arid country that is mainly covered by grass and shrublands in the western and southern parts, which are desert and semi-desert. There are however forests in the northeastern part of the country (Figure 1). The extent of these dry forests is only vaguely known. The main reason is that different definitions of forest and woodlands have been used in Namibia. Local vegetation maps refer to Namibia's forests as tree savanna or woodlands (Edwards 1983, Giess 1998, Burke *et al.* 2002). The classification used by the Directorate of Forestry in Namibia defines forest as areas with forest cover higher than 75% (Edwards 1983, FAO 2020).

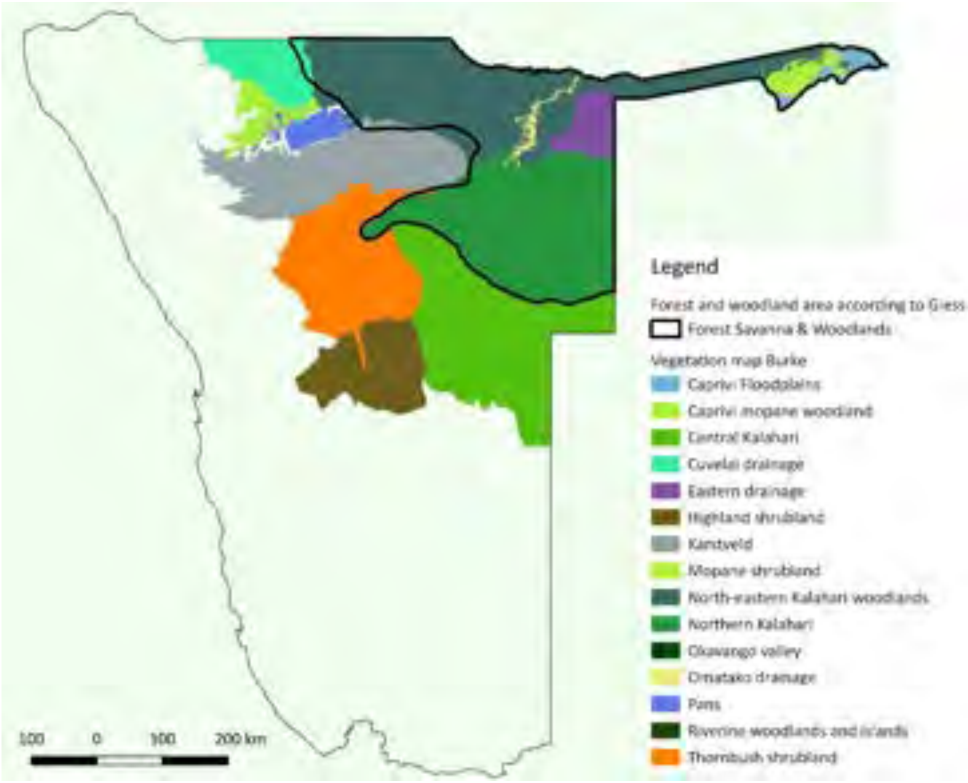

Figure 1 – Forest and woodland in Namibia according to the vegetation maps of Giess (1998) and Burke (2002)

The Namibian forest definition is very different from the internationally most used definition, that of the Food and Agricultural Organization (FAO), which most countries use to report their forest resources, including Namibia. According to the FAO definition (Box 1), Namibia's forests extend much more west and southwards than on the preliminary Namibian vegetation map of Giess (1998). The riverine vegetation found along the perennial rivers and the larger ephemeral rivers of Namibia are also forested according to this definition.

The terms "woodland" and "savanna" used in the Namibian classifications are often used on the African continent, e.g. for mopane or miombo woodland (Timberlake and Chidumayo 2011, Chirwa *et al.* 2014). However, there is no internationally accepted definition for woodland (Putz and Redford, 2010), making the term difficult to use for management purposes. Woodland in the regional context has a wider meaning than the FAO term "other wooded land". The canopy cover can be higher than 10%, up to 60% (Hirota *et al.* 2011, Kutsch *et al.* 2011). The understorey, the layer of vegetation beneath the main canopy of a forest, is characterised by C4 grasses (Putz and Redford 2010, Ratnam *et al.* 2011, Oliveras and Malhi 2016). The C4 photosynthetic pathway makes these grasses tolerant to higher temperatures and drought but less tolerant to shade compared to C3 grasses (Ratnam et al.

2011, Oliveras and Malhi 2016). This woodland definition overlaps with that of savanna in the more heavily "treed" versions of the spectrum (Ratnam et al. 2011). The characterising presence of C4 grasses in woodlands, and savannas in general, is however difficult to monitor as they are not always present during long droughts, after fires, or because of overgrazing by livestock or game.

Box 1: Forest monitoring by FAO

The Food and Agricultural Organization (FAO) has been monitoring the world's forests at 5 to 10 year intervals since 1946. The Global Forest Resources Assessments (FRA) are now produced every five years in an attempt to provide a consistent approach to describing the world's forests and how they are changing. The FRA is a country-driven process and the assessments are based on reports prepared by officially nominated National Correspondents. If a report is not available, the FRA Secretariat prepares a desk study using earlier reports, existing information and/or remote sensing based analysis (FAO 2020, p. 2).

FAO introduced definitions that are applied at a global scale (FAO 2004):

- Forest is "land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10%, or trees able to reach these thresholds in situ".
- Other wooded land refers to land that is not classified as "Forest" and spanning more than 0.5 ha with trees higher than 5m and a canopy cover of 5 to 10% or trees able to reach these thresholds; or with a combined cover of shrubs, bushes and trees above 10%.

Canopy cover or crown cover, is defined as the proportion of the forest ground covered by the vertical projection of the tree crowns. It can not exceed 100% (Jennings *et al.* 1999).

The FAO definitions appear to be well aligned with the quantitative definition given for the tree and shrub savanna biome of Namibia given by Thuiller et al. (2006) and based on a vegetation model: the biomass of deciduous broad-leaved trees is higher than 0.94 tonnes per hectares (ha), or the biomass of the C4 pathway plant functional types is higher than 49.5 tonnes per ha.

2.2 How much forest does Namibia have?

The accurate forest area of Namibia is not known since there is no regular national land or forest cover mapping (FAO 2020). The most comprehensive forest map of Namibia was established from 1992 to 1997 and covers Namibia north of latitude 20° S (Erkkilä and Löfman 1999, Graz, pers. comm. 2022). SPOT XS data obtained in 1993 was used to map the most eastern areas and LANDSAT data obtained in 1993 and 1996 for the remaining parts. The map covered Kavango West, Kavongo East, Zambezi, Ohangwena, northern Kunene, Omusati, Oshana, Oshikoto and northern Otjozondjupa. Data for Omaheke and Khomas is lacking. This map is the basis of the five-yearly reporting of Namibia to FAO (FAO 2005) and applied the term forest similarly to FAO (Box 1). Figure 2 shows that most forests were concentrated in the northeastern parts of the country in 1992. Western Ohangwena and northern Omusati used to have a much higher forest cover but there was a lot of deforestation before Independence (Erkkilä and Löfman 1999).

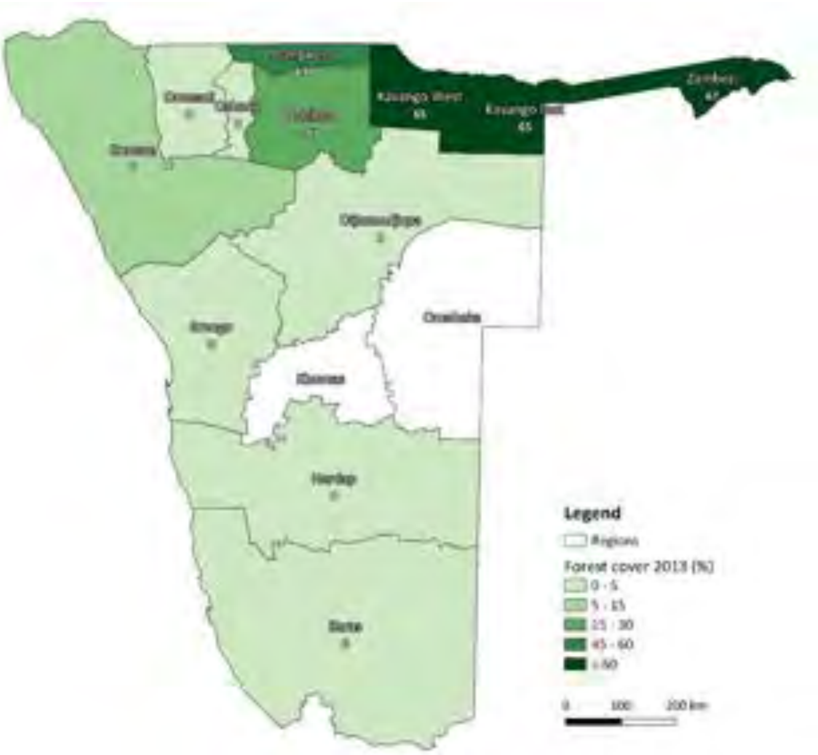

Figure 2 – Forest in Namibia according to the forest cover mapping of northern Namibia (Holm & Graz, 1992 in FAO 2005). Forest cover includes only the dense, medium, open forest classes. The forest cover map only covered Namibia north of latitude 20° S. Areas south of this were assumed to have no forest, although there is forest in Khomas, southern Otjozondjupa and Omaheke.

All areas reported to FAO are based on desktop studies with rough extrapolations of the 1992 data. A deforestation rate of on average 1% is used and some savannah classes were converted to forest classes (FAO 2005). The forested area reported for 2020 was 6,638,900 ha or 8.1% of the total land area, considerably less than the 9.8% reported in 2000 (FAO 2020). A global forest assessment based on high-resolution satellite data (Landsat 7) showed that Namibia had only 13,000 ha of forest with a canopy cover of 25% or more (Hansen *et al.* 2013). Hence, nearly all of Namibia's forest has a canopy cover ranging between 10% and 25%.

The recently established Bush Information System (BIS) (MAWF & NSA 2020) provides a unique opportunity to create an updated forest map for Namibia. Thompson (2021) determined the extent of Namibia's forest and woodland according to FAO definitions based on two layers of the BIS (Figure 3). The *Canopy Cover* layer was used to identify a canopy cover of more than 5 % per ha and the BIS *Tree Height* layer was used to identify an average tree height of more than 5 m per ha. The resulting forest and woodland area is the area where both these layers intersect. The next step would be to separate the forest from the woodland area, however, it is clear that the forest area will exceed the extent of forest and woodland area as suggested by the vegetation maps (Figure 1) and the ecological zones defined by World Wildlife Fund (WWF) and FAO (Figure 4).

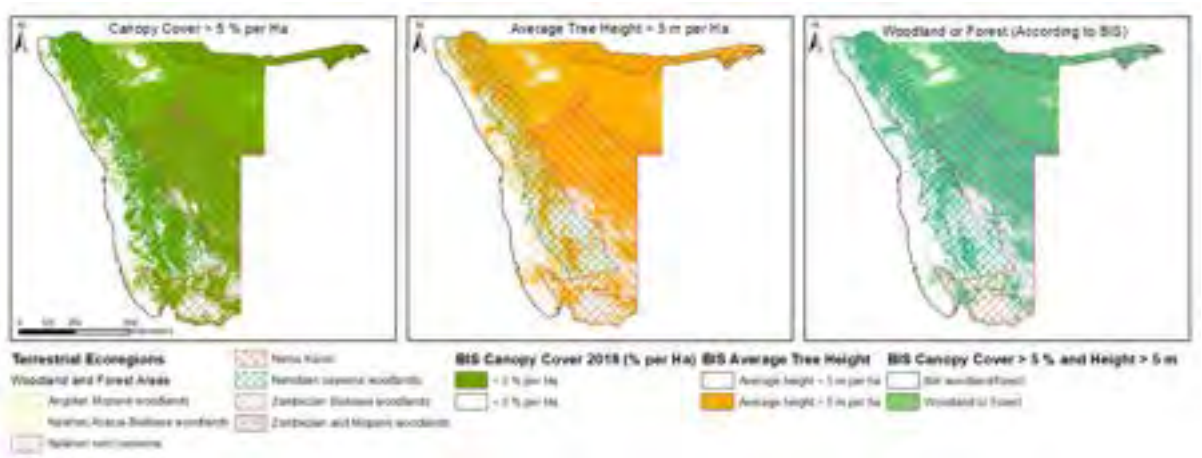

Figure 3 – Forest and woodland of Namibia based on data of the BIS compared with the WWF Ecoregions for woodland and forest (Thompson 2021): (a) 2018 BIS Canopy Cover bigger than 5 % per ha, (b) 2018 BIS Average Tree Height taller than 5 m per ha, (c) Overlap of (a) and (b).

2.3 Forest types in Namibia

Namibia’s forests are at the southern edge of the forest biome in southern Africa (FAO 2012). They are tropical dry forests mainly consisting of mopane woodlands and open *Burkea, Pterocarpus* and *Terminalia* forests (Figure 4). Towards the northeast, average rainfall increases and the forest gradually changes to Zambezian Baikiaea forests, which are considered part of the Miombo Ecoregion. The Miombo Ecoregion is an extension of White’s Zambezian regional centre of endemism and is characterised by semi-deciduous woodland composed of trees of the legume subfamily Detarioideae (previously Caesalpinioideae) (Timberlake and Chidumayo 2011, LPWG 2017).

The western edge of Namibia’s forest and other wooded land is semi-arid and formed by mopane woodland, which is also found in the south of the Zambezi region. There is no gradual transformation towards Miombo woodlands; boundaries are rather distinct, although there are patches of Baikiaea woodlands up till Omusati (Kanime and Laamanen 2003). More southwards, where annual rainfall decreases, the woodlands get progressively more intermingled with species of the legume subfamily Caesalpinioideae (formerly Mimosoideae), and gradually change into semi-arid scrublands (Burke *et al.* 2002). In general, the forest can be characterised by six main types (Figure 4):

- Zambezian Baikiaea woodlands;
- Mopane woodlands: Angolan and Zambezian;
- Kalahari Acacia Baikiaea woodlands;
- Karstveld (Figure 1);
- Acacia woodlands: northern and eastern parts of Kalahari xeric savanna;
- Riverine woodlands.

All forest and woodland areas are characterised by three seasons: cold dry from May to August, hot dry from September to December and (relatively) wet from January to April. There is great variation in temperature between winter and summer, and between day and night during winter. Many areas get frost during winter, while day temperatures may rise above 35°C during summer, causing severe stress for plants (Verlinden and Dayot 2005).

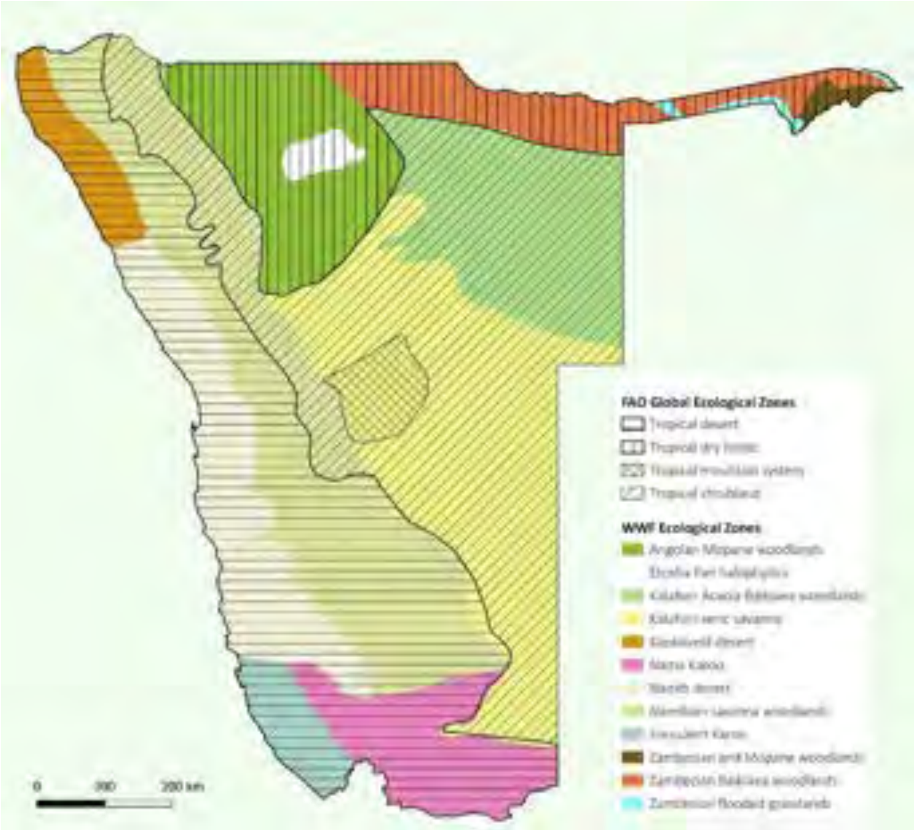

Figure 4 - Global ecological zones for Namibia according to FAO for forest reporting (FAO 2012) and WWF (Olson et al. 2001)

2.3.1 Zambezian Baikaea woodlands

The Zambezian Baikiaea woodlands are found on the deep, nutrient-poor Kalahari sand soils of the Omusati, Ohangwena, Kavango East, Kavango West and Zambezi regions. The terrain is fairly flat and situated at elevations of 900 to 1100 m above sea level. Mean annual rainfall ranges from 350 mm in the west to approximately 650 mm in the east. The woodlands extend more westwards than indicated in Figure 4, with Uukolonkadhi CF the most westward representation of this woodland type, where it is called Omuthitu/Omufitu (Kanime and Laamanen 2003, Verlinden and Dayot 2005). The Hamoye and Caprivi state forests and many CFs – such as Okongo, Omufitu Wekuta, and Likwatera - are covered by this type of woodland.

The Zambezian Baikiaea woodlands are open forests with canopy coverage of 10% to 30% and an average canopy height of about 10 to 12 m in Namibia. The woodlands are dominated by tree species of the Fabaceae family and are named after one dominant species; *Baikiaea plurijuga*, the Zambezi teak, an important timber tree (see 0). Forest inventories show that the species is less dominant in the Kavango regions than in the eastern parts of the Baikiaea woodlands, which extend into northern Botswana and southern Zambia (Childes and Walker 1987, Mitlöhner 1993, De Cauwer *et al.* 2016, De Cauwer, Knox, *et al.* 2018). Several authors, therefore, refer to the Kavango woodlands as Burkea (Frost 1996, Burke *et al.* 2002), Burkeo-Pterocarpetea (Strohbach and Petersen 2007), Baikiaea-Burkea (Stellmes *et al.* 2013a) or Baikiaea-Pterocarpus (De Cauwer *et al.* 2016) woodlands, because red syringa (*Burkea africana)* is the most dominant canopy tree, with the Zambezi teak and kiaat (*Pterocarpus angolensis)* as co-dominant species (Table 1).

Table 1 - Canopy tree composition based on sample plots (n = 1333) in the Kavango regions and represented as a portion (%) of the total basal area (De Cauwer *et al.* 2016). The term basal area is explained in Box 2.

Species	**Contribution (%)**
Burkea africana	22.9
Baikiaea plurijuga	16.4
Pterocarpus angolensis	16.1
Schinziophyton rautanenii	11.7
Guibourtia coleosperma	11.4
Dialium englerianum	5.8
Combretum collinum	2.2
Erythrophleum africanum	0.6
Acacia erioloba	0.4

Westwards, in Omusati, the Zambezi teak dominates again, together with *Commiphora mollis.* There is hardly any red syringa or kiaat and no mangetti (*Schinziophyton rautanenii)* (Kanime and Laamanen 2003). However, the tree layer has disappeared in most of the Zambezian Baikiaea woodlands of the Omusati region due to overharvesting, resulting in a shrub layer (Selanniemi *et al.* 2000).

Woody species in the understorey of the forest include mainly silver cluster-leaf (*Terminalia sericea),* large-fruited bushwillow *(Combretum zeyheri)*, sand corkwood *(Commiphora angolensis)*, and peeling plane *(Ochna pulchra)* (Kanime and Laamanen 2003, De Cauwer *et al.* 2016). In the Kavango regions, understorey species also include *Combretum psidioides*, *Diplorhynchus condylocarpon,* monkey orange or uguni (*Strychnos cocculoides)*, hairy corkwood (*Commiphora africana),* and the spine-leaved monkey-orange (*Strychnos pungens)* (De Cauwer *et al.* 2016). In Omusati, *Mundulea sericea* and *Ozoroa paniculosa* are common (Kanime and Laamanen 2003).

Common shrubs include sand camwood (*Baphia massaiensis*), white bauhinia (*Bauhinia petersiana)* and raisin bush *(Grewia)* species (Kanime and Laamanen 2003, De Cauwer *et al.* 2016). The ground layer mainly consists of grasses, although the dwarf jackal-berry (*Diospyros chamaethamnus*) is also common in Kavango. In Namibia, plant species richness is highest in the Kavango region, probably because of a variety of habitats, including the wetlands near the Okavango river, and the incursion of tropical species from Angola down the river (Maggs *et al.* 1998).

Total stem densities in the Baikiaea woodlands are in the order of 100 to 444 stems per ha (Kamwi 2003, Kanime and Laamanen 2003, De Cauwer, Knox, *et al.* 2018). Wood volume varies between 14.3 m^3 per ha for Uukolonkadhi CF in Omusati (Kanime and Laamanen 2003), 23.1 m^3 to 38.4 m^3 per ha in Zambezi (Geldenhuys 1991, Kamwi 2003) to 43.2 m^3 per ha in Okongo CF, Ohangwena (Angombe *et al.* 2000). The basal area was 5.6 m^2 per ha in the Kavango regions (De Cauwer, Knox, *et al.* 2018). While the wood volume is much lower than in ‘true’ Miombo woodland, stem diameters are larger on average, with a mean diameter at breast height (DBH, see also Box 2) of about 29.9 cm (De Cauwer, Knox, *et al.* 2018).

2.3.2 Mopane woodlands

Mopane woodlands are strongly dominated by the species *Colophospermum mopane*, commonly known as mopane, which can occur either as a tree up to 20 to2 5 m tall (Kamwi and Laamanen 2002, Geldenhuys and Golding 2008) or as a shrub. Canopy cover ranges between 10% and 25% but can be as high as 60% according to Musvoto *et al*. (2007). The distribution range of Mopane woodland covers areas with an annual rainfall of 400 to 700 mm (Chirwa *et al.* 2014), and little or no frost incidence in winter (Siebert *et al.* 2003). They are often found on fine-textured soils, such as the Angolan Mopane woodlands on the alluvial clays in the Cuvelai system or the Zambesian Mopane woodlands on fossil wetlands with shallow sands (Erkkilä and Siiskonen 1992, Mendelsohn and el Obeid 2005). CFs dominated by Mopane woodlands include amongst others the Ehi-Rovipuko CF in the Kunene, the emerging Ongandjera CF in the Omusati region and Sikanjabuka CF in Zambezi (Chakanga *et al.* 1998, Kamwi and Laamanen 2002, Directorate of Forestry 2004).

The average canopy height is much lower than in the Zambezian Baikiaea woodlands, ranging between 5.5 m and 9 m (Chakanga *et al.* 1998, Kamwi and Laamanen 2002, Directorate of Forestry 2004, De Cauwer, Knox, *et al.* 2018). The average tree diameter is not more than 20 cm (De Cauwer, Knox, *et al.* 2018). Tree densities are similar to the Baikaea woodlands, varying from 100 to as high as 440 stems per ha in the more protected and least populated areas (Kamwi and Laamanen 2002, Musvoto *et al.* 2007, De Cauwer, Knox, *et al.* 2018). The basal area can reach 5.2 m^2 per ha (De Cauwer, Knox, *et al.* 2018), while wood volume can be as low as 3.6 m^3 per ha in Ehi-Rovipuko CF (Directorate of Forestry 2004) and as high as 52 m^3 per ha in Sikanjabuka CF (Kamwi and Laamanen 2002).

Other tree species than mopane are in the minority. In the Angolan Mopane woodlands, they mainly consist of *Commiphora*, *Acacia,* and *Combretum* species, as well as purple-pod terminalia (*Terminalia prunioides), Albizia anthelmintica*, *Sesamothamnus guerichii,* and *Elephentorrhiza elephantina* (Chakanga *et al.* 1998, Siebert *et al.* 2003, Directorate of Forestry 2004). In the Zambezian Mopane woodlands, silver-cluster leaf, named muhonono in Zambezi, is the main tree next to mopane (Kamwi and Laamanen 2002). Shrub species can include *Bauhinia petersiana*, *Dichrostachys cinerea,* raisin bush species*, Combretum* species*, Maerua juncea, Rhigozum brevispinosum,* and *Euclea divinorum* (Kamwi and Laamanen 2002, Siebert *et al.* 2003, Directorate of Forestry 2004). The grass in well-developed mopane stands is very sparse, possibly the result of the dense shallow lateral root system of mopane (Erkkilä and Siiskonen 1992).

2.3.3 Kalahari Acacia Baikiaea woodlands

This forest type is a transition from the Zambesian Baikiaea woodlands to the Acacia shrublands further south. It is found in areas characterised by Kalahari sand soils and longitudinal, east-west orientated dunes. The dunes are less than 10m high due to erosion but the remnants of the dune fields are still visible in satellite images (Graz 1999, Strohbach and Petersen 2007).

Most of the tree layer of the Acacia Baikiaea woodlands is similar to that of the Zambezian Baikiaea woodlands, although canopy coverage, Zambezi teak, and false mopane (*Guibourtia coleosperma)* decrease in a southward direction. The more shallow and slightly heavier sand to loamy sand soils from dune depressions and drainage channels are dominated by *Acacia* species, especially *Acacia luederitzii* and *A. fleckii*. Shrub species include *Croton gratissimus, Dichrostachys cinerea* and *Bauhinia petersiana* (Strohbach and Petersen 2007). This vegetation type contains the Kanovlei state forest and several CFs such as M'kata and Nyae Nyae.

2.3.4 Karstveld

The Karstveld is an area characterised by underlying limestone rock, dolomite hills and underground caves south of Etosha (Figure 1). The mountainous savanna vegetation has a much higher species diversity than the surrounding areas (Maggs *et al.* 1998). Typical trees include tamboti (*Spirostachys africana),* marula *(Sclerocarya birrea),* strangler fig (*Ficus burkei*), common kirkia (*Kirkia acuminata), Commiphora mollis,* propeller tree *(Gyrocarpus americanus),* leadwood (*Combretum imberbe), Securidaea longepedunculata, Olea europaea* subsp. *africana*, and *Moringa ovalifolia*. The flatter, sandier areas are Mopane woodland intermingled with *Acacia* species, kudu-bush (*Combretum apiculatum),* silver cluster-leaf and purple-pod terminalia (Giess 1998, Mannheimer and Curtis 2018). Some areas have a tree layer that is high and dense enough or used to form a forest. There are no CFs in this forest type.

The Karstveld is the area closest to the copper mine of Tsumeb for which a lot of wood, especially tamboti, was harvested for energy and mine props since the early 20th century. The consumption of tamboti wood went up with the deepening of the mine, up to 13,000 m^3 per year by the 1950s (Erkkilä and Siiskonen 1992), a very large amount of wood compared with other historical harvest data (0). Today, most of the area is dense shrubland (Erkkilä and Siiskonen 1992), caused by amongst others overgrazing.

2.3.5 Acacia woodlands

Some of the northern and eastern parts of Kalahari xeric savanna have a tree layer that is high and dense enough or used to be to form a forest. Those areas are characterised by *Acacia recifiens, A. tortilis,* camelthorn *(Acacia erioloba), Ziziphus mucronata* and/or kudu-bush. Examples of this woodland type are some of the dense camelthorn stands near Rehoboth. In the more sandy areas, silver cluster-leaf is common, sometimes with Kalahari apple-leaf (*Philenoptera nelsii)* or red syringa (Giess 1998, Directorate of Forestry 2008), and with a canopy layer of 5 to 7 m high. This vegetation type is for example found near the road from Windhoek to Gobabis and Botswana. Otjombinde CF and the emerging Otjinene CF are situated in this forest type. Only one known forest inventory is available (Directorate of Forestry 2008). The Acacia woodlands are not indicated on most forest maps, although it should be possible to derive them from BIS (see 0).

2.3.6 Riverine woodland

All river valleys in Namibia support shrubs or woodlands that are taller and denser than the areas around them, often with a different species composition (Mendelsohn and el Obeid 2005). Riverine vegetations form linear forests along all perennial rivers of Namibia, as well as along most ephemeral rivers in the semi-arid zones. Vegetation composition varies with the rainfall zone.

Along the Kavango river, knob thorn (*Acacia nigrescens*) trees more than 20 m high are found, intermingled with species such as *Peltophorum africanum,* safsaf willow (*Salix mucronata* subsp. *mucronata*) and *Ziziphus mucronata* (De Cauwer 2013). The ana (*Faidherbia albida*) tree dominates in the Kuiseb valley. Along the Orange river, there are mainly *Searsia* species, Cape willow (*Salix mucronata* subsp. *capensis*), wild tamarisk (*Tamarix usneoides*), and sweet thorn (Acacia karroo) (Mendelsohn and el Obeid 2005). The riverine forest along ephemeral rivers is dominated by *Acacia* species, especially camelthorn, *Ziziphus mucronata*, and to a lesser extent leadwood, *Euclea pseudobenus*, and wild tamarisk (Giess 1998).

Riverine woodland along the perennial rivers is the most threatened forest type of Namibia as they are often cleared for agricultural fields, many forming form part of large irrigation schemes. Regeneration becomes near impossible as livestock overgrazes the areas along the river. It is not known to what extent regeneration is still possible in national parks situated along perennial rivers, such as Mahango along the Kavango River, because of the high densities of game. Only robust protection measures, such as fencing off areas, will allow protecting this vegetation type.

2.4 Forest dynamics in Namibia

Forest dynamics encompass the environmental and biological processes that shape and change a forest ecosystem. An understanding of forest dynamics is required to plan forest management interventions. However, the dynamics of natural tropical forests are difficult to understand because of the many natural disturbances, the high species diversity, and because the ecology of many of those species is not well known (Gourlet-Fleury *et al.* 2005, De Cauwer 2016). Relevant ecological parameters that are needed for each species include the tolerance for tree competition, diameter growth, regeneration and mortality rate (Gourlet-Fleury *et al.* 2005, Seifert *et al.* 2014). The lack of such data hinders the development of predictive dynamic models, essential for forest managers to simulate logging scenarios for sustainable exploitation (Gourlet-Fleury *et al.* 2005). In Namibia, the data available is not sufficient to give a full picture of Namibia's forest dynamics.

2.4.1 Tree regeneration

Few efforts have been made to understand the natural regeneration in Namibia's woodlands. In general, the dry conditions are associated with poor and erratic natural regeneration, particularly in the nutrient-poor deep Kalahari sands. Hence, the rate of tree recruitment is relatively slow and is probably a disincentive to public and private investment in forest management (Ministry of Agriculture, Water and Forestry 2011).

There is research evidence that the natural regeneration of several important timber and fruit species is problematic, especially in the Zambezian Baikiaea woodlands. The natural regeneration of Kiaat is limited compared to other woody species (De Cauwer 2016, Kabajani 2016), which is similar to findings in other parts of southern Africa (von Malitz and Rathogwa 1999, Caro *et al.* 2005). Reasons suggested for the lack of regeneration include high fire frequency, grazing and browsing pressure, climate change, and lack of light because of plant competition (von Malitz and Rathogwa 1999, Caro *et al.* 2005, De Cauwer *et al.* 2016). The Zambezi teak also showed limited regeneration compared to the number of mature trees in Kwando CF with 232 seedlings per ha (Kamwi 2003). The timber species is known to have regeneration problems in Zambia (De Cauwer, Chaka, *et al.* 2018).

There is also limited regeneration of the highly valued timber tree false mopane. Forest inventories show that the tree is not abundant (< 10%), especially in the smaller size classes. The fruit trees mangetti and monkey orange also show limited natural regeneration in northern Namibia (Kabajani 2016). The major reason may be the overharvesting of the fruit, and for mangetti, also of the wood.

Natural tree regeneration in Mopane woodland appears good as long as young trees are not overharvested (Erkkilä and Siiskonen 1992). Good regeneration of mopane was observed in Ehi-Rovipuko CF with 457 seedlings per ha (Directorate of Forestry 2012) and in Sikanjabuka CF with 5316 seedlings per ha (Kamwi and Laamanen 2002).

2.4.2 Forest disturbances

Tree growth and forest health can be affected by many environmental and anthropogenic factors, often referred to as disturbances. Long drought periods, frost, fungi and insects, and a high fire frequency can affect tree growth, and forest health and increase tree mortality in Namibia's forest. Heavy browsing by livestock and wildlife can also affect tree growth and cause seedling mortality. Elephants not only browse trees but also push them over. Large elephant populations can be a major disturbance in and near national parks, such as Khaudum or in the southern Zambezi region, which neighbours Chobe in Botswana (Ben Shahar 1998).

The unsustainable and/or illegal harvest of woodland resources is also a major disturbance in Namibia's forests. If timber is sustainably harvested, it should not affect forest structure and composition over the long term. Mopane is sometimes overharvested in the most populated areas, such as central Omusati (Musvoto *et al.* 2007), especially because it has so many uses (see 0). Timber is the main woodland resource that is illegally harvested. In some cases, it is legally but unsustainably harvested because there is no adequate management plan or is not followed or monitored. Unfortunately, there are rarely enough quantitative data to assess sustainability levels of harvest (see Chapter 0). Roads, and especially tar sealed roads, are the major vectors along which both timber harvest and deforestation take place, especially in areas with low population density (Kamwi *et al.* 2015, Schneibel *et al.* 2016).

Fires occur regularly in Namibia's forests; on average 7 % of the land area burned on an annual basis in Namibia during the period 2003 – 2012 (FAO 2015). Although fire has been a major driver of the southern African woodlands long before humans existed (Bond and Zaloumis 2016), most fires in the Baikiaea woodlands have an anthropogenic origin. Fire is used by subsistence farmers and hunters to clear the land or improve grass quality which is important for the rapid regeneration of grass. In addition, fires can break physical dormancy in the hard-coated seeds of fire-adapted tree species. However, the ecological effects of fire on vegetation are dependent upon many factors such as timing, weather conditions, fuel load, and frequency (Ministry of Agriculture, Water and Forestry 2011).

The fire season in north-eastern Namibia is in August and September, the late dry season, when hardly any natural ignitions take place (Archibald *et al.* 2008, Stellmes *et al.* 2013b). Unfortunately, at that time of the year, there is a large amount of dry biomass resulting in hotter and larger fires, not only affecting the understorey, but also the trees. Mid- to late dry season fires result in significantly higher stem mortality compared to early burning or no burning (Geldenhuys 1977). A single fire may not affect tree layer composition, but the accumulation of damage caused by recurring fires in the late dry season can result in shifts in species composition and forest degradation (De Cauwer and Mertens 2018). With northern Namibia projected to become warmer and drier, fire frequency is expected to increase (Pausas and Ribeiro 2013, Enright *et al.* 2015, De Cauwer *et al.* 2016). A limitation of fire frequency and intensity is needed to protect certain socioeconomically important species such as *Dialium englerianum* and false mopane (De Cauwer and Mertens 2018).

2.4.3 Forest degradation

Forest degradation is a process during which biomass, wood volume and carbon sequestration decrease, and changes in species composition take place as a consequence of severe or long-term disturbances. Shifts in species composition can for example be towards more fire resistant (De Cauwer and Mertens 2018) or drought-resistant species, or by removal of species targeted for timber or other purposes. Climate change is likely to accelerate the rate of woodland degradation (see 0).

Forest degradation is difficult to quantify as it requires comparison with an undegraded condition and often entails repeated measurements over time. Long-term studies in the Zambezian Baikiaea woodlands have been very limited (De Cauwer and Mertens 2018). One study of an annual burning experiment over 16 years in northern Namibia illustrated how fire negatively affected woody regeneration, especially of species such as Zambezi teak and *Commiphora spp.* (Geldenhuys 1977). The lower representation of Zambezi teak in the Kavango regions (see 0) may be caused by its higher fire sensitivity. The most fire-resistant timber species of the Zambezian Baikiaea woodlands appear to be kiaat and silver cluster-leaf, and the least resistant false mopane (De Cauwer and Mertens 2018).

2.4.4 Deforestation

Unlike forest degradation, deforestation is a loss of forest, the area is no longer forest because land use has changed (active deforestation), e.g. the forest was cleared for agriculture, or because, after a period of forest degradation, canopy coverage is no longer 10% (passive deforestation). The rate of passive deforestation is probably much larger than the active deforestation in Namibia, however, there is insufficient data to determine this. Passive deforestation may for example lead to the deforestation of large areas in Bwabwata National Park.

According to the reporting of Namibia to FAO, forest loss was 11,130 km^2 or 16.1 % of the forest area from 2000 to 2015 (FAO 2014). However, this is a rough estimate as stated earlier (0). It does seem to correspond with the estimate of 13% forest loss for the period 2000 to 2012 based on Landsat data (Hansen *et al.* 2013).

Active deforestation in Namibia is mainly for subsistence or commercial agriculture (Wingate *et al.* 2016, De Cauwer, Knox, *et al.* 2018). The area covered by the Zambezian Baikiaea woodlands and associated shrublands decreased by 4,607 km^2 (4.3% of the area) during the period 1975 – 2014 because the agricultural area doubled (Wingate *et al.* 2016). Forest cover in Kavango East decreased from 58% in 1990 to 55% by 2016, while cropland increased from 3% to 6% (Muhoko *et al.* 2020). Local farmers remain on the same fields, resulting in permanent clearings (Erkkilä and Löfman 1999, Pröpper *et al.* 2010), or temporary fallows in the Kavango regions (Hilukwa 2018). An increasing population causes the expansion of clearings, even into areas with very marginal cropland, as on the Kalahari sand soils of the Zambezian Baikiaea woodlands. These sand soils are generally unsuitable for crop production because of their low water-retention capacity and limited nutrients. The relatively low rainfall means that rain-fed crop production is risky and with low yields (Jones and Barnes 2009), e.g. only 250 to 600 kg per ha for maize (Pröpper *et al.* 2015).

The Kavango and Zambezi regions are considered the breadbaskets of Namibia and the government has stimulated commercial agriculture through the development of green schemes near perennial rivers. Forest is sometimes cleared (Jones and Barnes 2009, De Cauwer, Knox, *et al.* 2018), for example at the Liselo scheme (Figure 5). There were also plans to start plantations of *Jatropha curcas*, a biofuel crop, in north-eastern Namibia. These plans have not been realised because potential yields were unknown and a concern that biofuel would displace food crop production (Jones and Barnes 2009).

In the most populated areas of the Angolan Mopane woodland, the forest has been extensively converted to agricultural fields in the decade before Independence and in the western part to grazing land (Erkkilä and Löfman 1999, Verlinden and Dayot 2005).

Considering that the main driver of deforestation is the conversion to agricultural land, one of the best ways to stop deforestation is to intensify and diversify agricultural production on the existing fields that have the best soils and that have access to water, such as the green schemes. The most important will be to invest in soil improvement (Jeremy Ford, pers. comm.) and apply recent agricultural research, such as plant growth-promoting bacteria (Haiyambo *et al.* 2015) or planting of drought-resistant cultivars.

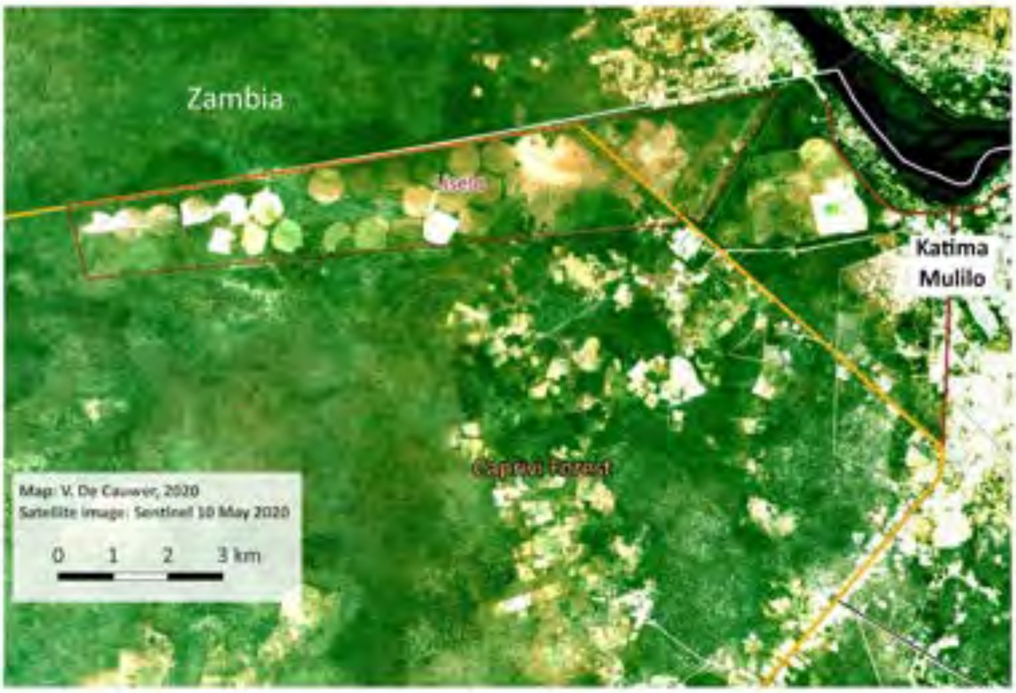

Figure 5- Liselo Farm in Caprivi state forest, Zambezi

2.4.5 Effects of climate change

The rate of surface temperature increase caused by human-induced climate change has generally been more rapid in Africa than the global average, which has caused an increase in aridity and droughts. A decrease in the mean precipitation in southwestern Africa has been observed (IPCC 2021). Satellite data have shown that there is a decrease in rainfall in October for north-eastern Namibia and that both the wettest and driest of the last 40 years in Namibia occurred in the last decade (Thompson, 2021).

Global warming and the observed increases in hot extremes are projected to continue throughout the 21st century. Predictions include an increase in dryness from 1.5°C, increased wind speed, and a decrease in rainfall of up to 30% for southwestern Africa (IPCC 2021). Namibia’s forests may receive 100 mm less rain on an annual basis by 2080 (De Cauwer et al., 2016). This will increase fire weather conditions and fire frequency is expected to increase (Enright *et al.* 2015, IPCC 2021).

The increasing evapotranspiration caused by the rising temperatures, increased fire frequency, and increasing droughts will cause more plant stress (Munalula *et al.* 2016), a decrease in tree growth (Fichtler *et al.* 2004), decreasing tree recruitment (Enright *et al.* 2015), and ultimately a potential increase in tree mortality (Allen *et al.* 2010). This will decrease the distribution ranges of many tree species in Namibia (Thuiller *et al.* 2006). De Cauwer *et al.* (2014) predicted a decrease in the distribution area of Namibia’s most important timber tree, kiaat. By 2080, the tree may almost have disappeared from the country.

As a result, ongoing climate change will cause Namibia’s dry forests to shift towards the northeast. This is consistent with the study of Thuiller *et al.* (2006) that predicted a decrease in tree cover in northern and northeastern Namibia by 2080. While it is difficult to observe a reduction of tree cover over time, considering the many other factors that affect this, other early warning signs can be monitored. Decreasing tree regeneration and increasing tree mortality, especially for the major timber species, can be monitored in permanent sample plots (PSPs) (0). This would assist natural resources managers to put mitigation plans in place to bridge the period during which the worst effects of climate change will manifest.

2.4.6 Forest succession

Forest succession is the process by which a forest community evolves over time. The term is especially used for the recovery process of the forest after a severe disturbance, as it is assumed that a natural forest community is in equilibrium. The type of disturbance, the climatic conditions, the presence of potentially colonising species, and the interactions among species all influence the path that succession will take.

Species composition and forest structure fluctuate throughout succession. Certain species are more equipped than others to deal with more light, wind, higher temperatures, and disturbed soils. These species are referred to as pioneer species. Pioneers among tree species include silver cluster-leaf and red syringa. Both can invade deforested and other disturbed or degraded areas. Silver cluster-leaf can form dense thickets, together with shrub species such as *Dichrostachys cinerea* and *Acacia fleckii*, on deep sand (Erkkilä and Siiskonen 1992, Strohbach and Petersen 2007). Kiaat is a light-demanding species however, research has shown that it is a long-living, late-successional species that has weak competitive abilities, especially during the juvenile phase. That is why it is doing relatively well in the Zambezian Baikiaea woodlands compared to its cousins in the wet Miombo woodlands (De Cauwer 2016).

In general, there is too little known about forest succession in Namibia, especially how long it takes for the different forest types to recover and which species have the best competitive abilities. Reasons for this are listed under the section on forest research (0).

2.5 Plantations in Namibia

Plantation forestry is limited to a few remnants of experiments with exotic species dating back to the German colonial time. Attempts were made to establish trial plantations during the 20th century as local wood production was not sufficient to satisfy local demand. It was decided that indigenous species were too slow-growing to be planted for wood production and exotic species should form the basis of large-scale plantations (Erkkilä and Siiskonen 1992). The species trials concentrated on *Casuarina*, *Eucalyptus* and *Prosopis*, as well as ornamental species for planting in the cities and around farm dwellings, such as *Cupressus sempervirens, Pinus radiata, Schinus molle, Tecoma stans,* and *Morus alba* (Erkkilä and Löfman 1999, Ministry of Agriculture, Water and Forestry 2011). Species trials were based in Okahandja and Grootfontein (Ministry of Agriculture, Water and Forestry 2011). Several of the trial species were then planted in experimental plantations, e.g. near Brakwater, Grootfontein, Rundu, and Ngoma, and mainly with *Casuarina* and *Eucalyptus* (Erkkilä and Löfman 1999, Ministry of Agriculture, Water and Forestry 2011).

Plantations of Zambezi teak and kiaat have not been attempted in Namibia, and have been limited to trial plantings in neighbouring countries (Piearce 1986, DFSC 2001, Caro *et al.* 2005). In general, there is much less plantation forestry in southern Africa than in the rest of the world. However, this may change in the future considering the increasing wood demand and an emphasis on renewable, carbon-friendly commodities (De Cauwer, Knox, *et al.* 2018).

3 Forest services and resources in Namibia

Namibia's forests provide valuable forest products and ecosystem services, despite the relatively low tree density. Forest products include both timber, as well as non-timber forest products (NTFP's) such as firewood, thatching grasses and fruits. The products and services not only benefit the local communities but also the Namibian population, and economy, while ecological services have an impact at a global level. Hence, the value of Namibia's forests is much more than just the wood and includes the ecological and socio-economic value, which is much larger and difficult to quantify.

Multifunctional forests provide multiple services and products to the users, as Namibia's forests do. Managing a multifunctional forest is complicated because management interventions targeting a single product or service may affect the forest's capacity to provide for others. Intense timber harvesting may affect a forest's value as a habitat for wildlife. Decisions on tradeoffs in the provision of various goods and environmental services are best made using processes that involve the full range of stakeholders. Forest managers applying SFM must continually balance various management objectives that inevitably will change over time as social and community needs and values change; this is the challenge of multipurpose forest management. Although embedded in the laws of many countries, multipurpose forest management has proven to be a complex endeavour that faces a range of economic, social and institutional barriers. Nevertheless, success stories around the tropics, particularly in community-based initiatives, show that it can be made to work—for the benefit of communities and the forest (ITTO, 2015).

3.1 Ecosystem services

Ecosystem services are the contributions of the natural world that people value (Domptail and Mundy 2013). Namibia's forests are ecologically important for carbon storage, soil erosion control, climate regulation, water storage, providing a habitat or movement corridor to a range of species, including commercially important game, and maintaining biodiversity; these are all services valued by people. Additionally, people value forests for recreational, spiritual and cultural reasons. During a project in the Kavango regions, stakeholders were asked to rank the ecosystem services of the Okavango River and neighbouring forests according to their perception. After the provision of water, species diversity was given the highest priority, especially by the national and district stakeholders. This was followed by mitigation of hazards (floods, fires, drought) and climate regulation, while environmental setting (sense of place and respect for landscape) got the lowest ranking, especially by local stakeholders (Domptail and Mundy 2013).

While all ecosystem services are valuable, it should be noted that the recreational value is currently underused or not valued. Only a small portion of tourists visit the forested areas of Namibia.

3.1.1 Carbon pool, emitter and sink

Carbon dioxide (CO_2) is the major greenhouse gas. Globally, tropical and subtropical forests store the largest amount of carbon in terrestrial ecosystems, approximately 600 Gt and are thus the major terrestrial carbon pool (Foley 1995). The global carbon pool for tropical dry forests and savanna's is estimated at 220 Gt, with almost 60% stored in the soil (Foley 1995). Hence, in Namibia, it is safe to state that most carbon is stored in the tree and shrub savannah of northeastern Namibia and especially in its soils. The actual amount of carbon in Namibia's forest soils is unknown. Unfortunately, this carbon pool is decreasing because of climate change (see 0).

CO_2 is globally also the most emitted greenhouse gas. Forest degradation and deforestation are major contributors to carbon emissions in Namibia (see 0 and 0). While the extent of woodland degradation is difficult to assess, it is estimated that it is a much larger contributor to carbon emissions than deforestation in sub-Saharan Africa (Bombelli *et al.* 2009).

As a signatory to the Paris Agreement, Namibia has to reduce the amount of carbon emitted. Hence, proactive forest management is needed. This can include assisting subsistence farmers to increase agricultural yield without clearing more forests and managing forests for sustainable production of more firewood and better timber (see 0). Once concrete steps have been taken toward reducing emissions, the reductions become eligible for carbon trading. Namibia can consider taking part in the carbon market, which includes e.g. REDD+, the UN Programme for Reduction in Emissions from Deforestation and Forest Degradation. REDD is based on the idea that funds are provided to developing countries for reducing emissions from deforestation or forest degradation through various policies and measures (Peskett *et al.* 2008).

A study by Jones and Barnes (2009) assessed the possibility of REDD for forests in Caprivi. Although no legislation specifically provides local communities with rights over carbon, it can be inferred from cabinet decisions and the Forest Act, that the CF has rights over carbon. The study concluded that REDD is not appropriate in Caprivi, primarily because the potential for alternative uses of the woodlands in this region is poor. It argued that the woodland had value while other land uses in Caprivi are not entirely economic. The cost of implementation of the REDD system in Caprivi was at the time estimated at some N$ 33 million per annum (Jones and Barnes 2009). However, history has shown that conversion of the woodlands in Caprivi has continued. Moreover, the application of the REDD system was only approached from a community angle, with the use of community structures. As the REDD application is very complex, it would be much more efficient and less costly if an NGO like IRDNC or WWF applies for a group of CFs. This would then be a kind of outsourcing of the REDD application. There is however a limited understanding among decision-makers in government, community-based organisations and the private sector of the opportunities and challenges for pro-poor payments for avoided deforestation and degradation (Jones and Barnes 2009). It explains why there is no Namibian participation in the carbon market yet.

Namibia's forests also are a carbon sink; they can remove atmospheric carbon. Hence, encouraging natural forest regeneration, expanding forests and planting trees allow mitigating climate change (see 0). While increasing the carbon sink by tree planting is important, it is more important and efficient to maintain the current carbon pool through proactive forest and fire management and fulfilling international agreements.

3.1.2 Soil protection and improvement

Forests and woodlands can retain soil and prevent erosion, with riverine forests protecting riverbanks. Moreover, many tree species belonging to the Fabaceae family can fix nitrogen from the air and enhance the nutritional status of the soil. This is very important as most of Namibia's forests and woodlands are on Kalahari sand or arenosols. Sandy soils are always low in nutrients because they consist largely of quartz sand and thus contain little humus (Mendelsohn and el Obeid 2005). Namibia's arenosols are deficient in most major nutrients, but especially phosphorous, which limits the nitrogen content of the soil (Mendelsohn and el Obeid 2005, Verlinden and Dayot 2005). The soils are also deficient in micro-nutrients such as manganese, iron and zinc (Verlinden and Dayot 2005).

3.1.3 Maintaining biodiversity

Forests contain a wealth of biodiversity, both flora and fauna. Many species would disappear if their forest habitat would be removed. Forest managers can also establish measures to improve biodiversity, such as better control over fires and keeping (some of the) dead wood, which many insects, spiders, and reptiles (Mannheimer and Curtis 2018). Many bird species specifically look for insects in dead trees. The National Botanical Research Institute (NBRI) becoming part of the

Directorate of Forestry contributes to the recognition of the biodiversity component of Namibia's forests.

3.2 Timber and poles

Timber and wood from smaller-sized trees, often referred to as poles, are major woodland resources for both local and commercial users in Namibia, even though Namibia's open forests do not produce much wood. This section describes the main species harvested for wood in Namibia and their main uses.

3.2.1 Major timber species

Pterocarpus. angolensis is considered the most valuable timber species in Namibia. It is a deciduous tree, reaching a height of 10 m to 18 m in Namibia and growing in mixed stands of open forest (Figure 6). Its wood - known as kiaat, bloodwood, mulombe or mukwa - is sought after for furniture and decking because of its beautiful grain, colour, durability and good stability. It is also used for woodcrafts. The density is about 620 kg per m^3 (12% moisture content) (ITTO 2015b), similar to that of European oak. The species is only commercially interesting when the bole is large enough to obtain planks of the dark heartwood. Despite its economic importance, there are no estimations for the amount of wood, also named growing stock (Box 2), of the species on a national level (FAO, 2010a). This makes it hard to determine if the current harvest is sustainable. The mean stem diameter growth of kiaat is 5.5 mm per year in Namibia (De Cauwer 2016).

Figure 6 - Left: Kiaat (*Pterocarpus angolensis*) during the dry season near Rundu, Right: Kiaat during the rainy season near Cuangar, Angola, just north of the border with Namibia at Nkurenkuru (Photos: V. De Cauwer)

Box 2: Growing stock, the amount of wood in a forest

According to FAO, the growing stock is the "*volume over bark of all living trees more than X cm in diameter at breast height (DBH)*". This includes the stem from ground level or stump height up to a top diameter of Y cm, and may also include branches up to a minimum diameter of W cm. Each country defines their X, Y and W values. In Namibia, the growing stock is calculated with volume equations for all trees of more than 5 cm in DBH (=X) and includes all branches. The equations were established as part of the Namibia – Finland Forestry programme and are based on trees felled in four regions (De Cauwer 2015). Forest inventories from before Indepence used 10 cm for X (Geldenhuys, 1975).

Growing stock and wood volume are measured in m^3.

Tree diameter is measured at breast height, which is 1.3 m from the ground, and referred to as diameter at breast height or DBH.

Basal area (BA) is often used as a proxy for wood volume and biomass; it is the sum of the cross-sectional areas of tree stems at DBH in a stand.

Zambezi teak (*Baikiaea plurijuga)* – known as mukusi/mukusu or umgusi in the timber trade - is the second most harvested timber species in Namibia and has a reddish, harder wood with a wood density of 900 kg per m^3 (12% moisture content) (ITTO 2015b). The tree can reach a height of 20 m in Namibia, but its average height is much lower and decreases toward the south and west. For example, the tree has an average height of 12 m in the Kavango regions and 8 m in the most western parts of its distribution area, Omusati (Kanime and Laamanen 2003). Namibian Zambezi teak grows a bit slower than kiaat with a mean stem growth rate of about 3.9 mm per year (Van Holsbeeck *et al.* 2016).

The wood of false mopane (*Guibourtia coleosperma)* is known under the tradename of rosewood or local names ushivi (Namibia), musivi (Angola), and muzauli (Zambia). Its harvest is on the rise (IRDNC, 2015a) because of the high demand for Hongmu wood, a Chinese term for the timber of dense tropical hardwood species with a reddish hue. Namibia's rosewood is very similar to Zambezi teak, which has the same wood density. The local market for rosewood consists mainly of poles, for which young trees are cut (De Cauwer 2020). The tree occurs in the Zambezian Baikiaea woodlands but is not very common, representing on average 2% of the trees (Angombe *et al.* 2000). No data are available on the growth of rosewood but it can be assumed that the growth rate will be similar to Zambezi teak.

The yellow wood of the silver cluster-leaf (*Terminalia sericea)* - mugoro in Rukwangali and muhonono in Silozi - is mainly used for poles. This pioneer species is a small tree in Namibia, reaching an average height of 5 m in Omusati and Kunene (Kanime and Laamanen 2003, Directorate of Forestry 2004) and about 8 m in the Zambezi region (Kamwi and Laamanen 2002). The species tends to deploy its roots near the soil surface which enables it to compete for water and nutrients with other shallow-rooted plants, such as grasses (Hipondoka and Versfeld 2006). The mean diameter growth of silver cluster-leaf ranges from approximately 4.2 mm in Oshikoto to 8.9 mm in Kavango (Van Holsbeeck *et al.* 2016). The wood of *Terminalia* species is termite-proof (Rothauge 2014).

Mopane reaches an average tree height of 5.5 m and a maximum height of 9 m in Omusati and Kunene (Kanime and Laamanen 2003, Directorate of Forestry 2004). The dense wood provides good quality firewood and is suitable for construction, especially as it is resistant to beetles and fungi (Mannheimer and Curtis 2018), and termite-proof (Rothauge 2014). Young regeneration of mopane is often removed for fencing and constructing kraals (Directorate of Forestry 2004). Roots are sometimes used for artwork or aquaria. The mean growth rate for mopane in north-central Namibia is about 3.6 mm per year (Cunningham and Detering 2017).

The softwood of *Schinziophyton rautanenii* or mangetti is used for dug-out canoes, the main form of transport in the Okavango area, but also as fuel (De Cauwer, Knox, *et al.* 2018). The tree has a high mean stem growth rate of approximately 7.6 mm per year in Kavango (Van Holsbeeck *et al.* 2016).

Red or wild syringa (*Burkea africana*) - musheshe, or mukarati in the timber trade - is one of the most common tree species in Namibia's forests but is hardly used as timber, although it is a stable and durable wood with high density (850 kg per m^3) (12% moisture content) and resistant to termites (ITTO 2015b). This is mainly because the trees are difficult to saw and work with, requiring powerful and specialised equipment, and because the trunk of mature trees is often hollow (De Cauwer 2020). Red syringa has a mean stem growth rate of approximately 4.2 mm per year in Namibia (Van Holsbeeck *et al.* 2016)

3.2.2 Local use

Local users mainly harvest smaller trees for construction purposes, fencing, or cash. Communal farmers will build houses and fence their homesteads and kraals with poles. According to the Forest Regulations, poles are trees with DBH between 15 and 30 cm [1]. For example, people living near M'Kata CF in Otjozondjupa need an average of about 54 poles per household to construct or renovate a house and every third year a house is constructed or renovated (Otsub *et al.* 2003). Other wood uses include woodcraft and domestic tools such as axe handles, pestles and mortars, cooking sticks, and slingshots (De Cauwer, Knox, *et al.* 2018). Commercial farmers will produce fence droppers and straining posts for their own use or informal sale to other farmers (Rothauge 2014).

The most preferred timber species for local use are kiaat and Zambezi teak (0). The wood of silver cluster leaf, mopane, and false mopane are mainly used for poles. For carvings and other handicrafts, only the most suitable species for the purpose is targeted, which includes amongst others sand corkwood, Kalahari apple-leaf, red seringa, and peeling plane (*Ochna pulchra*). Carving in the northwestern forestry region is not as common as in Kavango where some CFs earn their living from carvings, such as Ncumcara and Mbeyo (Hilfiker 2011).

3.2.3 Commercial use

The commercially most important timber species of Namibia are kiaat, Zambezi teak, and false mopane, all indigenous species as there are no timber plantations in Namibia. Only the merchantable or squared logs are traded, with the remaining harvested wood being underutilised. For kiaat, which has a large portion of sapwood, this is approximately 28% of the utilisable timber wood volume (Moses 2013). Even then, the timber use-value of kiaat, estimated at ZAR 485, for a tree of harvest size, surpasses the carbon value (Moses 2013).

Untreated poles are sometimes sold by private farmers on a commercial scale. The supply and quality vary depending on the extent of bush control activities on the farm (Rothauge 2014).

3.2.4 Historical harvesting

The commercial harvest of indigenous hardwoods in Namibia dates back to the German colonial period at the end of the 19^{th} century when a lot of wood was needed for the operation of mines and the construction of railways. This is also the period that the first harvest permit systems were introduced to limit overharvesting. Based on data in Namibia's archives, the timber volume harvested

[1] Forest Regulations Annexure 3 on fees for forest produce

during the period 1959 – 1987 was on average 1,360 m^3 per year, while permits for 8,850 m^3 were granted in 1990 (De Cauwer 2020). More information on timber harvest before independence is given in the book of Erkkilä and Siiskonen (1992).

In the last decades, local and regional timber is increasingly exported via Namibia to South Africa and China. The timber comes from Angola and Zambia, and sometimes the Democratic Republic of Congo (DRC). The most-traded wood was that of kiaat, followed by Zambezi teak. The mean volume harvested for the period 2010 – 2016 was 2,138 m^3 per year (Nott *et al.* 2019). In 2018, there was a peak in the harvest of Zambezi teak and false mopane, partially illegal as no clearance certificates were obtained. The exact number of trees that were harvested in 2018 is not known, but the media reported 60,000 to 100,000 logs. Considering that a tree of harvestable size can provide approximately 0.5 m^3 timber wood, this would result in 30,000 - 50,000 m^3 wood harvested in 2018, which is considerably more than historical harvest rates (De Cauwer 2020) (Figure 7). The timber was harvested in communal areas. It is therefore surprising that in the past, many statements (e.g. Hilfiker 2011) were made about the fact that the timber harvest in the many CFs is hardly commercially justifiable.

The Karstveld is closest to the copper mine of Tsumeb for which a lot of wood, especially of Tamboti, was harvested for energy and mine props since the early 20th century. The consumption of Tamboti wood went up with the deepening of the mine, up to 13,000 m^3 per year by the 1950s (Erkkilä and Siiskonen 1992).

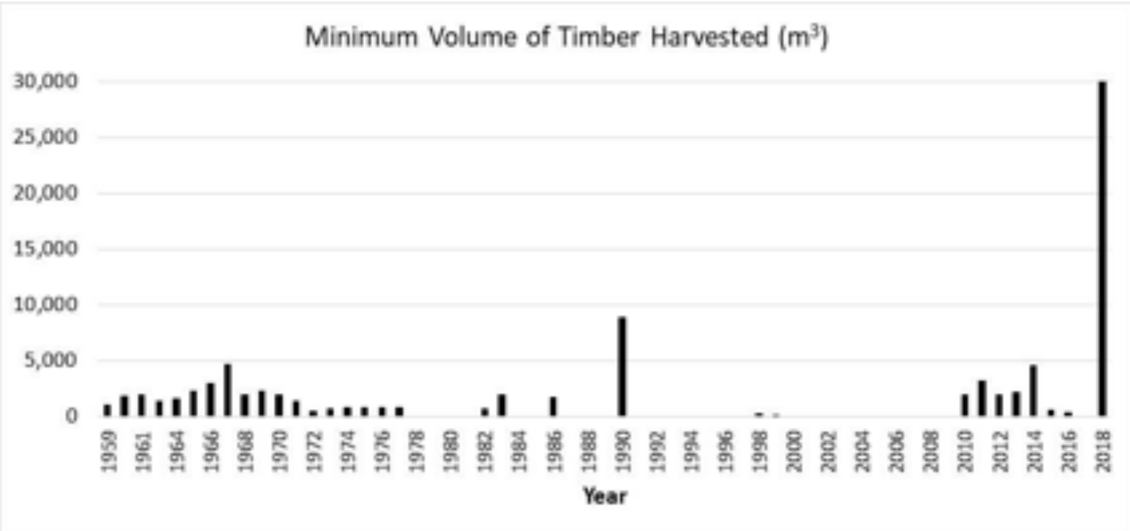

Figure 7 - Estimation of the minimum volume of wood harvested in Namibia in the past 60 years. The values represent wood volumes declared on harvest permits and are based on data from Namibia's Archives (1959 – 1977, 1982 – 1983, 1986), Hilbert (1990), Chakanga (1998 – 1999), and a study done by IRDNC for TRAFFIC (2010 – 2016). The value for 2018 is an estimate based on the number of logs reported in the media. No data are available for the other periods.

3.3 Non-timber forest products

The most important NTFP is firewood, a primary source of domestic energy, especially for cooking (Mendelsohn and el Obeid 2005). Deadwood or smaller branches are collected in the vicinity of settlements and fields. More community members collect firewood than those that harvest timber. For example, nearly two-thirds of the CF members consulted during the baseline survey in the Kavango and Zambezi regions indicated that they only harvest wood for fuel (Chapter 8). This aligns with a study in central Angola that showed that annual consumption of wood amounted to 484 kg per person, of which 78% or about 370 kg was for firewood and the remainder for house construction

(Kissanga Vicente da Silva Firmino 2016). Annual firewood consumption in M'Kata CF in Otjozondjupa amounted to about 160 kg per person (Otsub *et al.* 2003). Good fuelwood species include mopane (0) and purple-pod terminalia. Purple-pod terminalia is common in Kunene and reaches an average height of 5 m (Kanime and Laamanen 2003). The mean growth rate for purple-pod terminalia in north-central Namibia is about 3.8 mm per year (Cunningham and Detering 2017).

Charcoal production mainly occurs on commercial farms further south to combat bush thickening. However, it can also be a side product of logging agreements, such as has happened in Kwandu CF (Hilfiker 2011).

The forest also provides grazing and browsing for livestock and game, which is regulated by the Forest Act for protected forests. Browsing game includes economic important species such as impala, black rhinoceros, elephant, and kudu. Bark and leaves are browsed, with some species more preferred than others. At the end of the dry season, when there is no grass, many grazers, including cattle, will also browse.

Wild fruits and vegetables form an important source of nutrition and cash income, especially towards the end of the dry season, or during droughts when crops fail and the forest resources act as a safety net (Jones and Barnes 2009, Chidumayo and Gumbo 2010). In the Zambezian Baikaea woodlands, the fruits of false mopane or ushivi, Kalahari podberry (*Dialium englerianum*), marula, monkey orange or maguni, the dwarf jackal-berry and raisin bush are eaten fresh or used to make alcoholic beverages (De Cauwer, Knox, *et al.* 2018).

The seeds of white bauhinia and mangetti yield oils of high nutritional quality (Yeboah *et al.* 2017). The oil yields for mangetti are high (60%) and comparable to those of sunflower and peanut oils (45–55%), indicating their potential for the commercial production of cold-pressed (virgin) oil. White bauhinia oil yields are lower (19%) but comparable to those of soybean oil (17–22%) (Yeboah *et al.* 2017). The amount of unsaturated fatty acids in both species is 73–80%, comparable to good quality oils like olive oil, which has about 72% unsaturated fatty acids. The presence of α-eleostearic acid (α-ESA) was also detected in mangetti oil. Studies have shown that α-ESA is a tumour suppressing agent and can inhibit breast cancer (Tsuzuki *et al.* 2004, Grossmann *et al.* 2009), thus demonstrating the potential suitability of the oil as a health food supplement (De Cauwer, Knox, *et al.* 2018).

The fruits of several tree and shrub species of Namibia's forests and woodlands – especially marula, blue sourplum (*Ximenia americana*), baobab (*Adansonia digitata*), mangetti and mopane - produce oils that are used commercially in cosmetic applications.

The list of forest products with traditional medicinal uses is too long to add here. More information can be found in reference books such as those of Mannheimer and Curtis (2018) and von Koenen (2001). One product is harvested at a commercial level; devil's claw or wool spider (*Harpagophytum procumbens* and *H. zeyheri*), a creeping plant of which the tuber has medicinal qualities, especially against arthritic conditions (von Koenen 2001). The tuber is mainly harvested in northeastern Namibia (Hilfiker 2011), although it is also present in other parts of the country.

Honey collected from wild bees is a major source of cash income in the wetter Miombo woodlands (Shackleton and Gumbo 2010), but less so in Namibia. It appears to be one of the most promising forest products in north-eastern Namibia. Initiatives in northern Namibia seem less successful as communities do show limited ownership over apiary sites mostly installed by the Directorate of Forestry (DoF). Despite less favourable environmental conditions such as the availability of water and vegetation, the DoF continues to promote beekeeping as an agent for pollination, remedy and income opportunity for communities (Hilfiker 2011).

As long as local houses and lodges require thatching grass, this raw product will have local markets. The construction of a house needs on average 150 to 200 kg of grass (Otsub *et al.* 2003). Usually, CFs benefit in form of revenue from harvesting permits or sale (Hilfiker 2011). It is an important source of income in the Kavango regions (Domptail and Mundy 2013).

In the Mopane woodlands, mopane plays an important socio-economic role in the life of the communities as it has many uses. Next to timber, mopane provides medicines, fodder for game and domestic animals, young bark for ropes, and it is a food plant for mopane worms (Madzibane and Potgieter 1999, Mannheimer and Curtis 2018). The mopane worm (*Imbrasia belina*) is the caterpillar of a moth of the Saturniidae, which feeds primarily on the leaves of mopane. The caterpillars are dried before consumption or sale in both rural and urban centres and provide an important source of protein (61% of dry matter) (Headings and Rahnema 2002). Unfortunately, the supply of mopane worms varies from year to year, depending on rainfall.

4 Main stakeholders of Sustainable Forest Management in Namibia

4.1 Government

A large portion of Namibia's forests is vested in the state, including those in communal areas. As a consequence, a range of institutions is involved in the regulation and management of forests in communal areas (Table 2) (Jones and Barnes 2009). At the national level, the Ministry of Finances plays an important role with regard to the import and export of wood.

Table 2 – Authorities involved in regulating and managing forest resources on communal land (Adapted from Jones and Barnes, 2009).

Resource	Line ministry	Regional government	Traditional authority	Forest Management Committee
Land	MLR (control) is responsible for land-use planning; CLBs allocate titling, registration and leases	Development planning including land-use planning	Allocation of residential and grazing land, endorsement of leases and establishment of community forests	Broad management rights over community forest within gazetted boundaries
Grazing	MAWL (advisory)	/	Allocates grazing	Authority overgrazing
Forest	MEFT (control); DoF manages state forest reserves	Development planning including land-use planning	Management authority	Devolved authority

MLR = Ministry of Lands and Resettlement; CLB = Communal Land Board; MAWL = Ministry of Agriculture, Water and Land Reform; MEFT = Ministry of Environment, Forestry and Tourism; DoF = Directorate of Forestry.

The Directorate of Forestry (DoF) was established as part of the Ministry of Environment and Tourism shortly after Independence to manage and develop Namibia's forest sector (Benkenstein *et al.* 2014). By 2002, it became part of the Ministry of Agriculture, Water and Forestry. The Directorate's mandate was expanded in 2008 to include the entire country and to integrate newly established CFs into the overall programme (NACSO 2022). The National Botanical Research Institute (NBRI) was merged with the DoF at a later stage. In the year 2020, the Directorate of Forestry was incorporated within the Ministry of Environment, Forestry and Tourism. This decision allows Namibian plant resource management to be more closely integrated with the conservation of other natural resources (NACSO 2022).

The Directorate was created with two divisions for management and research, each led by a Deputy Director and supported by regional and field offices (Ministry of Agriculture, Water and Forestry 2011). The Division Forest Management is responsible for (FAO 2020):

- the development of policy and legal framework,
- protection and management of classified forests,
- promotion of community and environmental forestry,
- provision of extension services,
- maintenance of an efficient sector-wide management information system.

It has four subdivisions representing regional offices of four Forestry Regions: North-West, Central, North-East, and South. The North West Forestry Region (NWFR) is administrated through the Ongwediva Regional Forestry Office. It covers the four forestry districts that are at the same time the political regions: Oshana, Omusati, Ohangwena and Oshikoto. Each forestry district is headed by a District Forest Officer which is responsible for different forestry stations (Hilfiker 2011).

The Division Forestry Research is responsible for conducting forestry research and disseminating forestry research information (FAO 2020). It has two subdivisions; the Subdivision Research Programmes and Stations has its research headquarters in Okahandja, at the National Forestry Research Centre (NFRC) which dates back to 1902 (Erkkilä and Siiskonen 1992, Ministry of Agriculture, Water and Forestry 2011). The NFRC houses a Tree Seed Centre with cold storage facilities and a laboratory. The NFRC is headed by a Chief Forester, who also manages three field stations; Hamoye (Kavango), Kanovlei (Otjozondupa), and Ngoma (Caprivi). Both Hamoye (Figure 8) and Kanovlei are situated next to a state forest and near CFs. Hamoye Forestry Research Station runs a few species trials and some work on tree propagation methods. Kanovlei Forestry Research Station runs a long-term burning trial. Ngoma Forestry Research Station was transferred to the Directorate of Forestry in 2003 (Ministry of Agriculture, Water and Forestry 2011).

Figure 8 - View of eastern border of Hamoye state forest (Photo: V. De Cauwer)

The second subdivision is the Subdivision Forest Monitoring and Mapping, which includes the National Remote Sensing Centre (NRSC) and the National Forestry Inventory (NFI) Department (Ministry of Agriculture, Water and Forestry 2011). The NRSC was established in 1995 to provide technical services to the Directorate of Forestry in particular and other line ministries and the Namibian public in general. The NFI Department carries out forest resource assessments across Namibia (Government of Namibia n.d.).

In 2006, the Directorate had a total of 120 staff, of which 60 were technical staff, 42 forest guards and 18 had university degrees (Louw 2007). It struggles to fill all its positions with well-trained foresters. The total research budget, excluding salaries, was 7 million N$ in the 2009 – 2010 financial year. Most of this budget is for the maintenance of research facilities and the construction and purchase of capital goods. However, a detailed overview of research expenditures is hindered by the use of one cost centre for the Directorate of Forestry (Ministry of Agriculture, Water and Forestry 2011).

4.2 Communities and Community Forests

In northern Namibia, the communities are the main forest users. Traditionally, they have had relatively unhindered non-commercial use rights regarding resources such as grazing, forest products, and fish. Some areas of forest have even been illegally fenced by wealthy individuals for their use (Jones and Barnes 2009). Community rights were expanded with the introduction of CFs through the Forest Act of 2001 (5.2.4). Community forestry is a relatively new mode of participatory forest governance, giving local communities rights to manage forest resources owned by the state. It is based on the assumption that the buy-in of the community will provide an incentive to use forest resources sustainably, to conserve forests, while improving the community's living standards (Schusser 2012).

Namibia is a pioneer in community-based natural resource management, with community management of wildlife starting before Independence in 1990 (Owen-Smith 2010). Since the mid-1990s, the new Namibian government adopted a strong policy of devolving use rights over renewable natural resources to local communities. This approach was first adopted in the wildlife and tourism sectors. A national policy on use rights over wildlife in communal conservancies was approved in 1995 (Jones and Barnes 2009) and the first communal conservancies were established in 1998. Community forestry is an extension of this Community-Based Natural Resource Management (CBNRM) Programme.

The Community Forestry programme makes the involved communities important stakeholders in SFM. The programme aims at supporting and empowering local communities through transferring rights to manage forest resources and benefit from related income and employment opportunities (Government of Namibia n.d.). Local people are encouraged to take responsibility and to become actively involved in forest management. Most of the CFs overlap with a communal conservancy. However, CFs differ from conservancies in one fundamental respect: all residents within a CF are members of the forest, and have member's rights, whereas not all residents of conservancies are members (NACSO 2022).

The first 13 CFs were proclaimed in 2006 and included amongst others Okongo CF (Hilfiker 2011, Schusser 2012). In 2013, a further 19 CFs were declared. The last declarations were made in 2018 and 2019. By early 2022, Namibia had 43 registered and 27 emerging CFs. The 43 declared CFs are in ten regions spread across northern Namibia (Figure 9), covering approximately 8,730,000 ha or 10.6% of the country (Appendix 1) (NACSO 2022). This is much more than the official amount of forest in Namibia (0), however, many of the CFs have very little forest according to the FAO definition (Box 1). For example, Ongandjera CF consisted of 77% shrubland and 14% bare land in 1998 (Chakanga *et al.* 1998).

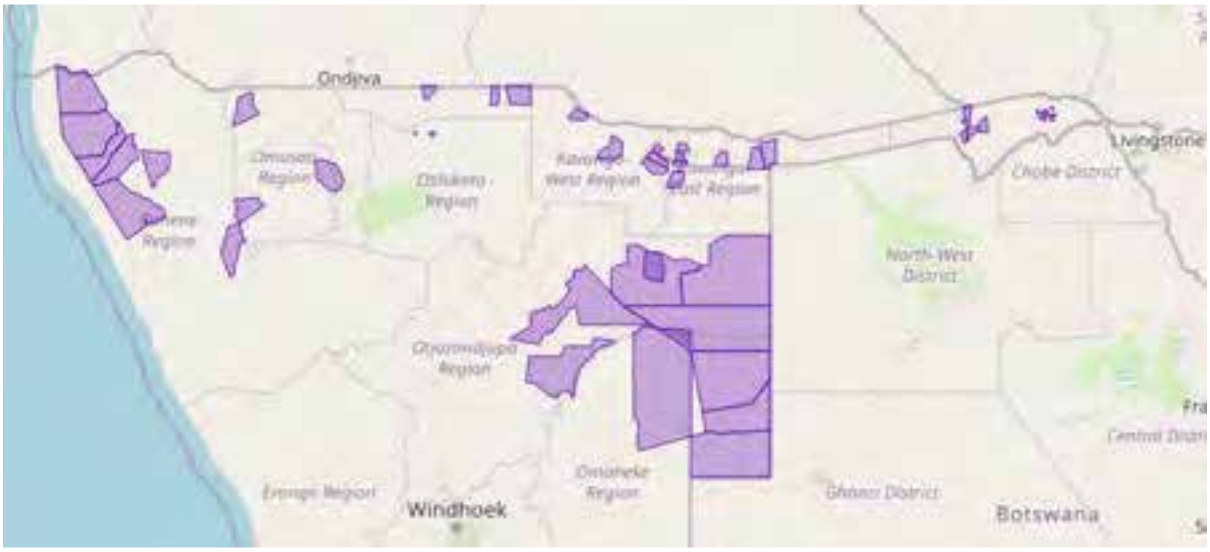

Figure 9 - Community forests of Namibia (NACSO 2022)

Significant support from the government and the donor community has helped to establish CFs, to build capacity, and to promote more sustainable harvesting practices (Hilfiker 2011, Benkenstein *et al.* 2014).

Through the involvement of the communities, the Directorate of Forestry has now better control over deforestation and illegal harvesting in large forest areas (Schusser 2012, KFW 2013). For example, illegal harvesting of all harvestable trees was discovered in Mbeyo after it became a CF. Before community forestry started in Mbeyo, the area was known as a hotspot for illegal harvesting activities, but no illegal activity was ever officially reported (Schusser 2012).

More information on the management of CFs is given in section 0.

The Forest Act (5.2.4) specifies that CFs can be established through a written agreement between the minister responsible for forestry and the representatives of those who have rights over the relevant area of communal land. This is under the provision that the consent of the chief or traditional authority is secured (Jones and Barnes 2009). The act also sets out the conditions that need to be met before an area can be declared a CF, which includes for example election of a body that is representative of the community. This can but does not have to, take the form of a Forest Management Committee (FMC).

The establishment of the first CFs did however not always run smoothly (Schusser 2012, Benkenstein *et al.* 2014). It was a learning process for both communities and the Directorate of Forestry (Hilfiker 2011), and attempts were made to facilitate the process based on the first experiences (Ministry of Agriculture, Water and Forestry 2005). In 2012, a standardised implementation process was designed by the Directorate of Forestry and a range of stakeholders that was legally correct, integrative and pragmatic. This agreed standardized process is reflected in two documents, the Community Forestry Manual and the Community Forestry Toolbox (Directorate of Forestry 2012).

The toolbox explains the necessary process to implement the official declaration or gazetting of a CF in 10 implementation steps or milestones. It also details further milestones for forest management (Directorate of Forestry 2012). The toolbox can be found on the Forestry Data Portal: https://forestry.gov.na/web/community-forestry/general-documentation.

4.3 Traditional authorities

Traditional authorities are important stakeholders in SFM as they allocate land, endorse leases and their support is needed for the establishment of CFs (Table 2). Often, they are the driving force behind the establishment of Cfs, as in the Zambezi region (Jones and Barnes 2009).

4.4 Private sector and Civil Society

There are many stakeholders in the private sector, especially companies involved in timber harvesting or forest derived products, such as carpenters, commercial farmers on forested land, and companies who want to invest in tree planting and carbon sequestration.

There are not many NGOs in Namibia and those that are most involved in SFM are the Namibia Nature Foundation (NNF), the Namibian Chamber of Environment (NCE), Integrated Rural Development and Nature Conservation (IRDNC), the Centre for Research Information and Action in Africa – Southern Africa Development and Consulting (CRIAA SA-DC), and DRFRN.

4.5 Academic sector

Specialised forestry degrees are not offered in Namibia and have to be followed abroad. From 1998 till 2008, the Ogongo campus of the University of Namibia (UNAM) offered a 3 year National Diploma in forestry. This diploma evolved from a forestry training programme that was established in 1992 at the then Ogongo Agricultural College with the assistance of the Finnish government. The aim was to produce sufficient qualified technical forestry and resource management personnel, who could for example work in forest extension. New forestry students were taken in only every third year due to the low demand in Namibia (Louw 2007). However, while the National Diploma was abolished, the need for technical and computer skills within the Directorate of Forestry remained (Chakanga and Nyambe 2003, Ministry of Agriculture, Water and Forestry 2011).

Currently, a forestry option is offered in year 4 of the Bachelor in Integrated Environmental Science (Honours) at the Ogongo campus. The Namibian University of Science and Technology (NUST) offers a course in forest management in year 4 of its Bachelor of Natural Resources Management Honours. There is no vocational training for forest technicians. The most important role of the academic sector in SFM is forest research. Academics perform almost all forest research in Namibia (see 0).

5 Legal framework of Sustainable Forest Management

5.1 International policies

There are many international policies related to tropical forests and forest management. These include the adoption, in 1993, of the Convention on Biological Diversity, the United Nations Convention to Combat Desertification, and the United Nations Framework Convention on Climate Change (UNFCCC); adoption of the Kyoto Protocol in 1996; various UNFCCC decisions (since 2007) on the development of REDD+ to mitigate climate change; and the 2007 agreement on the Non-legally Binding Instrument on All Types of Forests. There is also the development of REDD+ as part of a global climate change mitigation agenda and the increasing recognition of forests in the climate change adaptation agenda. The role of tropical forests in climate-change mitigation and adaptation has raised their visibility to the highest political level (ITTO 2015a).

The Convention on Biological Diversity (CBD) has three main goals: biodiversity conservation, sustainable use, and sharing of benefits generated by genetic resources. The latter is relevant for the CFs as it addresses the concept “Access and Benefit Sharing” (ABS) of biodiversity. The Nagoya Protocol of 2010 further stipulates that Prior Informed Consent (PIC) is required where communities have the right to grant access to valuable plant resources. This is relevant for extracted forest products such as marula, blue sourplum and mopane (Hilfiker 2011). However, only trivial products have been developed and marketed since the ratification of the CBD, while the USA, the base of most pharmaceutical multinationals, has not ratified it. Hence, the complex protocols to prevent biopiracy can be considered as an expensive and ineffective exercise to prevent a non-existent problem (Huntley 2017). Moreover, the political correct intent of the protocol, written by bureaucrats and lawyers with no tropical fieldwork experience, has unintended consequences for biodiversity research. It has put an almost complete halt to research collaboration in many developing countries (Huntley 2017).

Within the Southern African region, the SADC Protocol on Forestry (2002) is the overarching policy framework for future forestry collaboration among the Member States. The Protocol upholds the principles of SFM. Article 4 states amongst others that the Member States recognise their responsibility to protect, manage and where necessary, restore degraded forest ecosystems, and use the precautionary principle in the protection and management of forests, where there is insufficient scientific information (Ministry of Agriculture, Water and Forestry 2011).

5.2 The legal framework in Namibia

Forest policy and legislation are relatively recent in Namibia, while it is only since 1996 that the government has given attention to forestry as a sector in its own right (Jones and Barnes 2009). This section gives an overview of the key policies and strategies.

5.2.1 Constitution

Article 95 (l) of the Constitution states that Namibia shall actively promote and maintain the welfare of the people, by adopting policies, which include: “… the maintenance of ecosystems … and utilisation of living natural resources on a sustainable basis for the benefit of all the Namibians, both present and future” (Ministry of Agriculture, Water and Forestry 2005).

5.2.2 Forest Policies of 1992 and 2001

Shortly after the Independence of Namibia, a forest policy was promulgated in 1992 (Benkenstein et al. 2014). It identifies several instruments that are needed for its successful implementation. These include the development of a supportive regulatory framework, the strengthening of extension services, and the promotion of forest management, including community forestry, supporting forest research, education and training (Ministry of Agriculture, Water and Forestry 2005). Two of the strategic objectives directly refer to the importance of forest research and underline the need to provide information for management and to provide baseline data on forest resources (Ministry of Agriculture, Water and Forestry 2011). A new Forest Development Policy was formulated in 2001.

5.2.3 Forestry Strategic Plans of 1996 and 2008

The 10-year Forestry Strategic Plan of 1996 was the main instrument for implementing the Forest Policy of 1992 (Ministry of Agriculture, Water and Forestry 2005). Its guiding themes were production, protection and participation. There were four main areas of implementation, namely Capacity Building, Environmental Forestry, Community Level Management of Natural Forests, and Farm Forestry, of which the first three areas were significantly funded by Finland, Germany and other donors (Ministry of Agriculture, Water and Forestry 2011). The Plan laid the basis for greater involvement by local communities in forestry governance, particularly through the establishment of CFs (Benkenstein *et al.* 2014). The Plan also clearly articulated the importance of forest ecosystems in biodiversity conservation, carbon sequestration and as reservoirs of plant-based products with known and potential values (Ministry of Agriculture, Water and Forestry 2011). The Strategic Plan ultimately culminated in Namibia's Forest Act (Ministry of Agriculture, Water and Forestry 2005).

In 2008, a new strategic focus for forestry was developed as part of the overall Strategic Plan for the Ministry of Agriculture, Water and Forestry. This Forestry Strategic Plan was for five years (2008–2012) and had seven focal areas, including Sustainable Natural Resources Management (Ministry of Agriculture, Water and Forestry 2011).

5.2.4 Forest Act and Regulations

The forest sector of Namibia, including all bush harvesting, is governed by the Forest Act of 2001 and the much later published Regulations of the Forest Act (2015). The Forest Act provides for the establishment of classified forests - state and regional forest reserves and CFs - which all require management plans. No harvesting is allowed in a classified forest unless it is authorised by a management plan or harvest license. The Act also allows for the declaration of fire and forest management areas.

While 43 CFs have been established since 2006, no state or regional forests have been declared. There are three recognised "state forests", Hamoye, Kanovlei and Caprivi (Chakanga *et al.* 1999, Muhoko and Kamwi 2014), however, they were never officially declared. Currently, the proclamation of the state forests is being pursued by NILALEG (Namibia Integrated Landscape Approach for Enhancing Livelihoods and Environmental Governance to Eradicate Poverty), a project funded by GEF – UNDP with as the main project partner of the Ministry of Environment Forestry and Tourism (https://nilaleg.eif.org.na/).

The Forest Act specifies that legal occupiers of land, including communal land, can harvest forest produce without a license. However, it also states that no one can clear more than 15 ha of wooded land or cut more than 500 m^3 of forest produce from any piece of land in one year without the approval of the Directorate of Forestry, which is regulated through harvesting permits. The Forest Regulations specify the permits needed for harvesting trees and transporting, importing, exporting and marketing wood. Permits and suspension of permits can only be done by forest or licensing officers appointed by the minister. However, it appears that the appointing of such officers has been problematic in the past, resulting in too few officers that can legally intervene (Axel Rothauge, pers. comm.).

The Forest Act Regulations provide an updated list of protected plant species. These include tree species often harvested for fuel, such as mopane and camelthorn, and timber species such as Zambezi teak and kiaat. The Regulations do however not provide information on the "conditions under which that protected plant shall be conserved, cultivated, used or destroyed by any person", as indicated in the Forest Act.

The Forest Act is in the process of being reviewed since 2020.

5.2.5 Environmental Management Act

Forestry activities that require authorisation under the Forest Act may require an Environmental Clearance Certificate in areas greater than 150 ha per annum under the Environmental Management Act. The Environmental Management Act of 2007 and its 2012 Regulations are administered by the Environmental Commissioner in the Department of Environmental Affairs (DEA). For bush harvesting, the application process has been simplified to reduce costs and time delays. All wood harvesting activities in areas less than 150 ha per year require only a Harvesting Permit from the Directorate of Forestry. However, bush harvesting in areas larger than 150 ha requires an Environmental Clearance Certificate (Rothauge 2017).

In 2018, the media reported that large numbers of timber trees were harvested in north-eastern Namibia. This resulted in a harvest ban in November 2018 and a temporary transport ban until March 2019. The basis of the ban was non-adherence to Environmental Management Act regulations. Although 161 harvest permits had been issued by the Directorate of Forestry for the leasehold farms in Kavango East, the harvest was declared illegal as no environmental clearance certificates (ECCs) had been issued (De Cauwer 2020).

5.2.6 Forest Research Strategy for Namibia (2011 – 2015)

The first Forest Research Strategy developed for Namibia aims to address the issues that are relevant to SFM from a research perspective. It is an acknowledgement that research and technological development are essential tools to address problems and challenges hindering SFM. The strategy focuses on the key drivers of deforestation and forest degradation, and core SFM issues such as natural and artificial regeneration of commercially exploited species (Ministry of Agriculture, Water and Forestry 2011).

The strategy suggests a priority list of research topics:

1. Understanding the drivers of deforestation and forest degradation – Justification for a monitoring programme
2. Growth and yield of forest resources
3. Developing or applying technologies to improve natural and artificial regeneration
4. Forest products (value-added) research
5. Economic and social aspects of SFM, including issues of governance
6. Management of data and information

An implementation strategy is advised to achieve this research programme portfolio:

1. Redefining roles within forest research and management divisions
2. Forging strategic partnerships with other institutions
3. Managing the research process – identification; proposal writing; execution; analysis of data; peer review; publication
4. Developing programme performance indicators
5. Supporting forest researchers
6. Introducing a Performance Management System

7. Implementing a Monitoring and Evaluation System
8. Fund-raising for research and development
9. Acknowledging the personnel implications of the research strategy.

The strategy document stresses that the Directorate of Forestry develops and facilitates partnerships and also provides the necessary support to the research processes, considering the personnel constraints of the Division of Forest Research in 2011. It advises that the Directorate of Forestry and particularly the Division of Forest Research should pursue its personnel recruitment targets so that most of its established posts are filled in line with the strategy (Ministry of Agriculture, Water and Forestry 2011). However, 10 years later, the personnel situation has not improved but rather deteriorated.

6 Sustainable Forest Management in Namibia

6.1 Introduction

SFM aims to balance the various uses of forests while ensuring their ecological functioning and the provision of benefits and functions into the future (ITTO 2015a). The International Tropical Timber Organization (ITTO) developed a set of criteria and indicators that can be used to guide forest management and assess its sustainability. The seven criteria constitute the basis for the assessment of SFM (ITTO, 2015):

1) Enabling conditions for SFM
2) Extent and condition of forests
3) Forest ecosystem health
4) Forest production
5) Biodiversity
6) Soil and water protection
7) Economic, social and cultural aspects.

For the first criterium, one of the main enabling conditions for SFM is a good legal framework, which was discussed in the previous chapter. Another important enabling condition is a large pool of well-trained forest technicians, managers and researchers. This is lacking in Namibia, as was discussed under Chapter 4 (main stakeholders). This chapter explains tools that allow assessing most of the other criteria needed for SFM and how they are applied in Namibia, especially forest monitoring, forest management, silviculture and research.

6.2 Forest monitoring

Forest monitoring aims to obtain comprehensive information on forest resources needed to manage forest ecosystems sustainably. Hence, it especially addresses criteria 2 to 5 for the assessment of SFM. Information that needs to be collected can be quantitative data, including the extent of the forest area and the amount of timber, and qualitative, such as tree health and damage. Assessing forest extent is done with remote sensing data (see 0).

6.2.1 Forest inventories

The main tools of forest monitoring are forest inventories, which need to be repeated regularly because forest disturbances (0) constantly affect forest resources and can cause forest degradation (0). A common interval between intervals is 5 or 10 years, as in the FAO reporting (Box 1). The focus of a forest inventory is assessing wood biomass, especially timber and the carbon pool, but also forest health and ecosystem functioning (Köhl *et al.* 2006). The principle of an inventory mirrors the annual game counts carried out in communal conservancy areas; the counts are analysed before quotas are set for the sustainable use of game (NACSO 2022). However, instead of counting, forest inventories are based on tree measurements in sample plots that represent the total forest area.

The intensity of an inventory varies according to the scale and purpose. At a national and regional level, they provide strategic information for policy and decision-makers, such as forest extent and composition, the size of the carbon pool, and potential uses of forest resources. At the local level, for example for a state forest or CF, inventories provide detailed information for the planning of forest management operations at the stand level (Geldenhuys 1991, Selanniemi *et al.* 2000). A forest stand is a community of trees sufficiently uniform in composition, structure, site quality, or location to distinguish it from adjacent communities (Nyland 2016).

Almost all forest inventories will collect data on tree species and the stem diameters within the sample plots. Tree height, damage and timber quality are also important measurements, especially for local inventories. At the plot level, information on the site needs to be collected, such as the exact location, topography and vegetation cover. Canopy cover is an important parameter affecting the forest micro-climate (see also 0).

Forest inventories are upscaled to the total forest area by extrapolation of the plot data, and often with the assistance of remote sensing data (0). The forest inventory results feed into forest management, especially planning of harvest or silvicultural measures, and thus the management plan. As there are many forest disturbances, forest inventories need to be repeated over regular intervals of time.

6.2.2 Forest inventories in Namibia

The Directorate of Forestry recognises that "*the protection, management and use of forest ecosystems to provide commercial products and also vital ecosystem services require a comprehensive monitoring, reporting and verification system of the forest resources"* (Ministry of Agriculture, Water and Forestry 2011, p. 4). However, no comprehensive national forest monitoring has been done for Namibia yet. The total forest extent is not known, nor are national deforestation rates (see 0). The need for repeated forest inventories is not recognised in Namibia. This is the case for the whole southern African region, where none of the countries has a repeated national forest monitoring system in place (Morales-Hidalgo 2015).

Regional forest inventories in Namibia are incomplete, outdated, and were never repeated (see 0). Monitoring at a local level is much better with the forest inventories for the CFs.

The inventory of Namibia's woodlands started during colonial times, in 1975 (Geldenhuys 1975, 1976). In 1995, the Directorate of Forestry in cooperation with the Finnish International Development Agency (FINNIDA) started a National Forest Inventory (NFI) as part of the Namibia-Finland Forestry Programme (NFFP) to produce regional inventories for northern Namibia (Kamwi and Kätsch 2009). Four regions were covered by the regional forest inventory: Oshikoto, Zambezi (then Caprivi), Omusati and Oshana (De Cauwer 2015, FAO 2020). Of these four regions, Omusati and Oshana had almost no forest cover (Selanniemi *et al.* 2000, FAO 2005). Forest inventory data were also collected for the eastern part of the Otjozondjupa Region (Korhonen *et al.* 1997a, 1997b). The regions with the largest amount of forest cover (Kavango East and West), as well as four other regions with potential forest cover were not included in the national forest inventory (Figure 2).

Since 2000, there has been a shift from regional to local-level forest inventories (Kamwi and Kätsch 2009). The German Development Service, through the Community Forestry in Namibia project, assisted with the inventories of the first CFs. They developed a forest inventory technique and assisted with the implementation and funding of ten Participatory Natural Resource Assessments (Schusser 2012), whereby community members themselves conduct the inventory. Nowadays, the National Forestry Inventory Department provides technical guidance, analyses the data and compiles inventory reports (NACSO 2022). Currently, forest inventories have been carried out for all the registered CFs (Appendix 1), and some of the state forests, but these data do not represent larger areas of the country (FAO 2020).

The WWF also coordinates annual vegetation surveys with the communities in selected conservancy and CF areas, which are collated into the Namibian CONINFO database and can assist with the management of NTFPs (NACSO 2022). Forest inventories have also been performed by the research community, targeting specific research problems (see 0).

Box 3: Forest inventory method in Namibia

The national inventory system uses a systematic sample design; plots are placed at equal distances. For the regional inventories, a stratified systematic sample design was used with the density and structure of the woody vegetation used as criteria for the stratification.

Plots consist of three nested circles in which all woody species with a diameter at breast height (DBH) exceeding 5 cm are tallied. Trees with DBH > 45 cm are measured within a circle with 30 m radius. Trees with DBH > 20 cm are measured with a circle with 20 m radius, and all woody vegetation with DBH > 5 cm are measured in the circle with 10 m radius. In two subplots with radius 5 m all woody vegetation with DBH < 5 cm is tallied (Directorate of Forestry 1997).

6.2.3 *Allometric models for Namibia's trees*

The tree measurements of forest inventories allow determining the amount of wood (Box 2), biomass or sequestered carbon of the plots or stands sampled with the assistance of allometric models (Figure 10). Allometric models are formulas that calculate wood volume or biomass with for example tree diameter and height. Accurate models are required to provide reliable estimates of growing stock and carbon sequestration and model choice can lead to large differences in such estimates. Often, models are developed for a specific tree species or a specific site as they explain most differences in tree height-diameter relationships. However, site-specific models are labour intensive and expensive to develop for trees of natural tropical forests and woodlands, especially with destructive methods. Moreover, there is little quality control of the models developed, and often they are developed with too few sample trees and for relatively small study areas (De Cauwer *et al.* 2020). Henry et al. (2011) showed that at least 22% of the allometric equations reported for Sub-Saharan African forests resulted in inaccurate estimations of biomass or volume.

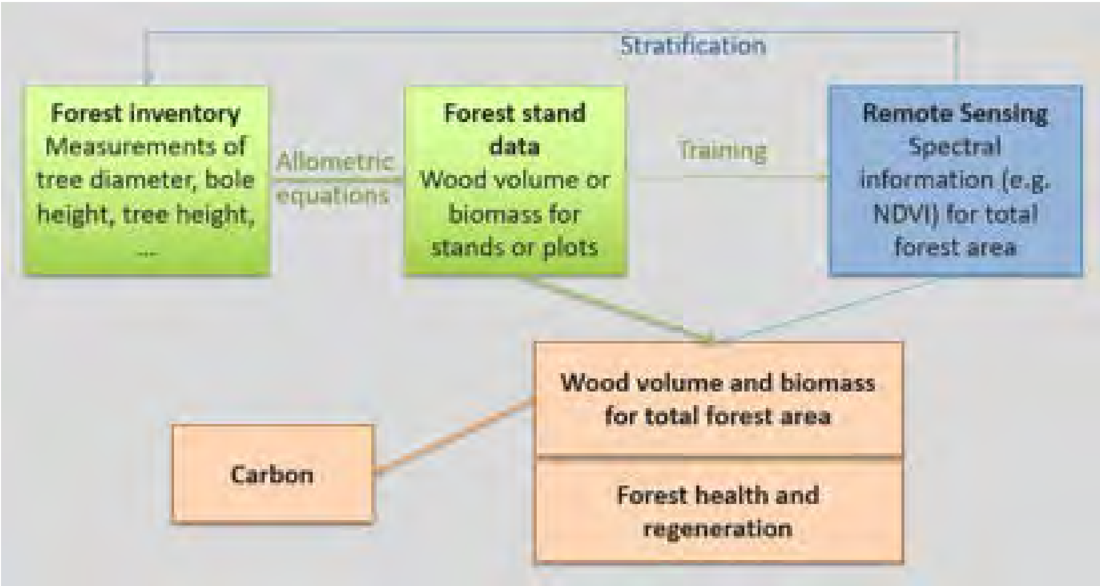

Figure 10 - The use of forest inventories and remote sensing data to determine wood volume, biomass and regeneration in a forest

A set of allometric models have been developed to calculate the total wood volume and above-ground biomass for the main timber trees of Namibia through the NFFP, and through university research (Verlinden and Laamanen 2006, Moses 2013, Nott 2018, De Cauwer *et al.* 2020). For kiaat, the best performing model to estimate the total wood volume was that of De Cauwer *et al*. (2020) with 22% relative error, followed by the NFFP model with 30% relative error (De Cauwer *et al.* 2020). Ideally, quality control should be performed for all other NFFP models.

For some of the other trees, equations of neighbouring countries can be used (Tietema 1993, Abbot *et al.* 1997, Hofstad 2005, Smit 2014). A generic volume model developed for Tanzania (Mauya *et al.* 2014) and a generic biomass model developed for Zambia (Ngoma *et al.* 2018) also appear to work well for some of Namibia's tree species (De Cauwer *et al.* 2020). However, the pantropical models for aboveground biomass of Chave *et al.* (2014) can perform as well as many local and regional models if accurate height and wood density data are used. The models have the advantage that they are calibrated with a large number of sample trees. Hence, the collection of more accurate height and wood density data in Namibia, rather than the development of new models is advised (De Cauwer *et al.* 2020).

6.2.4 Use of remote sensing

An important prerequisite for regional and national forest monitoring is the availability of a consistent remote sensing database (De Cauwer, Knox, *et al.* 2018). Remote sensing data allow preparing efficient forest inventories, especially by creating strata for a stratified sampling design. Strata represent forest areas with similar properties, for example, a vegetation type or forest cover. Afterwards, remote sensing data assist in upscaling the forest inventory data to the total forest area monitored. Hence, most university curricula for foresters will include GIS and remote sensing courses.

Before the seventies, aerial photos were the only type of remote sensing data available. Over the last decades, a wide range of remote sensing data has become freely available that can be used for forest monitoring, especially medium to high-resolution optical (passive) satellite data, such as those of LANDSAT, Quickbird, and Sentinel. Examples of forest studies in Namibia using such imagery include the detection of land cover change including forest (Erkkilä and Löfman 1999, Wingate *et al.* 2016), and the modelling of forest cover, stand density, biomass and/or stand volume (Verlinden and Laamanen 2006, Kamwi and Kätsch 2009).

However, forest cover estimated with traditional optical remote sensing methods tends to underestimate the surface covered by dry tropical forests (Naidoo *et al.* 2016, Bastin *et al.* 2017). The open and deciduous forest canopy cover makes it difficult to distinguish shrubs from trees with optical satellite data, which is further complicated by fires and very variable annual rainfall resulting in non-consistent NDVI time series for Namibia. Other promising methods have been explored such as object-based classification (Muhoko *et al.* 2020), phenology and biodiversity descriptors derived from long-term MODIS or AVHRR time series (Revermann *et al.* 2016, Thompson 2021), or by using radar and LiDAR as for the BIS (Mathieu *et al.* 2018). Synthetic Aperture Radar (SAR) penetrates vegetation canopies to varying degrees, allowing a better accuracy and measurement of physical attributes such as biomass or canopy height (Figure 11).

Lately, unmanned aerial vehicles (UAVs), or drones, have been introduced in forest monitoring, also in Namibia (Knox *et al.* 2018, Strohbach 2018).

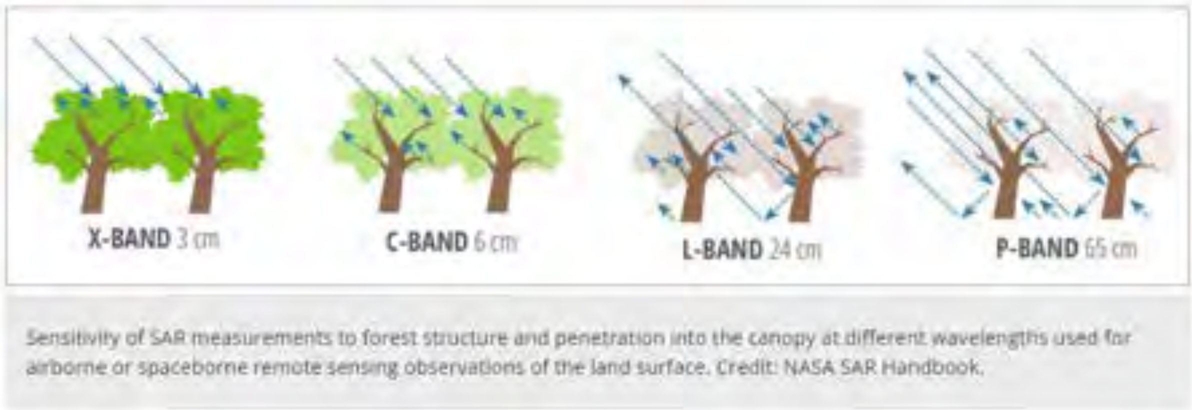

Figure 11 – Sensitivity of SAR measurements to forest structure at different wavelengths (Flores-Anderson *et al.* 2019)

6.2.5 Permanent sample plots

The most common method to monitor and understand tree population dynamics and ecosystem functioning is through the establishment of permanent sample plots (PSPs) (Picard *et al.* 2010, SEOSAW partnership 2021). PSPs are large sample plots, often 1 ha or more, that are repeatedly measured over a long period. Early warning signs of climate change (see 0) can be detected by forest researchers that monitor tree regeneration and mortality in PSPs.

Tree population dynamics are mainly described by determining tree diameter distribution, diameter growth, regeneration, and mortality, as well as the variables that influence them such as competition, soil, and climate (Namaalwa *et al.* 2007, Seifert *et al.* 2014). Additionally, it is necessary to monitor tree health and damage to get an insight into the potential drivers of mortality. As a consequence, a range of plot and tree variables needs to be collected in PSPs, and they require a lot of manpower and time to establish and measure.

There are few PSPs in Namibia where quantitative measurements are done. NUST established three plots in 2006 covering a total of 2.5 ha. Two plots are situated at the forestry research station of Hamoye (Kavango East), one within a fenced area and one outside, and a third plot is at the research station of Kanovlei (Otjzondjupa region) (De Cauwer 2006). The first complete remeasurements started in 2021 (Figure 12). The sample plots used for the regional inventories and the inventory of Okongo CF were regarded as PSPs and marked in the field with aluminium poles (Angombe *et al.* 2000, Selanniemi *et al.* 2000). To the authors' knowledge, the plots have not been revisited and many of the poles may have been lost by now. The oldest PSPs known in Namibia were established before Independence as part of fire trials of which no results were published since the study of Geldenhuys (1977). The establishment of 20 PSPs for Namibia's woodlands is planned for 2023 as part of the SECO[2] project (https://blogs.ed.ac.uk/seco-project/).

Since 2001, there are also biodiversity observatories established in Namibia for the BIOTA Southern Africa project, as part of a series of observatories extending from the Cape Peninsula in South Africa to the Kavango Regions. The observatories are 1 km^2 in size and aim for the long-term monitoring of vegetation. Some of these observatories are situated within the forest, for example, the Mile 46 observatory at the Livestock Development Centre (LDC) in the Kavango West Region (Strohbach and Petersen 2007). The vegetation surveys do however not collect the quantitative measurements needed for forest management.

[2] SECO is no acronym, but means "dry" in Spanish.

Figure 12 - Left: Tagging of trees at approximately 1.5 m tree height. Right: Assessing the cause of tree mortality (Photos: V. De Cauwer)

6.2.6 Tree growth and dendrochronology

Next to the long-term monitoring of tree diameter in PSPs (see 0), tree growth can also be determined by tree ring analysis or dendrochronology. This is possible if trees have annual tree rings, as is the case in climates where there is a seasonal growth interruption because of cold temperatures or a lack of rainfall. Although many tropical trees do not have annual growth rings, trees in areas with a distinct dry and wet season do, as in Namibia. This was proven through radiocarbon dating for several Namibian hardwood species (Worbes n.d.) and with cambial wounding for kiaat (De Cauwer *et al.* 2017).

Tree ring analysis allowed determining that the mean stem diameter growth of kiaat is 5.5 mm per year in northern Namibia and southern Angola. This is relatively high compared to the growth of the species in other parts of southern Africa (De Cauwer 2016). Taking into account that kiaat seedlings go through a long dying off – resprouting phase (Kayofa 2015), it takes about 80 years to reach a stem DBH of 40 cm (De Cauwer 2016).

Most trees do not grow constantly; they grow slower as they get older. Hence tree-ring chronologies get detrended to compare growth between different sites and for a better comparison with climate data (Worbes 2002). The growth of Kiaat appears however almost constant up to a DBH of 60 cm, a tree size that is now becoming difficult to find (De Cauwer 2016). We do not know what the maximum age is of a mature kiaat tree, except that it is at least 150 years (Fichtler *et al.* 2004, Worbes n.d.).

Tree ring analysis has shown that the Namibian Zambezi teak has a mean stem growth rate of 0.39 cm per year, similar to red syringa (Van Holsbeeck *et al.* 2016). This means that Zambezi Teak is approximately 100 years old when it reaches the minimum harvestable DBH of 40 cm (De Cauwer 2020).

6.3 Forest management

At Independence, the dry woodlands were not under any systematic forest management, other than the exploitation of kiaat, Zambezi teak, and false mopane. A renewed focus on forest management came after Namibia's Independence when a devoted Directorate was created. This was soon followed by new forest policies and plans (Ministry of Agriculture, Water and Forestry 2011), as elaborated in Chapter 5. Since 2006, attempts have been made to introduce SFM in the CFs based on forest management plans. However, while policies and CF declarations support SFM, the actual forest management and control of forest operations have been neglected over the last decade, both at a national level and on the ground.

6.3.1 Forest management plans in Namibia

Forest management plans are a requirement for all protected forests in Namibia and aim to support SFM. According to the Forest Act and Regulations, the forest management plans are "an agreement between the Minister and a management body which contains all operational work and administration" of a protected forest. The management plan needs to state the management objectives, and include a description of the area covered by the classified forest and the forest resources it contains. Subject to the management plan, the Director of Forestry determines the maximum quantity of forest produce which may be harvested in the protected forest; the "allowable harvest". The allowable harvests should be guided by the principles of SFM; not to deplete, but to maintain and improve the resource base (NACSO 2022).

However, there are no detailed guidelines on what information the management plan should give so that the maximum allowable harvest can be determined by Directorate of Forestry, nor do the Forest Act and Regulations indicate the minimum and maximum period the management plan should cover. Management plans should be revised after each repeated forest inventory (see 0) as sustainable yield will have changed.

6.3.2 Sustainable timber harvest

Many consider timber harvest the same as deforestation. This is not correct when SFM practices are used. Sustainable timber harvest aims to harvest a specific number of trees of specific sizes in a forest stand so that those trees can easily be replaced by regeneration and the growth of smaller trees before the next harvest (De Cauwer 2020). This should ensure a constant supply of wood resources with future timber yields unaffected or improved. The amount that can be sustainably harvested over a period is referred to as sustainable yield, total allowable offtake (TAO), allowable cut, or allowable harvest. To determine the sustainable yield, it is necessary to know the amount of timber available (see 0), the growth rate of timber trees (see 0), the tree regeneration (see 0) and the tree mortality caused by disturbances (De Cauwer 2020). Unfortunately, little is known about the sustainable harvest rates, tree mortality and tree regeneration in Namibia (Graz and von Gadow 2005).

There are several ways to regulate sustainable timber yield for natural forests. The easiest way is to remove trees of a minimum stem diameter; the minimum harvestable diameter. This method is often used in Namibia; a DBH of 40 cm is the minimum harvestable diameter of timber trees according to the harvesting licence conditions of the Forest Regulations[3]. The minimum harvestable diameter method assumes that sparing medium and small diameter tree classes will ensure a sufficient supply of timber in the future. This method is only cost-efficient if there are enough trees that have the minimum harvestable diameter (Lamprecht 1989). Moreover, it will only be sustainable if the

[3] Although the "Fees for Forest produce" in annexure 3 of the Forest Regulations indicate a DBH of 45 cm.

minimum harvestable diameter is large enough, if tree mortality is low in all diameter classes, and if there is good regeneration.

Another method is to determine harvest rates for diameter classes. This method is often used in Namibia for what is called "poles", trees with DBH between 15 cm and 30 cm. Ideally, sustainable timber yield should be based for tree populations (Graz and von Gadow 2005).

As stated by the Directorate of Forestry (Ministry of Agriculture, Water and Forestry 2011), "with no tradition for active stand management, Namibia's woodlands have suffered what is typically described as the "tragedy of the commons". Essentially common ownership and unregulated access without proper recognised rights of local people, has inadvertently fuelled a tendency to "mine out" available merchantable timber with no due regard or responsibility regarding regeneration for future harvesting products."

6.3.3 Community forest management

Although CF members can use wood and non-wood products for subsistence and commercial purposes, this is subject to the applicable management plan. Ideally, the management plan should indicate sustainable yields for all the natural resources that are harvested. In practice, harvest levels for the first CFs were set through block permits issued by the Directorate of Forestry. The block permit is an official document that allows the communities to harvest certain timber species. It was introduced because forest inventory and management plans were not finalised by the time of gazettement and to obtain community support for the CFs. Communities started to ask for new block permits when the old ones expired. However, neither the Forest Act nor the Community Forest Guidelines of 2005 describe this system (Schusser 2012).

Management plans are valid for a certain duration of time; the length of this period is not indicated in the Forest Act, but appears 5 to 10 years (NACSO 2022). Many CF management plans are currently outdated and not applicable anymore, as required by the Forest Act. When no management plan is applicable, persons who reside in a CF can harvest forest produce for household uses and do not have to follow a management plan.

The quality of forest management plans is a major concern. FMC and Directorate of Forestry staff members concede that in many cases forest management plans are either absent or incomplete (Benkenstein *et al.* 2014). Their format varies greatly and often the forest inventory report is used as a management plan. Estimates of allowable TAO are either not specified or if indicated, it is not clear whether standardized processes have been used to calculate the allowable harvest levels of timber (Nott *et al.* 2019).

The use of permits ensures that much of the decision-making on the use of forestry resources remains with the Directorate of Forestry rather than the relevant FMC. For example, commercial harvesters who have been issued a permit by FMCs to harvest in CFs are still required to secure transport and marketing permits from the Directorate of Forestry (Benkenstein *et al.* 2014).

Many NTFPs (see 0), including grazing, have an economic and local subsistence value and also need to be included in the inventory and management plan to allow sustainable utilisation. For example, the FMC can issue forest-use permits for grazing (Benkenstein *et al.* 2014, FAO 2020) however overgrazing should be avoided to avoid land degradation and bush encroachment. With the commercialisation of products such as marula and sour plum oils, data on the growth and yield of socio-economic important shrubs and trees could help in resource management plans and yield predictions (Ministry of Agriculture, Water and Forestry 2011).

CFs still face many challenges. Overlapping mandates in the management or use of forest areas can result in conflicting land uses. For example, land within CFs has in the past been allocated for small-scale commercial livestock farming, promoted by the Ministry of Lands and Resettlement, or crop growing with the permission of the traditional authorities (Jones and Barnes 2009).

Another problem is that most FMCs lack the incentives and technical skills to develop or implement forest management plans or to meet elementary requirements on reporting, accounting and forest monitoring, and they need external support (Ministry of Agriculture, Water and Forestry 2011, KFW 2013, Benkenstein *et al.* 2014). Moreover, the CF area to be managed is often so large that there are insufficient resources for monitoring, even for well-organised forestry committees. The Directorate of Forestry is understaffed and hardly in a position to offer effective support to the FMCs (KFW 2013). Self-financing of the FMC's out of CF revenues often seems not possible, especially small CFs do not provide an adequate economic basis (KFW 2013).

The CFs appear often to have become a tool for harvesting more trees, rather than harvesting sustainably and protecting the forest resources, the capital. Stronger partnerships between community forests and conservancies appear to be one way in which their viability may be enhanced (Benkenstein *et al.* 2014).

6.3.4 Monitoring of harvest

The Forest Act states that no one can clear more than 15 ha of wooded land or cut more than 500 m^3 of forest produce from any piece of land in one year without the approval of the Directorate of Forestry. It also states that no forest produce can be harvested in protected forests unless authorised by the management plan or a licence if not for household use. The Directorate of Forestry uses permits as tools to control tree harvesting and transport. After the Forest Regulations of 2015 were published, new permit books were printed in 2016 and issued to the regional offices. The system is however lacking a system for report-back on the permits issued. There is also a need for all permit data to be collated and summarised in a format that can be easily shared and used to inform management decisions (Nott *et al.* 2019).

The harvesting licenses indicate several conditions to ensure SFM, such as, where two or more stems grow from the ground, no more than half of the stems may be felled. Harvested timber logs must be marked by a forest officer, using a special hammer, before they are transported from the place of harvesting.

According to minister Shifeta, monitoring of harvest and enforcement on the ground has been minimal due to limited manpower at the Directorate of Forestry and because timber operations are often undertaken at night time. Controlling transport is difficult to implement due to the high volumes of trucks and timber and the variety of routes taken. Trucks should be weighed at the weighbridges, while timber harvesting needs to be restricted and carried out during the day (Shinovene 2019).

Fines for not following regulations are however not a deterrent; they can not exceed N$ 5000 and there is no discrimination based on the size of the tree harvested (Mannheimer and Curtis 2018). For the financial year 2017/2018, the Directorate of Forestry reported that 22 fines were issued to those that contravened the laws and regulations. Many forest products were confiscated, especially 39,575 tonnes of charcoal, 11,945 tonnes of firewood, 91,229 droppers, 22,895 poles, 175 tonnes of mopane roots, and 469 wood carvings (Ministry of Environment and Tourism 2018).

6.3.5 Certification

Forest certification is a tool to promote SFM. The certificate lets buyers of forest produce know that the product was produced in a socially beneficial, economically viable and environmentally responsible way. Certification of forest produce and conditions of production and harvesting is done voluntarily by companies in Namibia. The Forest Act Regulations indicate that any company accredited by the Forest Stewardship Council (FSC) may certify a forest produce to be traded within or outside Namibia. Most of the certifier assessments are done by South African experts.

The FSC certification is mainly used by the charcoal industry and is demand-driven; 1.6 million ha of Namibian wood- and shrublands were under FSC certification by June 2020. Namibia is the first country in Africa that has obtained an FSC group chain of custody certificate. The FSC group certificate holders have also included NTFPs, such as venison, into their scope of forest management certification (FSC 2020). FSC labelling is not done yet for timber and poles.

6.3.6 Fire control

Fire management of protected forests is a responsibility of the Directorate of Forestry, although this is often shared with regional governments and communal forest managers. Fire management includes both fire prevention and firefighting. Fire prevention is mainly done by reducing the fuel load through the establishment of fire breaks or, sometimes, the application of early burning. Fire breaks are referred to as fire cutlines in the Forest Regulations and they should have a minimum width of 15 m. Although the Directorate of Forestry rarely uses early burning, it has been applied by the Ministry of Environment and Tourism in Bwabwata National Park. Fire management in the National Park was dominated by fire exclusion, however, this resulted in uncontrolled wildfires (Figure 13). In 2007, Bwabwata National Park started an integrated controlled burning programme in the Zambezi Region that included early burning (Ministry of Environment and Tourism 2016). It is not clear yet to what extent this has assisted the forest vegetation.

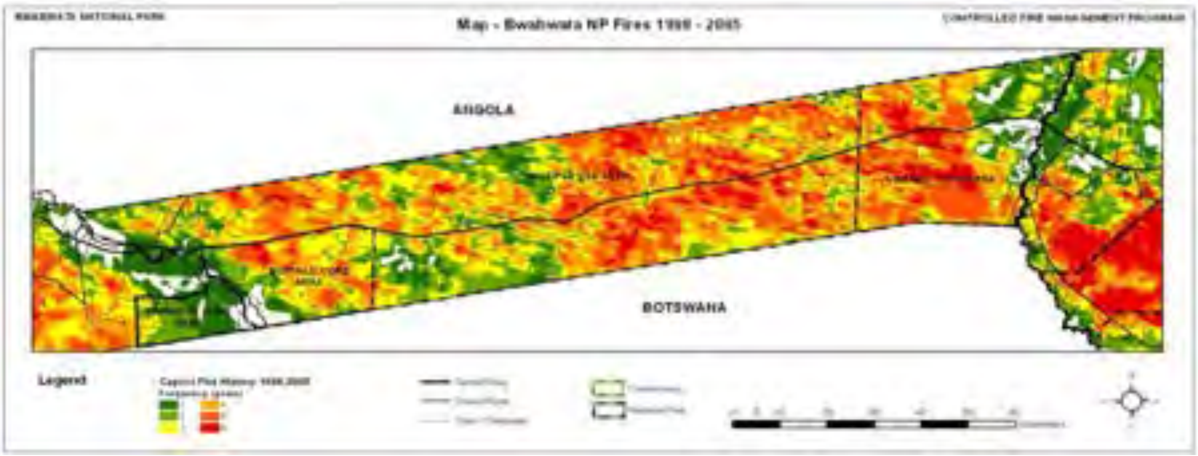

Figure 13 – Fire history of Bwabwata National Park in the period 1998 – 2005 (Ministry of Environment and Tourism 2016)

Firefighting is increasingly resource-intensive, as the number of active fires shows a rising trend and poses an ever-greater threat to the expanding population (Pricope and Binford 2012). Resources are often lacking to maintain the fire breaks or stop fires, making early fire alert systems such as AFIS (http://afis.meraka.org.za) superfluous. An alternative to manual clearance of fire breaks could be controlled grazing.

The Forest Act has several provisions regarding the management of fire. In areas adjoining or close to a classified forest, the minister may declare a fire management area and appoint a fire management committee that should draw up a fire management plan for the area. In terms of the Act, it is an offence to light a fire in a CF unless the fire has been authorised by the management authority and is following the management plan (Jones and Barnes 2009). In reality, most fires start during the clearing of the fields next to community forests and run out of control. The authors know of no cases where fire management is done by communities.

6.4 Silviculture in Namibia

6.4.1 What is silviculture?

Silviculture is the practice of tending a forest or woodland for specific purposes, for example, timber, charcoal, bark and/or pole production, and includes interventions such as thinning, planting, pruning, and the use of rotations (De Cauwer, Knox, *et al.* 2018). The distinction between forestry and silviculture is that silviculture is applied at the stand-level, while forestry is a broader concept. Forest areas are divided into spatial units that form the basic entities for management, referred to as stands or blocks. Adaptive management is common in silviculture, while forestry can include natural land without stand-level management and treatments being applied.

Many silvicultural methods depend on the manipulation of the forest canopy to create conditions favouring the survival and growth of desirable trees. The structure of the canopy controls the quantity and quality of light, the local precipitation and air movements in the forest, which affect for example air temperature and soil moisture (Jennings *et al.* 1999).

The first step toward introducing silviculture in previously unmanaged forests is domestication. Domestication includes all measures for improving the economic performance of stands to at least a level that can ensure that the costs of management for sustained yield are covered. It will involve a restructuring of the original growing stock so that the domesticated stands are more botanically and structurally homogenous. This will ensure larger supplies of timber of higher quality in the desired size classes. This does not mean that non-marketable species should be eradicated, they need to be kept to maintain biodiversity, supply of NTFPs, and maintain forest stability (Lamprecht 1989).

6.4.2 Application of silviculture in Namibia

There are virtually no silvicultural guidelines for forest management at the forest stand level in Namibia. Particularly interventions and regulations to aid the natural regeneration of key species are lacking (Ministry of Agriculture, Water and Forestry 2011), which will be further discussed in the next sections. Hence, woodland management in Namibia is restricted to the bare extraction of resources and thus can be rather compared to a mining operation where no actions are taken to invest in future woodland (Lamprecht 1989, Dewees *et al.* 2011). The decreasing forest area and the increasing urbanisation may change attitudes and approaches in the future. A study in the mopane woodlands of Namibia and Zimbabwe showed that communities living in well-wooded areas were less interested in managing woodlands than those in areas where woodland resources were less abundant (Musvoto *et al.* 2007).

6.4.3 Nurseries

There are tree nurseries at many of Directorate of Forestrie's regional offices, Hamoye research station and the National Forestry Research Centre (NFRC) in Okahandja. Unfortunately, Hamoye has high mortality among the seedlings because of frost conditions (Ministry of Agriculture, Water and Forestry 2011). The NFRC houses a Tree Seed Centre with cold storage facilities and a laboratory that is among others used for seed testing.

Many species in the Directorate of Forestry and private nurseries are however non-indigenous and hence should be avoided for afforestation. Tree growing of drought-resistant, indigenous species needs to be promoted on a national scale. The harvesting of wood or fruits of indigenous tree species cannot continue sustainably if the future of the species' populations is not ensured (De Cauwer, Chaka, *et al.* 2018). A first step would be to raise more public awareness on which tree species are indigenous and most suitable for the different regions of Namibia. Another way to achieve this would be to create tree nurseries at the community level as a way to create a regular income (Hilfiker 2011).

Genetically improved seedlings need to be cultivated; these are seedlings resulting from a strict selection process for specific traits, such as growth rate, fruit production, stem length and shape (De Cauwer 2020). Some work has been done for marula, with the identification of "ideotypes" based on fruit size, kernel versus flesh proportion, and dry matter contents (Leakey *et al.* 2002).

More documented nursery experiments are needed with indigenous species, which are often difficult to cultivate with problems arising at several stages (De Cauwer, Chaka, *et al.* 2018). Seed germination experiments have been done by the Directorate of Forestry, students and researchers (Moses 2012, Vander Heyden 2014, De Cauwer and Younan 2015, Heita 2015), but this has to be expanded to more tree species and include seedling survival and protection, while more results need to be published in popular literature. Another problem is that many tree species of the Zambezian Baikiaea woodlands develop deep taproots during the seedling phase, such as kiaat, which makes it difficult to transplant the species.

6.4.4 Tree planting

Tree planting in Namibia is mainly limited to orchards or planting of a few trees on special occasions, such as Arbor Day. There is no afforestation; the planting of trees in forest areas. This is reflected in the reports of Namibia to FAO (FAO 2015) and a global forest assessment with high-resolution satellite data that monitored afforestation (Hansen *et al.* 2013). A common view in Namibia is that the forest is non-exhaustive and does not need assistance to regenerate. However, natural forest regeneration is slow and erratic for most species (see 0). Many seedlings die because of drought, browsing, or fires in the late dry season, and in most years and especially during long drought periods, conditions are not good enough for seedlings to reach the sapling stage. In contrast, the harvesting of timber and NTFPs often increases during periods of drought when there is limited food and income. Moreover, timber harvest targets the best timber trees which results in the removal of the best genetic material of the forest. The most desirable mother trees will get less chance to propagate and this human selection results in a degradation of the timber quality of the remaining trees. Active intervention is needed to support the regeneration of seedlings with superior timber qualities.

According to the baseline survey (see Chapter 8), few villages and CFs have forest tree nurseries or are planting trees in the forest. This is confirmed by the fact that the majority of the CF members in the rural setting had never planted a tree.

Forest regeneration is also slow on abandoned fallows, which mainly consist of shrubs and resprouting trees. A study in northern Namibia showed that the tree seed density in the soil seed bank of fallows was low (0.04 seeds per m^2) with low species diversity (Hilukwa 2018). Reforestation projects in northern Namibia cannot rely on a quick natural restoration of the forest, especially when no tree root systems remain that allow coppice growth (De Cauwer, Chaka, *et al.* 2018).

The Directorate of Forestry encourages the establishment of community-based orchards and they received support from donor organisations, such as the Community Forestry in Namibia project of the German Development Service (BMZ). By 2011, 151 out of 207 established orchards were still being successfully operated (KFW 2013). However, communities are struggling to properly manage the orchards. This is among others because of high investment costs, reluctance in maintaining orchards by the community and weak management skills, including benefit-sharing mechanisms. Hence, planting may be more successful if done by individuals who take ownership of the planted trees and nurture them. Planting near homesteads is advised, as well as the promotion of agroforestry and public-private partnerships (Ratnam *et al.* 2020).

If afforestation projects are planned in the future, they will be affected by the low number of tree seedlings available at government and private nurseries, while most tree species are non-indigenous. When planting a forest, it is necessary to plant at least five times more trees than are required in a mature forest. Natural selection will make sure that the strongest and quickest growing individuals will survive. The lack of indigenous tree seedlings in nurseries is one of the reasons why assisted natural regeneration may be more successful.

6.4.5 Assisted natural regeneration

Assisted natural regeneration refers to low-cost methods that can be applied to natural forest stands to enhance natural regeneration, especially through the reduction of barriers to tree regeneration and preferably by involving local people (Ganz *et al.* 2003, Shono *et al.* 2007). It is a less expensive technique for landscape restoration (Ministry of Agriculture, Water and Forestry 2011), but is rarely used in Namibia. Techniques to assist natural regeneration include exclusion of grazing, controlling of fire (including patch burning), the use of pioneer shrubs as nurse plants, the removal of plant competition, and enrichment planting (Ganz *et al.* 2003, Aerts *et al.* 2007, Chazdon and Guariguata 2016). Few experiments have been done in Namibia, although they offer exciting research possibilities with direct applications for Namibia's forests.

Enrichment planting of nursery seedlings in Kanovlei state forest in the Otjozondjupa region was compared with direct seeding for kiaat, Zambezi teak and false mopane. Regeneration from seeds covered with a layer of soil was much better compared to that of broadcasted seeds and planted nursery seedlings. After one year, the seedling survival rate from seeds covered with a layer of soil was 11%, and that from noncovered seeds was 1.3%. A late rainy-season treatment resulted in no surviving seedlings, both for direct seeding and seedlings. All planted seedlings were destroyed by small mammals after six weeks, although a small experiment showed that individual tree protectors (sleeves) were able to protect the seedlings from small mammals (Chaka 2019).

The effect of browsing, plant competition and fire on the natural regeneration of woody species was studied in Onkumbula CF in northern Namibia. Browsing protection did not affect seedling density, species richness or seedling survival, but it improved the growth of seedlings both in height and diameter after one year. Plant competition removal did not have any significant effects within that period. A longer period of following up browsing protection and removal of plant competition would be needed to confirm this Master study. The effect of fire on woody species regeneration was observed five months after a fire by comparing it with neighbouring forest areas unaffected by the fire. Burned plots recorded 31% more seedlings and recorded 8 species more compared to 5 species in the unburned plots. Shoot production in trees and saplings increased with fire. However, fire negatively affected sapling survival with 36% of saplings recorded dead in the fire plots compared to 2% in the unburned plots (Amutenya 2020).

6.4.6 Tissue culture and grafting

Tissue culture is a vegetative means of *in vitro* propagation from small plant parts, such as cells and tissues. It entails a systematic procedure for the establishment and multiplication of shoots from plant material, root formation and seedling acclimatisation on a defined solid or liquid medium under aseptic conditions. The technique allows the rapid production of high quality, disease-free and fast-growing plants, however, is not easily implemented. Very few experiments have been done with tissue culture on Namibian tree species, although a lab was built for this purpose at the NFRC in Okahandja.

One study evaluated the technique for Namibian kiaat and monkey orange. The results show that germination of the species using tissue cultures is more successful and faster in comparison to seedling cultivation. Up to seven plantlets can be produced with tissue culture methods within seven days, while traditional nursery methods only produce two and seven seedlings from kiaat and monkey orange after 30 days respectively. The study developed a tissue culture protocol for both species (Heita 2017).

Grafting is another way to vegetatively propagate plants with desired tree qualities and thus superior genetic quality, for example, fruit trees that produce larger than average amounts of fruits. In 2009 and 2010, the German Agency for Technical Cooperation (GTZ) organised training in marula grafting for members of the Eudafano Women's Cooperative and 14 Directorate of Forestry staff of the North-West Forestry Region, including 10 nursery staff of Ongwediva. Scions from 21 recorded superior mother trees were collected and 187 marulas grafted. Of those, 48 marulas survived by March 2010 (corresponding to a survival rate of 25.7%) (Hilfiker 2011).

6.4.7 Thinning

Thinning is often done in tree plantations to avoid competition between trees. However, thinning can also be done to liberate the best trees for the production of high-quality timber (Lamprecht 1989). These improvement thinnings remove tree competition around the most promising timber trees so that there are no competing neighbours in a circle with a radius of at least 7 m. Shrubs and much smaller trees are not considered as competition, rather, they can assist in keeping the stem of the timber tree branch free. Thinnings allow intermediate wood harvests that, although of low timber quality, can be used for wood carving, droppers, poles, or firewood.

Thinning has little impact on tree height in mopane woodland but can result in the redistribution of basal area increment among fewer stems. Although reducing the total production per ha, thinning results in the faster achievement of the desired pole sizes and speeds up vegetative growth and seed-bearing for the remaining trees (Musvoto *et al.* 2007). In western Omusati, only 20% of households were interested in thinning and coppicing, with the majority perceiving woodlands as being managed by nature. Men ranked thinning higher than women and children as the technique was perceived as having a high likelihood of improving the supply of thick poles (Musvoto *et al.* 2007).

6.4.8 Pruning

Trees in open forests often develop strong branches, which negatively affects the timber quality. Pruning aims to systematically remove those branches, dead and alive, during tree development to obtain a longer branch free bole. The bole is the main stem of the tree and the part that is commercially the most useful for timber.

Only trees with the desired timber characteristics should be pruned. Pruning saws rather than hatchets or machetes are advised as the wounds heal better when cuts are smooth. For species with a pagoda-type crown, such as *Terminalia* sp., at least two "stories" should be left. Many *Eucalyptus* species do not need pruning, although *E. camaldulensis* does (Lamprecht 1989). No cases of pruning in Namibian woodlands and forest stands are known to the authors, although it would be very beneficial for kiaat (Figure 14).

Figure 14 – Kiaat (*Pterocarpus angolensis*) with undesired bole qualities. The stem would have been straighter if the side branch was removed when the tree was younger (Photo: V. De Cauwer).

6.4.9 Coppicing

Coppice is woody vegetation that has regrown from stump sprouts, shoots and root suckers, mainly after the harvest of the original trees. Coppice is used as a forest management system for the production of fuel, pulp or other low-quality wood. In the dry tropics, such as in Namibia, it can be a natural evolution of the vegetation when harvest and browsing pressure is high. Some species coppice much easier than others, for example, mopane coppices readily.

Coppice management is easy and well adapted to the situation in the dry tropics. According to Von Breitenbach (1965, in Cunningham and Detering 2017), mopane coppices so vigorously that an entirely cleared area regenerates fully to a dense forest within 15 years, while regeneration from seed to a pre-cleared state could take up to 40 years. Active coppice management is rarely done in Namibia but has a lot of promise. In central Omusati, where tree harvesting is intense and woodland resources relatively scarce, 40% of households expressed interest in using coppicing in mopane woodland given the opportunity as this was perceived to result in more firewood (Musvoto *et al.* 2007).

6.5 Forest research

The first Forest Research Strategy for Namibia (see 0) is a tacit acknowledgement that research and technological development are essential tools to address challenges that stand in the way of SFM (Ministry of Agriculture, Water and Forestry 2011). The strategy document highlights that Namibia does not have enough appropriately qualified researchers to implement its research strategy. And even where such skills exist, they are scattered over several institutions (Ministry of Agriculture, Water and Forestry 2011).

The Forest Research Strategy indicated key issues and problems that research should address. Out of seven strategic forest research areas, a priority list of research topics was made:

a) Understanding the direct and underlying drivers of deforestation and degradation (see also 0 and 0),
b) Developing or applying technologies to improve natural and artificial regeneration (see also 0 and 0),
c) Inadequate data on growth and yield on species of interest (see also 0),

d) Forest product research,
e) Economic and social aspects of SFM, including issues of governance.

However, 10 years later, limited progress has been made, and most of the recent research in that period was driven by the universities and externally funded programmes such as SASSCAL 1 (Southern African Science Service Centre for Climate Change and Adaptive Land Management). The first two research areas are most urgent considering the ongoing forest degradation and passive forest deforestation.

6.5.1 Forest research by the Directorate of Forestry

Most research done by the Directorate of Forestry is part of long-term programmes that were initiated long ago. The use of truncheons to vegetatively propagate kiaat was tested at Kanovlei research station. This was later abandoned for lack of rooting (Ministry of Agriculture, Water and Forestry 2011). There are burning trials at Kanovlei and Nkurenkuru that continue to be monitored, however, no results are being published. Likewise, there is little published on the tree seed research done by NBRI and NFRC, or the tree propagation and plantation trials at Hamoye and Ngoma respectively, except for the studies done by Directorate of Forestry staff members that are or were studying towards a degree.

6.5.2 Forest research by universities

Targeted forest inventories have been performed by the research community, allowing to study the ecology of Namibia's forests, especially forest vegetation patterns, the status of natural tree regeneration, the impact of fire, and tree growth (De Cauwer *et al.* 2016, 2020, Kabajani 2016, Schelstraete 2016, Van Holsbeeck *et al.* 2016, Mwansa 2018, Revermann *et al.* 2018, Amutenya 2020). Some of the research focused on allometric equations and assisted natural regeneration and have been described in the previous sections.

7 Sustainable Forest Management value chains

7.1 Existing Sustainable Forest Management value chains in Namibia

7.1.1 Timber

Currently, only registered CFs are allocated an annual TAO for the harvesting of timber. These amounts are low for CFs with only a small portion of forest or where major timber species are not well represented. Small TAOs are not always used because they are not economically viable for commercial logging. The areas with the highest percentage of kiaat are CFs in eastern Ohangwena, western Kavango, Okongo and Katope. It is especially in these areas that harvesting is still taking place. For example, the TAO for kiaat in Katope CF is 720 trees per year and in Okongo CF 916 trees per year. The TAOs for Zambezi teak are larger with 7727 trees in Okongo CF and 2654 in Katope CF (Nott *et al.* 2019).

Droppers are produced for own use or informal sale (see 0), although one building warehouse sells raw fence droppers produced in Namibia, without guarantee, at its Windhoek branch as part of a low-cost housing project (Rothauge 2014).

7.1.2 Non-Timber Forest Products

CFs have proven to have less revenue potential than conservancies, which generate funds primarily through tourism and hunting (Schusser 2012, Benkenstein *et al.* 2014). CF revenue depends to a large extent on available resources and social dynamics. While more densely wooded areas have a higher revenue potential for firewood, the availability of other NTFPs can provide local communities with a more important source of income. In certain CFs, harvesting of the devil's claw plant (*Harpagophytum procumbens*) contributes significantly to local incomes, as there is a high demand for this product from international pharmaceutical companies (Benkenstein *et al.* 2014). It is one of the first NTFPs that was commercialised and its export earnings are estimated to be in the region of N$20-30 million per annum (Cole 2014).

Seed oils derived from marula and sour plum have functional supply chains in Namibia as well as recognised market demand. Namibian indigenous lipid oils are commonly marketed in international markets as cosmetic ingredients but can be used for other purposes as well. Marula oil, in particular, is popularly used as a condiment in food, and is sold in both traditional and more formalised national markets in Namibia. Sour plum oil has attracted keen interest from the international market, mainly due to its anti-ageing properties (Cole 2014).

Mopane seeds are harvested and steam distilled at the Opuwo Processing Facility to extract the essential oil. The resource is abundant and the technology for extraction is locally available. The challenge is to develop the market (Cole 2014).

Mopane worms sometimes provide an important cash injection to CF members in the mopane woodlands. This income is however very variable, as the supply of mopane worms depends on rainfall. Despite distinct processing methods to increase storage characteristics, products usually perish within half a year.

Currently, the socio-economic benefits of most CFs lie primarily in their ability to enhance rural livelihoods by providing fuelwood, building materials, grazing, medicinal plants and other resources (Benkenstein *et al.* 2014), especially during droughts.

7.2 Potential Sustainable Forest Management value chains for Namibia

The Namibian government recognises that the full economic potential of natural products harvested within CFs is not reached. This is mainly because there are inadequate value-adding efforts for both wood and NTFPs. For example, most commercial timber harvested in Namibia is exported as raw or squared logs and planks. Treated poles mainly come from South Africa. More forest products could be brought to the market and contribute directly to rural development (Ministry of Agriculture, Water and Forestry 2011).

7.2.1 Timber

To create more value-adding to hardwood within Namibia, more technologies need to be adopted that could lead to the utilisation of a broader range of species. For example, as the common red syringa can yield flooring or furniture if powerful, specialised equipment, such as stellated blades for sawing and carbide tools for machining, would be used (Ministry of Agriculture, Water and Forestry 2011, ITTO 2015b).

Even more interesting technologies exist to make reconstituted wood products such as fibreboards, over which high-quality veneer can be bonded to produce high-quality wood-based panels for both local and export markets (Ministry of Agriculture, Water and Forestry 2011). Several factors hamper the establishment of such a pressed wood industry. Probably the biggest problem is that no standards exist to ease the logistics of the manufacturer to procure a steady supply of wood of desirable and uniform quality. The quality of the wood supplied varies tremendously and the risk of procuring the wrong type of wood is with the manufacturer. Secondly, while Namibian hardwood yields coarse chips of acceptable quality, the resins in the wood make for an uneven consistency of the pressed wood product. Thirdly, the high sand and ash content adds an expensive preprocessing procedure. It is much easier and more economical to make chip and press wood products from softwood such as pine, grown uniformly under controlled conditions in huge plantations than to struggle with a highly variable, uncompliant indigenous resource. The De-Bushing Programme might assist in developing norms and supply chains that can feed these latent building materials industries with the assistance of the Namibian Standards Institution (NSI) (Rothauge 2014).

There is a huge demand for raw, farm-made droppers, however, large agricultural input suppliers do not buy them up for resale to customers. Poles are not treated against decay and termites and are not normed to any standard, which can expose input suppliers to claims for damages if they sell raw droppers (Rothauge 2014). Standardisation of droppers, rafters and poles and potential treatment will help commercialisation.

A better-regulated wood market, with fair prices for wood, can increase the revenue collected through timber harvest and provide more incentive to protect the forest. The Forest Act Regulations indicate a price of only N$ 200 for protected commercial trees, although the ongoing revision of the Forest Act provides an opportunity to change this (De Cauwer 2020).

In conclusion, a lack of technical and price standards within the timber industry and barriers to technology transfer and accessing markets are the main challenges that Namibia must overcome.

7.2.2 Non-Timber Forest Products

Indigenous natural products (INPs), including NTFPs, have the potential to contribute significantly to improving food security, alleviation of rural poverty, and conservation. Some estimates have put the current annual value of the contribution to Namibia's Gross Domestic Product of INPs at between N$ 30–50 million, with the potential to increase considerably (Cole 2014). It is for this reason that the Ministry of Agriculture, Water and Forestry supported the creation of the Indigenous Fruit Task Team

(IFTT) in 2000, which evolved in 2003 into the Indigenous Plant Task Team (IPTT), a multi-stakeholder forum to develop a coordinated approach and strategy for the promotion of the commercialisation of INPs in Namibia. The Ministry of Agriculture, Water and Forestry has also established the Plant Product Development Section at the NBRI (Joseph S. Iita in Cole 2014). Because of the complexity of governance systems related to INPs, the IPTT has adopted a 'pipeline approach' with flexible support to INP development, both for production and marketing.

Many challenges however remain to be overcome for the INP sector to realise its full potential. These challenges include aspects such as resource-base sustainability, management and technical capacity of producers, managing supply and demand, undertaking local research and development, attracting appropriate investment, and consolidating and increasing local and international markets (Joseph S. Iita in Cole 2014).

Promising NTFPs include honey, mangetti nuts and mopane worms. Honey collected from wild bees is a major source of cash income in the wetter Miombo woodlands (Shackleton and Gumbo 2010), but less so in Namibia. It is one of the most promising NTFPs in north-eastern Namibia (Hilfiker 2011). Mangetti oil could be produced in larger quantities, but the demand for them is currently limited (Cole 2014). A pilot project in cooperation with a CF in mopane woodland and research institutions could assess opportunities for domestication, storage and value addition of mopane worms.

8 Baseline survey

As part of the NSFM-Project, a baseline survey was performed to assess the level of awareness, understanding and knowledge of SFM among the project's target groups. The target groups include, *inter alia,* CF members, regional administrative representatives, national, local and traditional authorities, nature and environmental organisations. The purpose was to provide an information base against which to monitor and assess the impact, progress and effectiveness of the project.

8.1 Methodology

8.1.1 Study design and analysis methods

In April 2021, a total of 154 stakeholders of the NSFM-Project were surveyed on their knowledge about SFM, their understanding of and attitude towards SFM, as well as their appreciation of different and diverging views on forest management. To reach out to the different stakeholders and to collect the data, three questionnaires were distributed: (1) a paper-based survey that was circulated to CF members in a rural setting during the NSFM-Projects' pre-visitation trip to the Kavango and Zambezi regions (sample size *n* = 104), (2) an online survey that was circulated online via the social media channels as well as the mailing list of the NSFM-Project (*n* = 18), and (3) a paper-based survey that was circulated at the end of a public discussion event hosted by the NSFM-Project in Rundu (*n* = 32).

The statements were predominantly measured on a 4-point scale from 1 (totally agree) to 4 (totally disagree). Additionally, an option 'don't know' (0) was available to avoid that survey participants felt forced to choose an answer when not understanding the question. Demographic characteristics were collected using nominally scaled questions. The questionnaire used in the rural setting to survey CF members included five extra statements and three extra questions, while the two other questionnaires included two extra statements that were not part of the former, and one question was removed from the online questionnaire (Table 3).

The data analysis was conducted using Microsoft Office Excel. All data were analysed by using univariate analysis; frequency distributions were conducted for all variables and the mean ($\overline{X}$) was calculated for all statements measured on the 4-point scale.

8.1.2 Sample description

The sample includes 154 stakeholders of the NSFM-Project with 59.1% male and 40.3% female. As illustrated in Figure 15, the majority of the survey participants were aged between 22 and 39 years (42.2%), followed by those aged between 40 and 55 years (40.3%) and the ones being older than 55 years (16.9%).

When the participants were asked how they would describe themselves best, the majority of the survey participants indicated to be CF members (70.1%). The CF members that filled in the questionnaire for rural settings were geographically well distributed with 31.7% of the CF members from Kavango East, 26.0% from Kavango West, and 42.3% from the Zambezi Region.

The second-largest stakeholder group among the survey participants is the nature/ environmental organisation representatives with 5.8%, followed by the NGO representatives (5.2%), and the community members, representatives from academia and interested individuals with each 3.9%. The remaining survey participants were administrative representatives and (political) decision-makers (Figure 16).

Table 3 - Overview of statements and questions used for the three questionnaires (Q) of the baseline survey

Variable	Statements and questions	Q1 Rural setting	Q2 Online	Q3 Public discussion
v_1	I have already heard about the concept of Sustainable Forest Management.	X	X	X
v_2	I have knowledge and skills on Sustainable Forest Management.	X	X	X
v_3	I am interested to learn (more) about Sustainable Forest Management.	X	X	X
v_4	I only cut down trees for energy reasons (wood fuel).	X		
v_5	The protection and judicious harvesting of fruit trees is important to me.	X		
v_6	It is only reasonable to cut down trees according to a management plan.	X	X	X
v_7	I only cut down trees with a straight trunk.	X		
v_8	It is important to maintain a nursery for seedling production.	X		
v_9	Thinning pruning and enrichment planting is important to me.	X		
v_10	It is NOT reasonable to cut down trees to sell the timber thereof.	X	X	X
v_11	I accept that some people have a differing view on forest management.	X	X	X
v_12	I am willing to listen to people with other opinions on forest management.	X	X	X
v_13	I do not understand if people in Windhoek are unhappy if we cut down big tree.	X	X	
v_14	Allowing young trees time to mature is Sustainable Forest Management.	X	X	X
v_15	I know that some people have a different opinion on how to manage forests.	X	X	X
v_16	Sustainable Forest Management aims to maintain and enhance the economic social and environmental values of our forests.		X	X
v_17	Managing forests sustainably means to log selectively (selective logging is the practice of removing certain trees while preserving the balance of the woodlands).		X	X
v_51	Kindly indicate your gender:	X	X	X
v_52	Kindly indicate in which region your Community Forest/ Farm is located:	X		
v_53	Kindly indicate how old you are:	X	X	X
v_54	Which of the following describes you best?	X	X	X
v_61	Please indicate how many trees you have planted in the past 10 years.	X		
v_62	Please indicate which tree species you are harvesting: Mchici/ Musibi	X		
v_63	Mukusu (Zambezi Teak)	X		
v_64	Mukwa/ Mulombe (Kiaat)	X		
v_65	Wild Syringa	X		
v_66	Mopani (Mopane)	X		
v_67	Mugoro/ Muhonono	X		

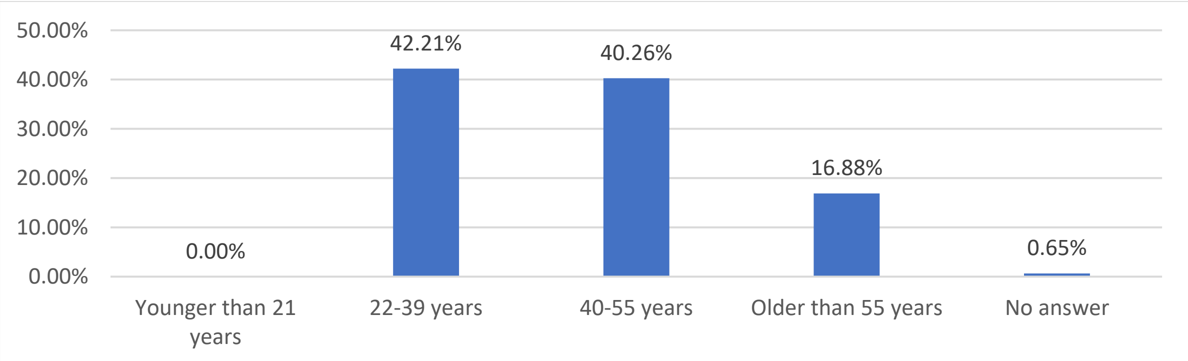

Figure 15 - Age distribution of participants in the baseline survey (sample size *n* = 154)

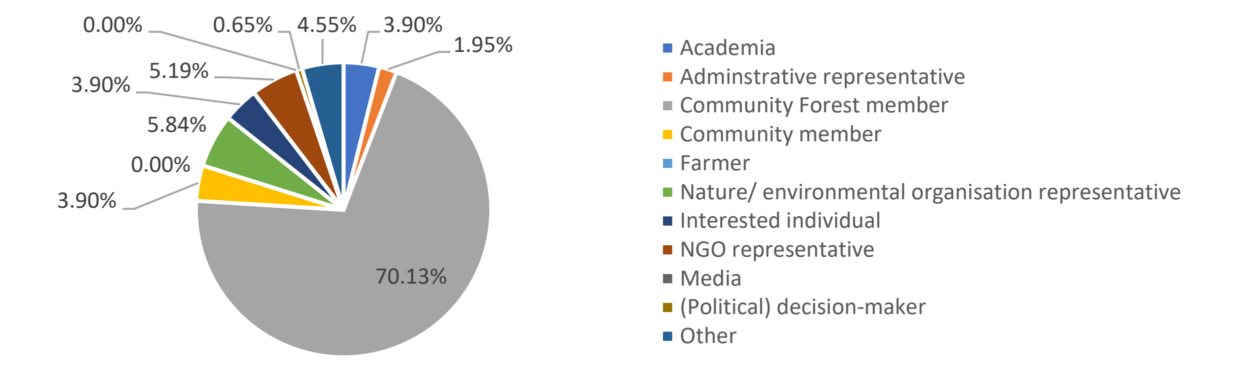

Figure 16 – Major groups of actors that participated in the baseline survey (*n* = 154)

8.2 Findings of the baseline survey

Most survey participants indicated to have already heard about the concept of SFM ($\overline{X}$=1.7) and to have knowledge and skills in SFM ($\overline{X}$=2.0). These findings are illustrated by the frequency distribution for the first two statements (Figure 17), with 44.2% that totally agree to have already heard about the concept of SFM and 43.5% that agree with the statement. Furthermore, 28.6% totally agree that they have knowledge and skills in SFM and 43.5% agree with that statement.

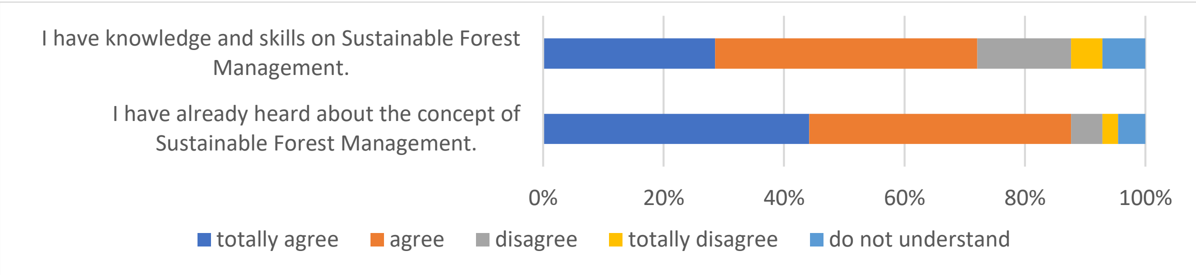

Figure 17 - Frequency distribution of SFM knowledge self-assessment questions of the baseline survey (*n* = 154)

The results of the self-assessment are also reflected by the results for the statements that measured the knowledge of SFM (v_14, v_16, v_17). The mean values indicate that the majority of the survey participants have a basic to a good understanding of SFM (*'Managing forests sustainably means to log selectively'* $\overline{X}$=1.5; *'Sustainable Forest Management aims to maintain and enhance the economic, social and environmental values of our forests'* $\overline{X}$=1.4; *'Allowing young trees time to mature is Sustainable Forest Management'* $\overline{X}$=1.5). The first two questions were not part of the questionnaire with CF members in the rural setting. More details are shown in the frequency distribution (Figure 18).

The understanding of and attitude toward SFM seems also to be quite positive as the mean values in Table 4 indicate. Remarkably, 92.2% of the survey participants are interested to learn (more) about SFM. On the other hand, 12.5% of the CF members did not understand the statement 'It is important to maintain a nursery for seedling production', while 78.9% agreed. Only the first statement (v_10) is poled in the opposite direction; many survey participants disagree with the statement that it is not reasonable to cut down trees to sell the timber thereof ($\overline{X}$=2.6). The frequency distribution of this statement (Figure 19) shows that 43.5% of the participants did agree with the statement. However, 40.3% disagreed, mainly in the online survey and public debate. A relatively large portion of participants did not understand the question (16.2%), especially in the rural setting (23.1%).

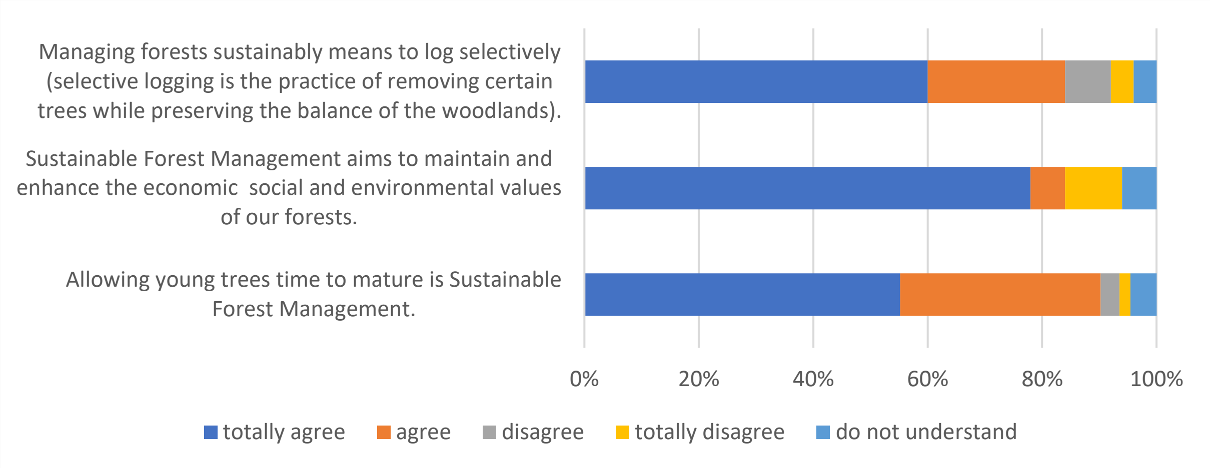

Figure 18 - Frequency distribution of statements measuring the knowledge of SFM in the baseline survey (*n* = 50 for the first two questions, *n* = 154 for the last question)

Table 4 - Mean values of statements measuring the understanding and attitude towards SFM in the baseline survey with an indication of sample size *n*

Variable	Statement	*n*	Mean
v_10	It is NOT reasonable to cut down trees to sell the timber thereof.	154	2.58
v_9	Thinning, pruning and enrichment planting is important to me.	104	1.73
v_8	It is important to maintain a nursery for seedling production.	104	1.51
v_7	I only cut down trees with a straight trunk.	104	2.04
v_6	It is only reasonable to cut down trees according to a management plan.	154	1.86
v_5	The protection and judicious harvesting of fruit trees is important to me.	104	1.51
v_4	I only cut down trees for energy reasons (wood fuel).	104	2.04
v_3	I am interested to learn (more) about Sustainable Forest Management.	154	1.44

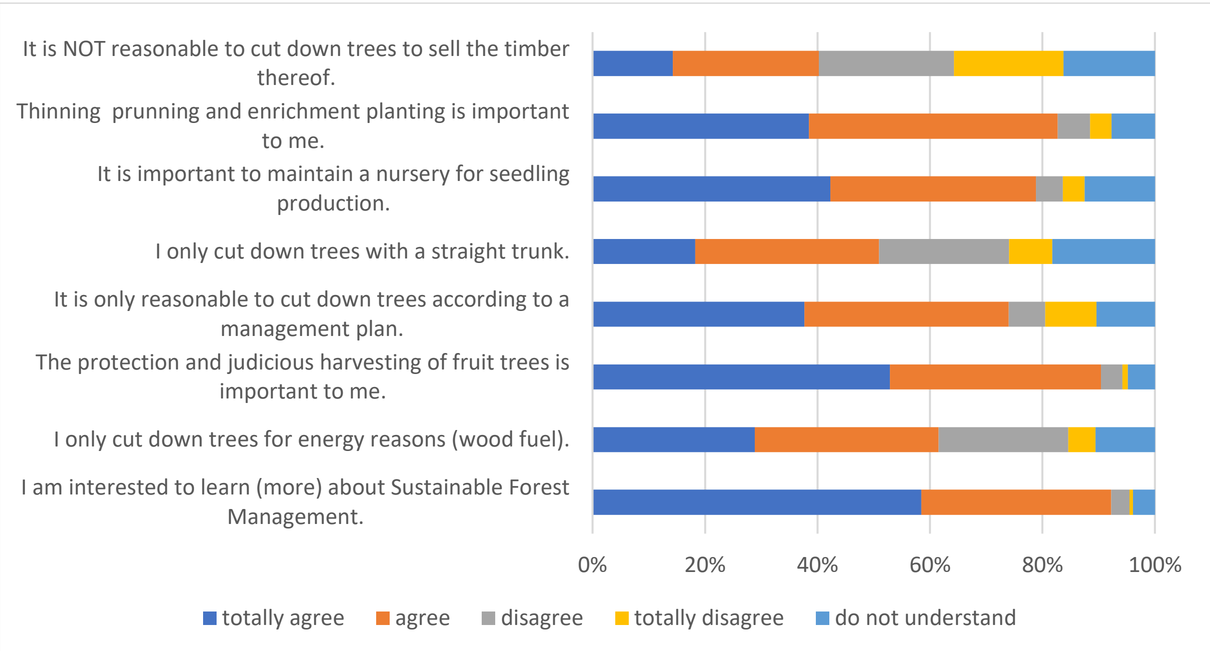

Figure 19 - Frequency distribution of statements measuring the understanding of and attitude towards SFM

While the frequency distribution of most other statements on the understanding of and attitude towards SFM shows a similar pattern as previously - the majority of participants agreeing - there are two other statements with fewer participants in accordance (Figure 19). Those two statements were only part of the questionnaire for the CF members in the rural setting. Half of the participants (51.0%) indicated to only cut down trees with a straight trunk (v_7). However, the statement is a bit ambiguous as those who disagree may either never cut down trees or they do not consider the straightness of the trunk. There were indeed 19 participants (18.3%) who indicated not to understand this question. For statement v_4, 61.5% of the participants indicated to only harvest trees for fuel.

The appreciation of different and diverging perspectives on SFM seems also to be positive. The mean values of the respective statements indicate that many survey participants agree to be open to others' opinions and perspectives (Table 5, Figure 20). For example, 89.0% of participants are willing to listen to people with other opinions on forest management. The only exception is the statement 'I do not understand if people in Windhoek are unhappy if we cut down big tree' with only 47.1% of the participants agreeing ($\overline{X}$ =2.4). Most of the remainder disagree (33.1%), indicating that they do understand that people in Windhoek are unhappy if trees are cut down in the Kavango and Zambezi Regions. However, this statement is a bit difficult to understand with the double negation, and 20.0% did not understand the question.

Table 5 - Mean values of the statements reflecting the appreciation of different and diverging perspectives on SFM in the baseline survey with an indication of sample size *n*

Variable	Statement	*n*	Mean
v_11	I accept that some people have a differing view on forest management.	154	1.74
v_12	I am willing to listen to people with other opinions on forest management.	154	1.62
v_13	I do not understand if people in Windhoek are unhappy if we cut down big tree.	136	2.40
v_15	I know that some people have a different opinion on how to manage forests.	154	1.72

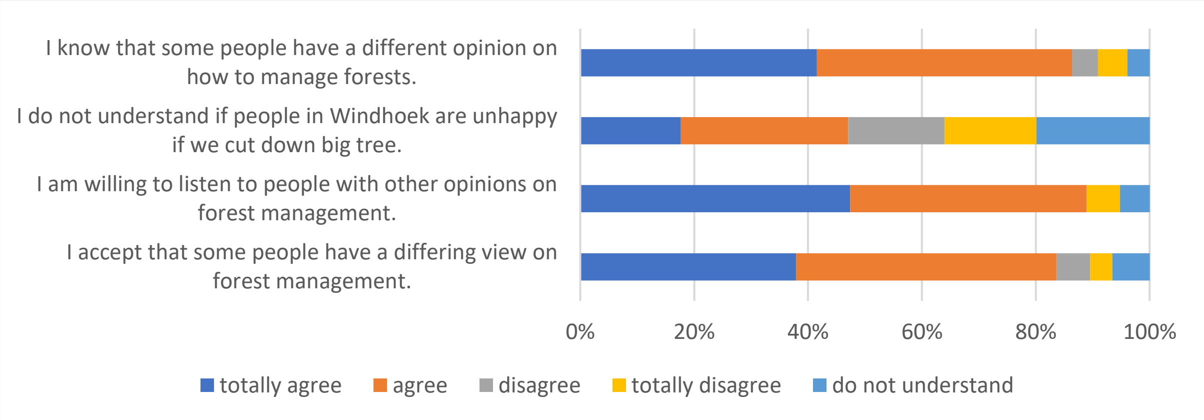

Figure 20 - Frequency distribution of statements measuring the appreciation of differing and diverging perspectives on forest management

Noticeable is that the male survey participants seem to be more in agreement with all statements than the female and that younger participants seem to be more in agreement than the older ones.

The survey participants in the rural setting indicated to have planted 25 trees on average over the past 10 years. However, two of the participants replied that they planted 1,000 trees which seems unrealistic and hence, are considered outliers. Once the outliers are removed, the average of trees planted per respondent was exactly 1 tree per person over the past 10 years. Most participants (81.7%) had not planted a tree (Figure 21).

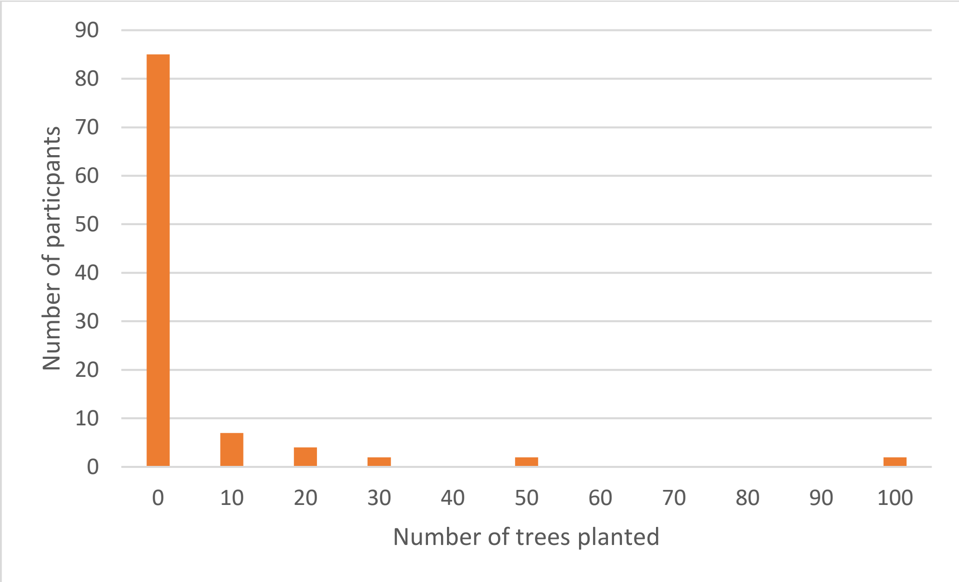

Figure 21 – Number of trees planted over the last 10 years by the community forest members in the rural setting (*n* = 102). Two answers (1000 trees) were removed.

The most harvested tree species was silver cluster-leaf (mugoro/muhonono) with 37.5% of the respondents indicating that they harvest it. Most other species seem to be harvested to a relatively similar degree by the participants in the rural setting: Zambezi teak (mukusu) 37.5%, mopane 37.5%, kiaat 30.8%, and false mopane 26.9%. Red syringa was harvested the least (19.2%).

8.3 Discussion and conclusions

In general, many participants appear to know and understand SFM well. This is however contradicted by a few statements, for example, many respondents (43%) do not consider harvesting trees for timber as reasonable. The general agreement with the fact that nurseries are needed for seedling production, or that pruning, thinning and enrichment planting are important, does also not align with what is seen in the field. Few villages and CFs have forest tree nurseries or are planting trees in the forest. This is confirmed by the fact that the majority of the CF members in the rural setting had never planted a tree. The response to the nursery statement may have been related to fruit trees only, while most fruit trees grown in the villages are not indigenous to Namibia. Or people may agree with the nursery statement but not put it into practice. It would be valuable in that case to find out why.

One of the reasons for the apparent contradiction may be that many of the knowledge and understanding questions were too general and too easy to agree to without really evaluating the respondents' knowledge. To avoid people agreeing with general statements that sound good and acceptable, it may be more advisable to ask very tangible questions that allow an assessment of the respondent's knowledge of the forest, knowledge which is necessary to apply SFM, such as:

- Do you agree with: Namibia has no forest, only shrubland and savanna.
- Do you agree with: thinning of a forest is the same as selective harvesting.
- Do you agree with: Every year, there are many new tree seedlings of timber trees in Namibia's forests that survive.
- Do you agree with: Rosewood/ushivi is one of the most common trees in Kavango's forests.
- Do you agree with: Kiaat is one of the most common trees in Kavango's forests.
- How old do you think a kiaat tree with a tree diameter of 45 cm is?
- Do you agree with: Forest tree seedlings need water and shade.
- Where have you planted trees (near house or homestead/in forest/near field/elsewhere/never)?

- Which forest tree species have you already planted? (add a few species here to choose from)
- Why do you need to prune a tree (to collect firewood/to increase growth/to obtain a single straight stem/to remove dead wood/I do not know)?
- How long does it take for silver cluster-leaf tree to grow to pole size (e.g. diameter of 15 cm)?

Another reason may be that not all questions were well understood, for example, it is doubtful that many of the respondents know what thinning a forest means. Especially negative statements appeared difficult to evaluate because of the double negation. The least understood statement had a double negation (I do not understand if people in Windhoek are unhappy if we cut down big tree). A final reason may be that not all questions were accurately answered. In many of the local cultures of Namibia, people do not like to admit that they do not understand something. So the ratio of participants that indicated that they did not understand a question is probably underestimated.

Very positive is that almost all participants are open to learning more about SFM and listening to others' opinions on SFM, which is an ideal starting point for the NSFM-Project.

9 Key messages and recommendations

A SWOP analysis was used to describe the status quo of the forestry sector and the challenges faced by SFM based on all information collected in the previous chapters.

9.1 Strengths

- Namibia has a policy framework that strongly supports SFM,
- There are many local forest inventories for the community forests with a treasure of information on Namibia's vegetation and natural resources,
- The recently established Bush information System (BIS) has detailed, nation covering information on the woody cover and canopy height for Namibia,
- Many forests and woodlands in Namibia are so far from roads and population centres that they are most likely not overharvested yet.

9.2 Weaknesses

- No comprehensive forest monitoring has been done for Namibia yet, while regional forest inventories are incomplete, outdated, and never repeated.
- The three state forests are not declared yet.
- There is no reforestation/afforestation in Namibia, despite a declining total forest area,
- The Forest Act and Regulations must be more specific, especially regarding the definition of forest, the "protected plant" status, the information the management plan should give and how the allowable harvest should be determined.
- The pole size indicated in the forest regulations is too big (15 – 30 cm), creating a loophole for overharvesting young trees in the forest.
- The permit system used by the Directorate of Forestry lacks a system to report back on the permits issued and summarise this in a way that can inform management decisions.
- A lack of skills and resources in the forestry sector is a major obstacle to SFM; the Directorate of Forestry has a very small budget and a small pool of well-trained forest technicians and managers. CFs have very little forestry knowledge, while forest researchers are very few and scattered over several institutions.
- Forest policies are not always well known and applied, even by Directorate of Forestry staff.
- The CFs appear to have become a tool for harvesting more trees, rather than harvesting sustainably. Common ownership fuels a tendency to "mine out" available wood.
- There is no independent quality control of forest inventories, management plans and allometric equations, which can lead to incorrect estimations of sustainable harvest (TAO).
- The management plans of most CFs are outdated or incomplete.
- There is no silviculture applied in Namibia; forest management is restricted to the bare extraction of resources with a trend of overharvesting young trees for droppers and poles.
- There are not enough indigenous trees grown in Namibia's nurseries, especially not enough for afforestation.
- There is very little public awareness on which tree species are indigenous and most suitable for the different regions of Namibia.
- There are no production trials with indigenous tree species of different provenances. This would allow selecting high-quality mother trees from which seeds can be collected or cuttings taken.
- Value addition for indigenous timber and NTFPs is too limited.

9.3 Opportunities

- The recently established BIS provides a unique opportunity to create an updated forest map for Namibia.
- Considering that the main driver of deforestation is the conversion to agricultural land, one of the best ways to slow down deforestation is to intensify agricultural production.
- The ongoing revision of the Forest Act and Regulations provide an opportunity to add more specifications, especially for the forest management plan.
- The Forest Act provides for the establishment of regional forest reserves, which could be considered for areas where ecological or wildlife corridors are needed.
- Deliberate efforts to overcome technical and management skills shortages in DoF and community forests must be made, preferably with short, applied and targeted courses.
- There are tremendous opportunities for forest and woodland research in Namibia as there is a general lack of information needed for SFM. For example, more research on assisted tree regeneration is urgently needed. The analysis of decennia of data collected in fire trials of DoF would provide urgently needed fact-based advice on fire management. Collaboration between institutions and people should be encouraged, potentially culminating in an independent, non-governmental research institute, possibly in cooperation with agroforestry and INP sectors.
- The establishment of at least 12 new PSPs for Namibia's woodlands as part of the SECO project will provide more information for SFM, especially on tree mortality and regeneration.
- Assisted tree regeneration in Namibia's forests offers a less expensive and potentially more successful option than planting indigenous trees.
- Cultivating indigenous fruit and timber tree species would improve food security and economic independence of local communities and it would reduce the pressure on natural forest and woodland resource stocks.
- Active coppice management shows a lot of promise, especially in the mopane woodlands.
- The continuously evolving carbon credit market may offer other ways of income for CFs by increasing fire intervals.

9.4 Threats

- The state forests are not legally protected until they are proclaimed.
- Global demand for African hardwood increases (this could become an opportunity if timber prices and value adding increase in Namibia).
- With northern Namibia projected to become warmer and drier, fire frequency is expected to increase.
- Deforestation for agriculture continues in northern Namibia, even in CFs, especially threatening the riverine forests along perennial rivers.

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Appendix 1: Declared Community Forests in Namibia

Community Forests	CF Area (ha)	Declaration
Kavango East	**211,742**	
Hans Kanyinga	32,000	2006
Ncaute	12,405	2006
Cuma	11,550	2013
Gcwatjinga	31,897	2013
George Mukoya	48,600	2013
Likwaterera	13,790	2013
Muduva Nyangana	61,500	2013
Kavango West	**174,266**	
Mbeyo	41,000	2006
Ncamagoro	25,000	2006
Ncumcara	15,000	2006
Kahenge	30,000	2013
Katope	63,266	2013
Kunene	**1,685,293**	
Marienflus	303,795	2013
Okondjombo	193,434	2013
Orupembe	356,500	2013
Otjiu-West	107,913	2013
Puros	356,909	2013
Sanitatas	144,728	2013
Ehi-Rovipuka	222,014	2018
Ohangwena	**126,453**	
Okongo	75,000	2006
Omufitu wekuta	29,197	2013
Omundaungilo	22,256	2018
Omaheke	**2,726,680**	
Eiseb	662,500	2018
Omuramba Ua Mbinda	382,400	2018
Otjombinde	589,100	2018
Epukiro	1,092,680	2019
Omusati	**111,700**	
Uukolonkadhi	111,700	2006
Oshana/Omusati	**109,218**	
Otshiku-Shithilonde	109,218	2018
Oshikoto	**3,302**	
Ohepi	2,495	2013
Oshaampula	807	2013
Otjozondjupa	**3,490,351**	
M'kata	86,671	2006
Nyae Nyae	901,885	2013
African Wild Dog	382,400	2018
Na#jagna	629,837	2018

Community Forests	CF Area (ha)	Declaration
Ondjou	876,280	2018
Otjituuo	613,278	2018
Zambezi	**91,434**	
Bukalo	5,323	2006
Kwandu	21,422	2006
Lubuta	19,914	2006
Masida	19,917	2006
Sikanjabuka	4,243	2006
Sachona	12,354	2013
Zilitene	8,261	2013
Grand Total	**8,730,439**	

Appendix 2: Names of common and socio-economic trees of Namibia

This appendix consists of two tables. The first table lists trees alphabetically by scientific name and the second lists trees alphabetically by the common name used in the text.

Scientific name	**Common names**
Acacia erioloba	camelthorn, muhoto
Adansonia digitata	baobab
Baikiaea plurijuga	Zambezi teak, mukusi, mukusu
Baphia massaiensis	sand camwood
Bauhinia petersiana	white bauhinia
Berchemia discolor	bird plum
Burkea africana	red syringa, wild seringa, musheshe, mukarati
Colophospermum mopane	mopane
Combretum apiculatum	kudu-bush, red bushwillow
Combretum collinum	variable Combretum, mububu
Combretum imberbe	leadwood
Combretum zeyheri	large-fruited bushwillow
Commiphora africana	hairy corkwood
Commiphora angolensis	sand corkwood
Dialium englerianum	Kalahari podberry
Diospyros chamaethamnus	dwarf jackal-berry
Grewia spp.	raisin bush
Guibourtia coleosperma	false mopane, ushivi, rosewood, musivi, muzauli, mchici, musibi
Ochna pulchra	peeling plane, lekkerbreek
Philenoptera nelsii	Kalahari apple-leaf
Pterocarpus angolensis	kiaat, mukwa, mulumbe, mukwa
Schinziophyton rautanenii	mangetti, mugongo
Sclerocarya birrea	marula
Spirostachys africana	tamboti
Strychnos cocculoides	monkey orange, maguni, uguni
Strychnos punges	spine-leaved monkey-orange
Terminalia sericea	silver cluster-leaf, muhonono, mugoro
Ximenia americana	blue sourplum

Common names	***Scientific name***
Baobab	*Adansonia digitata*
Bird plum	*Berchemia discolor*
Blue sourplum	*Ximenia americana*
Camelthorn	*Acacia erioloba*
Dwarf jackal-berry	*Diospyros chamaethamnus*
False mopane	*Guibourtia coleosperma*
Hairy corkwood	*Commiphora africana*
Kalahari apple-leaf	*Philenoptera nelsii*
Kalahari podberry	*Dialium englerianum*
Kiaat	*Pterocarpus angolensis*
Kudu-bush	*Combretum apiculatum*
Large-fruited bushwillow	*Combretum zeyheri*
Leadwood	*Combretum imberbe*
Mangetti	*Schinziophyton rautanenii*
Marula	*Sclerocarya birrea*
Monkey orange	*Strychnos cocculoides*
Mopane	*Colophospermum mopane*
Peeling plane	*Ochna pulchra*
Raisin bush	*Grewia* spp.
Red syringa	*Burkea africana*
Sand camwood	*Baphia massaiensis*
Sand corkwood	*Commiphora angolensis*
Silver cluster-leaf	*Terminalia sericea*
Spine-leaved monkey-orange	*Strychnos punges*
Tamboti	*Spirostachys africana*
Variable Combretum	*Combretum collinum*
White bauhinia	*Bauhinia petersiana*
Zambezi teak	*Baikiaea plurijuga*

The Member States of the European Union have decided to link together their know-how, resources and destinies. Together, they have built a zone of stability, democracy and sustainable development whilst maintaining cultural diversity, tolerance and individual freedoms. The European Union is committed to sharing its achievements and its values with countries and peoples beyond its borders. Visit the EU website: **http://europa.eu**

The Hanns Seidel Foundation (HSF) is a German non-profit organisation (NGO) currently implementing roughly 100 projects in 70 countries worldwide. The HSF Namibia office was established in 1978. In collaboration with its local project partners, HSF Namibia is committed to the promotion of democracy and good governance, the rule of law and anti-corruption, sustainable development, and environmental sustainability as well as climate change mitigation and adaption. Through each of its respective projects, the organisation seeks to facilitate information-sharing and active civic engagement in all facets of society. Visit the HSF website: **www.hss.de/namibia/en**

The Desert Research Foundation of Namibia (DRFN) is a Namibian NGO which has served both communities and government in the building of capacities for sustainable development since Independence. DRFN projects are implemented across several key thematic areas including energy, land, and water for which a combination of institutional knowledge, field research and experience as well as local and national relationships are utilised. The DRFN also provides support to multiple stakeholders ranging from government, decision-makers, community members, local authorities, and private sector actors in the development, planning and implementation of policies in support of sustainable development. Visit the DRFN website: **www.drfn.org.na**