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Is there a win for conservation, livelihoods and governance?

– The implications of *Broussonetia papyrifera* as an ecological resource substitute. A field study in Uganda

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Abstract

Wood extraction and invasive species are commonly perceived as harmful for ecosystem services and detrimental for conservation efforts. However, they can also be beneficial for forests as well as for local communities. Interactions among economic, institutional and ecological factors may in some cases turn these impacts on their head. Here, I present a case study of a location where this may be the case. Villages often depend on nearby forests for natural resources, as is the case around Mabira Central Forest Reserve in Eastern Uganda, where such needs are intensified by the lack of other income-generating opportunities. The demand for forest products such as charcoal and firewood is high due to population pressure and the cost of other energy sources. The park is managed by the Ugandan National Forestry Authority (NFA) and faces pressures from within the reserve and from external actors. It is also beset by a lack of functioning governance structures. This demand for wood products is to a high degree met by *Broussonetia papyrifera*, an invasive exotic tree introduced in the 70s. As a fast-growing species, it supports multiple uses that may spare slower-growing native species from being harvested. It has also shown positive effects on soil fertility. This study compares previous biodiversity data from these sites with current forest measurements and data gathered through social science methods including semi-structured interviews, key informant interviews and focus group discussions in two communities adjacent to the forest reserve. Results show that although still controversial for conservation efforts, *Broussonetia papyrifera* can support the regeneration of indigenous species and as such increase species richness and at least maintains biodiversity. The results also show that *Broussonetia papyrifera* has a crucial role for local livelihoods as it supplies various provisioning services such as fodder for livestock, fuelwood for energy, medicinal use, raw material for timber and poles and regulating services such as a soil fertilizer and stabilizer. It also has medicinal uses that are not explored yet. In a country like Uganda where there is a lack of strong institutions, implementing forest protection policies, *Broussonetia papyrifera* acts as a resource substitute with the potential to help avoid further degradation deeper in the reserve and to support local livelihoods.

Keywords: Biodiversity – *Broussonetia papyrifera* – Mabira Central Forest Reserve – Forest Regeneration – Community Involvement – Resource substitution

Zusammenfassung

Energieholzgewinnung und invasive Arten werden oft als schädlich für Ökosystemdienstleistungen als auch für Naturschutzbestrebungen gesehen. Dennoch sind solche Arten auch nützlich sowohl für den Wald als auch für die lokale Bevölkerung. Wechselwirkungen zwischen den ökonomischen, institutionellen als auch ökologischen Faktoren stellen diese auf den Kopf. Diese Arbeit beschreibt eine solche Fallstudie. In vielen Gegenden der Welt sind Bewohner abhängig von nahegelegenen Wäldern. Eine solche Situation existiert auch in Ost-Uganda im Mabira Reservat, wo solche Bedürfnisse durch mangelnde einkommensschaffende Maßnahmen verstärkt sind. Der Bedarf für Waldprodukte wie Holzkohle und Brennholz ist, auch auf Grund des Bevölkerungsdruckes und den hohen Kosten für andere Energiequellen, hoch. Das Reservat wird von der nationalen Forstbehörde (NFA) geführt. Die große Nachfrage nach Waldprodukten wird zum Großteil von *Broussonetia papyrifera* gedeckt, einer invasiven, exotischen Baumart, die in den 70er Jahren dort eingeschleppt wurde. Als schnellwüchsige Art, bringt sie eine Vielzahl an Nutzungen mit sich nicht zuletzt, da sie langsam wachsende Arten schützt und auch die Bodenfruchtbarkeit erhöht. Die vorliegende Arbeit vergleicht frühere Daten mit aktuellen Waldmessungen und kombiniert diese mit Biodiversitätsindikatoren sowie sozialen Daten aus teilstrukturierten Interviews, Schlüsselpersoneninterviews und Gruppendiskussionen in zwei angrenzenden Bevölkerungsgruppen. Die Ergebnisse zeigen, dass *Broussonetia papyrifera*, trotz verbleibender Kritik für Naturschutzbestrebungen, die Regenerierung von einheimischen Arten unterstützt sowie Artenreichtum erhöht und Biodiversität zumindest erhält. Die Ergebnisse zeigen, dass der Baumart eine Schlüsselrolle für die lokale Bevölkerung zukommt, da sie unterschiedliche Dienstleistungen innehält: als Futtermittel für Nutztiere, Brennholz für Energiegewinnung, medizinische Nutzung, Rohstoff für Schnittholz und Masten sowie für Bodenfruchtbarkeit und als Stabilisator. In Uganda ist die Implementierung von Waldschutzbestimmungen mangelhaft. Auch deshalb kann *Broussonetia papyrifera* als Rohstoffsubstitution wirken, um besonders weiteren Degradierungen tiefer im Reservat vorzubeugen und um die lokale Bevölkerung in, dieser sich klimatisch verändernden Zukunft, zu unterstützen.

Schlüsselwörter: Biodiversität – *Broussonetia papyrifera* – Mabira Zentralreservat – Walddegradierung – lokale Einbindung – Rohstoffsubstitution

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Abbreviations

CBO	Community-based Organization
CFM	Collaborative Forest Management
CFR	Central Forest Reserve
DBH	Diameter at breast height
FGD	Focus group discussion
FM	Forest management
GHG	Greenhouse gas
IEA	International Energy Agency
IFRI	International Forestry Resources and Institutions programme
IGN FI	Institut national de l´information geographique et forestiere
INDC	Intended Nationally Determined Contribution
IUCN	International Union for Conservation of Nature and Natural Resources
LFR	Local Forest Reserve
MWE	Ministry of Water and Environment
NFA	National Forest Authority
REDD+	Reducing Emission from Deforestation and Forest degradation plus Sustainable Forest management, conservation and enhancement of forest carbon stocks
SCOUL	Sugar Corporation of Uganda Limited
SDG	Sustainable development goal
SFM	Sustainable Forest Management
THF	Tropical High Forest
UNEP	United Nations Environment Programme
UNHS	Uganda National Household Survey

1 Introduction

Significant areas of tropical forests continue to disappear, and biodiversity is lost with them (Carreño-Rocabado *et al.*, 2012; Mwawu & Witkowski, 2008). This has consequences for the provision of essential products (food, fuelwood, timber, and medicine) that are the basis for local livelihoods, for ecosystem regulating functions (climate regulation, nutrient provision, and water cycling) as well as for recreational activities (Rands *et al.*, 2010). Hence, by reducing the variety of genes, species and ecosystems, forest degradation causes loss of various essential services for society. Thus, the term ´forest degradation´ in this thesis is understood as a conversion from a native species cover to a cover dominated by an invasive, exotic spcies, resulting from overexploitation and inappropriate use both from subsistence and commercial use (Nel, 2014; Lambin *et al.*, 2001). Eventually, such exploitation impacts the carrying capacity of forests, leading to changes in biodiversity and in the provision of ecosystem services.

However, such change is not necessarily negative when the broader social and ecological context of ecosystem functions is considered (Hajdu & Fischer, 2016; Rist *et al.*, 2014). Meanwhile, biological introductions and invasions have resulted in changes to biodiversity and ecosystem functioning across the globe that further impact the provision of ecosystem services (Wardle *et al.*, 2011; Grosholz, 2005). Halting losses of such services requires action and strategic long-term conservation management (Dawson *et al.*, 2017). Such management is also suggested by the Sustainable Development Goals (SDGs) upon which Member States at the United Nations Conference on Sustainable Development (Rio+20) agreed upon wherein forests play an integral part (Goals 6 & 15) (IIED, 2015). Under the SDGs, priority shall be given to marginalized poor communities as making the connection between people´s activities, and socio-cultural background is vital for decision-making on their natural resource use (Berkes, 2004; Seymour & Busch, 2016).

Population pressure in developing countries leads to an enormous biomass demand. Often this leads to overexploitation of resources as people rely on forests to maintain their livelihoods. However, , holding the poor in local areas solely accountable misses the wider point. Their activities can be the proximate cause of forest-cover change or degradation (Stringer, 2009; Lambin *et al.*, 2001), but the underlying causes of what pushes people to exploit forest resources are too often ignored (Altieri & Toledo, 2011). The International Renewable Energy Agency (IRENA) in 2015 estimated that about 730 million people in Africa currently rely on biomass fuels. They are the single most important primary energy source, accounting for about half of the energy supply in 2013 with an annual growth rate of about 3%. Furthermore, 600 million people remain without access to electricity (IRENA, 2015). Woody fuels across Africa account for about 40% of forest income. The majority is covered by fuel wood, while charcoal makes up roughly 5% of it. Construction materials (timber, poles, building materials) comprise about 25%, while food accounts for another 30% (Angelsen *et al.*, 2014). In urban areas charcoal is essential as it easier to transport than firewood (IRENA, 2015) and is a significant source of income accessible to the rural poor (Arnold *et al.*, 2006). Charcoal is primarily produced in inefficient earth kilns causing higher GHG emissions than improved charcoal production processes with negative multiplier effects on human health (Ekeh *et al.*, 2014). Hoffmann (2016) argues that by 2030 even with very optimistic assumptions, the wood-based energy use will remain at two-thirds of today´s levels, while charcoal will stay the primary source of energy for the urban area across Sub-Saharan Africa.

Fuelwood dependence on fuelwood is strongly linked to poverty (Démurger & Fournier, 2011; Heltberg, 2004; Lee, 2013; Arnold *et al.*, 2006; IEA, 2002). In many cases, woody fuels are the most available option for rural and urban populations to cover basic energy needs and generate cash income. However, it will be challenging to support livelihoods of future generations with current rates of exploitation (Kambugu *et al.*, 2013). In practice this means that conservation management shall not only encompass a shift in local resource use as the charcoal use is a regional-scale economy.

Changing resource-use practices can lead to various trajectories in ecosystem response to those changes (Mayfield *et al.*, 2010) that modify species composition, and thus also biodiversity of an ecosystem. Biodiversity supports forest ecosystem functioning and fosters the provision of crucial ecosystem services (Harrison *et al.*, 2014; Kricher, 2009) which are vital for rural communities in form of food, fodder, fiber and medicines. Recent research has

described functional relationships between biodiversity and such ecosystem services (Diaz *et al.*, 2006). Analysis of functional traits has proven to be especially useful in understanding links between species, processes, and services (Harrison *et al.*, 2014). Species traits are closely related to the species´ ecological function and contribution to ecosystem services (Díaz & Cabido, 2001). Furthermore, early- successional ecosystems recovering from disturbance or growing following abandonment of other land uses, are dominated by fast-growing plant species.

Fast-growing species drive changes in plant communities with, for example, high rates of resource use per unit biomass (Garnier *et al.*, 2004; Bernard-Verdier & Hulme, 2015). Such early-successional species are often exotic invaders and are considered detrimental to biodiversity. Their dispersal is often supported both by natural and anthropogenic disturbances (Kyereh *et al.*, 2014). They play different roles in ecosystems where they appear (Bernard-Verdier & Hulme, 2015) as they interact with species that are already there (Russo *et al.*, 2014) which remains challenging to predict. Many exotic species enhance their own success through positive feedbacks (Suding *et al.*, 2008). The spread of such species can change the structure, composition, function, and process of native ecosystems (Bernard-Verdier & Hulme, 2015; Vilà *et al.*, 2011; Pyšek *et al.*, 2012; Simberloff *et al.*, 2013), but they can also bring positive interactions for native species and ecosystems (Russo *et al.*, 2014) . Although the distribution of invasive species influences both regional and global environmental changes (Rejmanek, 2015; Kalusová *et al.*, 2013; Simberloff *et al.*, 2013), the consequences of such changes remain widely unknown as they compensate for variations of other species (Russo *et al.*, 2014) and enhance resilience of the ecosystem. That is why the study of invasion by exotic species is important in ecology and of global concern for conservation biology, which then further determines the need for control and management measures (Becerra & Montenegro, 2013; Levine *et al.*, 2003; Haysom & Murphy, 2003).

Uganda is a country with a developing agrarian economy in which over 90 percent of its people rely heavily on natural resources for their livelihoods (Mwawu & Witkowski, 2008). About two thirds (64%) of Ugandans use firewood and about 30% use charcoal (UNHS, 2017). Also, a big portion of small-scale industry is fuelled by biomass from forests (MWLE, 2001). With an annual population growth rate of 3.3% the country ranks as the 6th fastest growing in the world (World Bank, 2018). Energy security is a major issue for economic development and better living standards. Uganda´s per capita energy consumption is only 2.7% of the world average (Lee, 2013). According to the country´s Intended Nationally Determined Contribution (INDC) from 2015, the

forest cover shall increase from 12% in 2015 to 21% in 2030 (MWE, 2016), which in light of the high demand for forest products remains a challenge. In 2015, MWE revealed that the total forest cover between 1990 and 2015 shrank by 47%. A similar image is also depicted by Hansen *et al.* (2013), who for the period between 2000 and 2012 alone calculated a net forest loss of 2,969 km^2 for Uganda. Encouragingly according to authorities, each year about 200 km^2 of land is replanted on private tree plantations (MWE, 2017). Plantation establishment is often portrayed as one such solution, which de facto brings problems to local people related to disregarded land rights and a decline in food security (Hajdu & Fischer, 2016). The increase in monoculture tree plantations, however, does not compellingly increase biodiversity, fairly the opposite as the increase in forest cover does not stem from regrowth of natural forests.

This study looks at aspects of rural livelihoods, forest degradation and biodiversity and invasive species in Mabira Central Forest Reserve where all these factors overlap. I thus intend to integrate the local context of the study site to be able to argue that a single invasive species, *Broussonetia papyrifera* is both beneficial for local livelihoods and can enhance regeneration of the forest reserve.

1.1 Background on Mabira CFR

Mabira Central Forest Reserve (CFR) is the forest in focus of this study. It is an ideal study site as *B. papyrifera* (the paper mulberry) dominates the formerly populated parts of the reserve and remains there after intense exploitation due in part to past external political pressures. Yet, it is also subject of current political pressures giving it full public attention (NTV Uganda, 2018) as *´the disappearing forest´* questioning the integrity of the CFR, a narrative frequently used to justify evictions of local people.

In 1994, the government banned harvesting in forest reserves for everyone except communities neighbouring reserves who were, and still are, allowed to use resources such as dead wood, food and medicinal plants for subsistence purposes (Baranga, 2007). Massive forest exploitation in the 1970s and 80s continued up until 1995, when community involvement in the management of Mabira CFR started and a decentralization process was intended (Galabuzi *et al.*, 2015) as political leadership at the time encouraged extensive degradation inside CFRs as well as the reformation of the forestry sector. Some of that perseveres today. Decentralization of rules and regulations was necessary to increase legitimacy for local communities and to adapt to the relevant local context (Banana *et al.*, 2007). These changes were captured in: the Forest Policy

in 2001, a new ´National Forest Plan´ in 2002 and the ´National Forestry and Tree Planting Act´ in 2003. The latter paints people using the reserves as ´encroachers´ even though this description is problematic and over-generalizing and often completely incorrect if people are local residents following the above stated rules (Lyons *et al.*, 2017), while often depicting the private sector as a potential saviour (Nel, 2014). As it stands, current forest policies remain uncoordinated and some actors exploit this confusion for further deforestation (Nel, 2014).

In 2003, the management of CFRs was handed over to the autonomous National Forest Authority (NFA) (Banana *et al.*, 2007) which is one out of four principal actors for the management of forests in Uganda. In 2007, the government together with the commercial enterprise Nile Ply Ltd. increased the pressure on the reserve. ´T*he degazettement proposal´* aimed at eliminating the legal protection of parts of the reserve by converting it to sugar cane plantations. The proposal has not yet been implemented, most likely due to the vast amount of protest (Galabuzi *et al.*, 2014) within the country´s densest populated area (225 people per km^2) (Child, 2009). As the reserve is bordered on two sides by tea and sugarcane plantations run by SCOUL, the government aimed to follow the company´s request to allow sugarcane plantations (Nature Uganda, 2011) which remains a threat up until today.

Figure 1. Forest patch after clearing. (Photo, own picture)

1.2 Background on *Broussonetia papyrifera*

1.2.1 Ecological properties of *B. papyrifera*

The paper mulberry is a medium-sized, deciduous, hardy fast-growing tree native to north-eastern Asia (Japan, Taiwan) (Chang *et al.*, 2015; CAB International & IUCN, 2009). It can cope with a variety of climates, being hardy enough to survive even in northern Europe, however not as strong as in warm, humid climates (CABI, 2018). It thrives in openings created in the forest canopy (Addo-Fordjour *et al.*, 2009), regenerates well after fire (CAB International & IUCN, 2009), has high seed viability and abundant seed production (540,000

seeds per kg) (Peñailillo *et al.*, 2016; CABI, 2018) and it reaches maturity at between six months to a year (Kisekka, 2012) with a rotation period of usually 4 -6 years.

Paper mulberry not only grows fast from seeds, but also from stump and root sprouts (Kyereh *et al.*, 2014; Bosu & Apetorgbor, 2010) and it coppices vigorously (CABI, 2018). Its leaves are of high nutrient concentration (phosphorus and nitrogen), and they are easily decompostable, which pushes them into the fast carbon return group (Kyereh *et al.*, 2014). It fruits twice a year as documented by Tweheyo & Babweteera (2007) while larger individuals tend to fruit more (Kyereh *et al.* 2014). *B. papyrifera* has male and female flowers on separate individuals. When only male clones (no seeds) are introduced it does not act invasive (Whistler & Elevitch, 2006). But, with both male and female plants, wind transport distributes it and thus establishes a self-regenerating population (Peñailillo *et al.*, 2016).

1.2.2 Uses of *B. papyrifera*

People have traditionally used its inner bark for coarse-textured parchment (Watanabe *et al.*, 2004). The paper mulberry produces large amounts of aboveground biomass even after a short-fallow of only two years (Aubertin, 2004). It is adapted to all kinds of soils, although it does not do well on rocky and dry ground (Malik & Husain, 2007) and functions as a soil stabilizer, waste-water bioremediatory, food source as well as a resource for construction and medicinal purposes (Sun *et al.*, 2012; Tweheyo & Babweteera, 2007; Whistler & Elevitch, 2006; Van Dusen, 2017). It is rather short-lived, soft-wooded and weak compared to other comparable timbers in respect to mechanical properties, hence less durable but it produces significant amounts of leaf litter which decompose fast, suggesting a faster nutrient return into the soil (Anning & Gyamfi, 2017). Its fruits are rich in several mineral elements and vitamins usable in dietary supplements or as food additives (Sun *et al.*; 2012).

Figure 2. Inflorescence of a female *B. papyrifera*.tree (Photo, own picture)

1.2.3 Historical background of *B. papyrifera*

To achieve successful reforestation within a reserve dominated by *B. papyrifera*, the implementation of a *Taungya* system was intended in Ghana and it might be the most promising practice. A *Taungya* system is a form of reforestation system that establishes food crops in association with tree species, until the trees close the canopy (UNEP, 2012). Such a reforestation system was experimented with in a Ghanaian forest reserve where the establishment of the paper mulberry was supposed to be hampered by providing enough initial shade with the prevalence of other fast-growing species or food crops. The long-term feasibility remains unclear, and no concreate management measures followed the project in the Ghanaian reserve (ibid).

Figure 3. A stack of cut *B. papyrifera* for charcoal burning. (Photo, own picture).

Paper mulberry can be used for multiple purposes and as indicated above it grows under a variety of conditions. As documented by Haysom & Murphy (2003), *B. papyrifera* (Family: Moraceae) is regarded as both naturalized and invasive in Uganda and Ghana. It was first reported in Uganda in the 1950s (Kisekka, 2012) while the species has partially colonized Mabira CFR in the 1970s. It was introduced either by local people or by the government (dispersal via airplanes has been claimed) while MWE (2017b) claims forest researchers to be responsible for its introduction.

1.3 State-of-the-art

The worldwide task of maintaining biodiversity and pushing for conservation while meeting demands for food and forest products remains discouraging (Harrison *et al.*, 2014). Everyone obtains an array of benefits from diverse ecosystems. However, the rural poor and subsistence farmers face the most serious and urgent risk from biodiversity loss (Diaz *et al.*, 2006) as they are most dependent on the access to basic materials from the forest.

Due to people´s use of forest products, biomass consumption in the short and medium term across Africa, will most likely grow, causing parallel increases in deforestation (Hoffmann, 2016). In CFRs such as in Mabira, conservation practices need to simultaneously integrate both changes in the resource use and behaviour of people which is linked to their empowerment (Galabuzi *et al.*, 2014), as well as the management of threats hailing from the commercial

pursuits of the sugar and tea companies which border the reserve (Welch Devine, 2004). Constraining use of forest resources by local people is challenging (Galabuzi *et al.*, 2014). However, in most cases local degradation is intensified by commercial exploitation caused by high external pressures leading to an increase in exploitation - ´mega development´ (Lambin *et al.*, 2001; Benjaminsen (1997). Fuelwood scarcity may lead to the usage of more available fuels (Benjaminsen, 1997), thus more accessible woody species. Such harvesting is supported by the local by-law of NFA. With respect to empowerment, NFA established a by-law following decentralization efforts in the Forest and Tree Planting Act (2003) valid in the entirety of Mabira CFR, allowing people only on weekends to get headloads with dead wood out of forest for subsistence use.

Figure 4. Firewood transport for market. (Photo, own picture)

Emerging evidence shows that exotic species can facilitate regeneration in forest ecosystems (Svriz *et al.*, 2013; Becerra & Montenegro, 2013; Rodriguez, 2006). As documented by Eilu *et al. (*2007) people often prioritize species based on their marketability, availability and establishment in the field of them (Galabuzi *et al.*, 2014) and favour those that provide shade and construction materials, regenerate quickly and resist pests. Such requirements are then often the economic entry point for exotic species as they are often profitable, fast growing and have readily available markets (Eilu *et al.*, 2007; Galabuzi *et al.*, 2014). Research suggests that some exotic species change soil chemistry and ecosystem processes (Gibbons *et al.*, 2017) and in early stages of forest regeneration fuel an increase in for example net primary productivity. Paper mulberry grows continuously with adequate soil moisture, which may pose a severe threat to the native ecosystem richness and diversity as well as it does stand in competition with root crops (CAB International & IUCN, 2009). Paired with a lack of adequate and systematic management and its widespread dispersal by birds and bats eating its fruits, *B. papyrifera* covers high-light habitats within a short time (Agyeman *et al.*, 2016). However, such availability might also contain certain benefits.

2 Objectives & Hypotheses

The purpose of this thesis is to describe the contribution of the invasive paper mulberry tree to local livelihoods in Mabira CFR and to describe its ability to facilitate regeneration of the forest. Its socio-economic potential stems from its nearly inexhaustible source of various products like fodder for the communities´ livestock, firewood and cash generation from the selling of charcoal.

Apart from satisfying multiple resource demands, paper mulberry also cushions other species (slower-growing indigenous ones) from further degradation. Incorporating new findings of this widely dominating species and its implications in the existing enrichment practices and policies in Mabira CFR are therefore needed and thus an object of this thesis. The species potential to facilitate regeneration is based on an analysis comparing previous forest inventories of the area. By doing a biodiversity analysis, a more critical examination of its specific impacts is done. As such, the paper mulberry is analysed from its social and ecological dimension which is not a common practice in human livelihood and biodiversity conservation literature (Persha *et al.*, 2011). Resulting in an enhancement of ´practical wisdom´ which thus stems in both local knowledge of people´s practices as well as in scientific knowledge (Adams & Sandbrook, 2013), to be able to dismantle the prevailing negative representation of the paper mulberry.

Interwoven in this context are big land use conflicts, mutual distrust between local people and authorities and common corruption cases even at a small -scale. Considering population pressure in such a densely populated area and the lack of alternative sources of income, the pressure on the forest will likely continue to rise. Most of which relates back to the particular historical background of the area, particularly events following 1989 when efforts started to rehabilitate the reserve. Abandoned banana (*Musa sapientum*), corn (*Zea mays*) and jackfruit (*Artocarpus heterophyllus*) plantations continued to form an integral part of the forest (Baranga, 2007). Local people whose livelihoods depend on the forest, are and will most likely continue to be further marginalized and impoverished as

external pressures such as the high urban market demand for fuelwood and commercial exploitation for tea and sugar are on the rise and lead to more exploitation. Participatory approaches that include both farmers and experts are needed as knowledge is often unevenly distributed, however, such approaches only work if farmers are given a real ´seat at the table´ (Koning & Smaling, 2005; Lyons *et al.*, 2017). Such a status quo gives reforestation strategies able to mitigate alike demands, high priority (Lee, 2013), as well as the availability of woody species readily available with little negative impact on local species composition and biodiversity. The following research questions address the above-mentioned issues and are tackled within this thesis:

RQ1: *What is the potential of Broussonetia papyrifera to facilitate the regeneration of indigenous tree species and how is biodiversity of Mabira CFR affected?*

RQ2: *What socio-economic impacts does Broussonetia papyrifera have and what role does it play in the local livelihoods?*

RQ3: What factors inhibit land management in the study area?

The tree composition in the area of interest in Mabira CFR is critically analysed to make a statement about current species composition and biodiversity, while also considering its importance for the local livelihoods. As people living nearby the reserve are to a large extent dependent on it for fuelwood and construction material, resource substitutes able to mitigate for slower growing indigenous species to facilitate resource needs to maintain people´s livelihoods are required. Land management able to yield such benefits is thus required and the lack of such in the study area needs to be traced to its routing factors incorporating local governance and collaboration. There is the need to incorporate an enhancement of the present tree composition in such a strategy, which is facilitated for instance by the fast-growing, exotic species *B. papyrifera*. Following that reasoning the hypotheses of this thesis are the following:

- ***Broussonettia papyrifera* facilitates the regeneration of indigenous woody species within Mabira CFR**
- ***Broussonettia papyrifera* can yield benefits in a community that is struggling to maintain its livelihoods**
- **Lacking collaboration and weak governance inhibit a community-oriented land management in Mabira CFR**

Further details about the detailed research objectives can be found in Annex 1.

3 Methods

3.1 The study area

The present study was conducted in two communities Nakalanga and Kirugu (0.506° N, 33.079° E and 0.521°N, 33.084°E respectively), bordering the Mabira CFR. This area is about 90km east of Kampala City and about 20km north of Jinja City within the administrative boundaries of Mukono District in Wakisi sub-county (Fig. 5). According to a survey done by Nakalanga´s village leader, Nakalanga has 1,357 people (in 296 households) and Kirugu has about 500 people. The entire forest is a source of livelihoods for over 200,000 residents of neighboring communities. They use forest products as a base for food, energy, non-timber products and medicine (Nature Uganda, 2011).

The two communities comprise rather poor households with little land making the forest an important nearby source of resources (Arnold *et al.*, 2006). Mabira is classified as a Central Forest Reserve within the National Forestry-, and Tree Planting Act of 2003 and covers an area of about 295 km^2. It was established in 1932 under the Legal notice No. 87 (MWE, 2017b) under the British colonial rule. It is an essential hub for many rare and threatened species, and it is predominately occupied by tropical high forest species (Baranga, 2007). The forest is the only medium altitude semi-deciduous forest among Uganda´s protected areas and considered an area with core conservation value by the current government of Uganda and a critical biodiversity hotspot in the country (Nature Uganda, 2011). It lies between 1070 and 1340 m above sea level with undulating plains of many flat hills and broad shallow valleys. The climate is tropical with two rainfall seasons from April to May and October to November totalling between 1,250 -1,400 mm per year (Tugume *et al.*, 2016). Daily temperatures vary little, with night-time lows between 16-17°C and daytime highs of 28-29°C (MWE, 2017; Tugume *et al.*, 2016). The reserve is important as a water catchment and is the source of two rivers – Musamya and Sezibwa –

making it a critical component of the local and regional hydrological cycle (Nature Uganda, 2011).

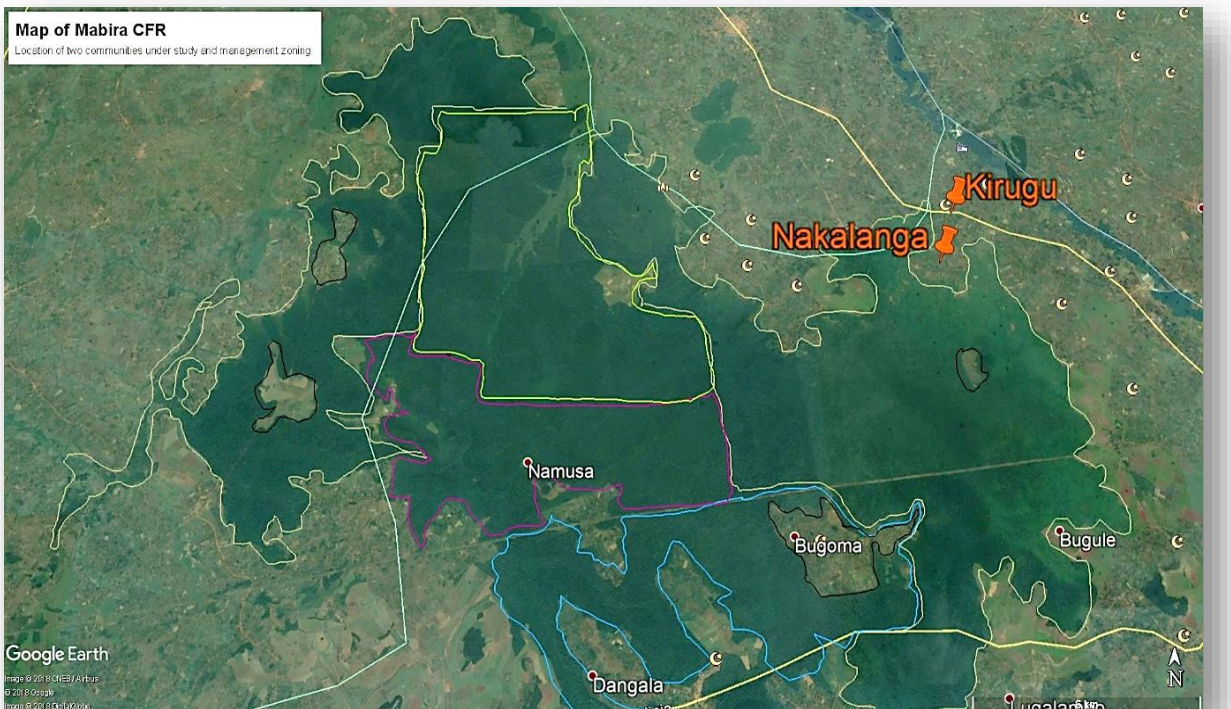
The surroundings of Mabira CFR are as diverse in people as the reserve is in species. In 1949 there was an influx of many settlers who migrated from Bugerere County, which continued throughout the 1970s with people from different tribes from the East and Central part of the country such as the Banyarawanda, Basoga, Bagisu, Bakiga, Banyankole and Batoro (Bahati, 2010; Tugume *et al.*, 2016). They remain until today in the Buganda traditional kingdom (Welch Devine, 2004). An estimated 25% of the reserve was cleared under the regime of Idi Amin in the 1970s which was fuelled by an increase in population through laid-off workers from nearby sugarcane and tea plantations (Bahati, 2010; Vedeld *et al.*, 2016; MWE, 2017). After the civil war ended in 1986, attempts to resettle workers elsewhere were made during 1988 and 1989 (Baranga, 2007). However, many people stayed, some deep in the forest (Bahati, 2010). People who managed to escape eviction and remained inside the forest, became bona fide occupants following the Land Act of 1998 (MWE, 2016).

During 1994 – 1997 the reserve was divided into multiple management compartments: ecotourism/recreation, production, buffer (´low-impact use zone´ that accounts for about 26% of the reserve) and strict nature reserve (about 21% of the reserve (MWE, 2017; Tugume *et al.*, 2016) (Fig. 5). The two communities of this study lie next to and partially in the production zone of Mabira CFR (Baranga 2007; Weldemariam *et al.*, 2017) and have previously been a research site for IFRI. In the production zone, only low impact use by neighbouring communities and silvicultural practices by private companies as well as enrichment plantings are allowed. All harvesting done by people from the community that exceeds subsistence use, is thus illegal (MWE 2017).

Figure 5. Map of Mabira CFR with the location of the two communities (Nakalanga & Kirugu) and forest management zones. Only four enclaves that are biggest are displayed here. Source `Mabira`. Google Earth. January 30, 2018. October 2, 2018.

Uganda

Buffer Zone
Recreation/Buffer Zone
Production Zone
Strict Nature Reserve
Enclave



Subsistence farming is one of the main activities in the two communities with people engaging in the maintenance of their gardens, many of which are on land which the NFA claims to be inside the border of the CFR, where they grow maize, cassava, groundnuts (peanuts), beans, cooking bananas (*matooke* in the local language Luganda) and onions and tomatoes. Many trees and shrubs are used as a food and feed source. Some of the women run small-scale business of selling tomatoes, avocados or onions to their neighbours, at the closest market or in front of their huts. Each household keeps some livestock (goats, chickens, and cows) that sometimes change owners during financial transactions among households. Infrastructure, such as the main road through the community as well as some houses, are better maintained than during previous field visits (observation from Mr. Sekindi, collaborating botanist). Nevertheless Nakalanga remains for example without a health facility. The reserve is managed by the autonomous NFA which in some areas collaborates with local communities under the Collaborative Forest Management (CFM) arrangement.

This thesis reports on both social and ecological aspects of Mabira CFR. To increase validity and to be able to analyse the research questions from multiple perspectives, triangulation of data is done by comparing multiple sources of information, including interviews with multiple types of stakeholders, historical documents and direct observation of the forest (Guion *et al.*, 2002). The type of triangulation considered is a methodological triangulation as the situation involves multiple qualitative methods such as interviews and discussions as well as forest plot data.

3.2 Forest data collection

Verbal permission was collected from the District offices of NFA to conduct field work in the forest reserve. Data from previous IFRI Forest plot forms (P), as well as data from forest plot forms from 2013 from the Nyabyeya estate from the Rwensama Central Forest in Western Uganda were consulted. Forest data was collected during the second week in the field in March 2018. Within each of the 30 plots with their equivalent GPS coordinates, woody and non-woody species were identified. The plots were structured as three concentric circles based on the IFRI methodology (IFRI, 2011). The first circle counts woody seedlings and visually estimates herbaceous ground cover. In the second circle, shrubs, saplings, and woody and herbaceous climbers are counted. In the largest circle tree stems that are ≥10 centimetres in diameter at breast height are counted (IFRI, 2011) (Fig. 6). If a species was not identified or only the local name was

known in the field, it was collected and later identified using the flora of Hamilton (1981), Katende et al., (1999), Katende et al., (1995) and Fern (2014).

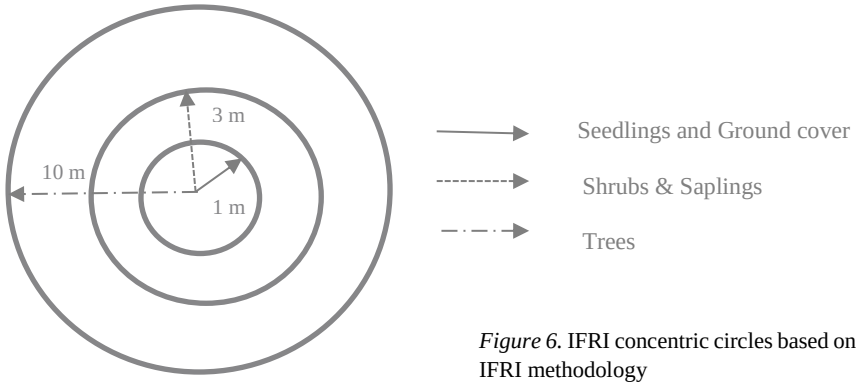


Figure 6. IFRI concentric circles based on IFRI methodology

This process was supported by the botanist Mr. Sekindi, the local guide Mr. Livingstone Kasujja and my field assistant and interpreter Ms. Bridget Babirye. As the main objective was to identify current species composition, the encountered forest composition was compared to previous field visits. However, some plots were moved (within a range of 2 – 420 feet) mostly deeper into the thicket when a clear-cut area was encountered or simply not a dense species composition was apparent at the located site. These new plot coordinates are kept as a reference for possible future research. By collecting data around the same plots, changes in the land use and the forest cover were noted down as well as the mechanisms driving the regeneration of the forest (Morris *et al.*, 2014). Gaining additional data on species abundance deeper in the production zone of the reserve can be described as a delimitation of this thesis. As described by Salk *et al.* (2013) landscape-level sampling is better for showing the larger scale context of forest change than merely noting stand-level changes over a period.

3.2.1 Statistical analyses of forest data

Chao richness (S_{Chao})

Protecting species diversity is an important goal of conservation programs as rates of species extinction are of concern for biodiversity. Depending on the particular application, there are many ways of quantifying species richness (Simberloff 1986 in Gotelli & Colwell, 2001). Species richness gives the number of species that are found in an area (Maurer & McGill, 2011). Yet, a simple count of the number prevalent in a system can be misleading, as surveys do not encounter all rare species. By using the Chao (1984), estimator this issue is bypassed as it deems rare species (with only single or double individuals)

differently than more abundant species. Thus, it also allows estimating the number of undetected species in a sample (Chao *et al.*, 2015), which are usually quite challenging to sample (Chao, 1984).

Rarefied diversity (E_s)

Rarefied diversity attempts to reduce biases due to sampling intensity. It is calculated by producing species accumulation and rarefaction calculations. In other words, a rarefied diversity calculation (E_S) accounts for diversity in sampling intensity and size, allowing for a standardized sampling of each sample while reducing bias and the problem of sensitivity to rare species (Walker *et al.*, 2008). Such rarefaction is achieved by repeatedly re-sampling the entirety of *N* individuals, to then plot the average number of species represented by *N* individuals (Gotelli & Colwell, 2001) as traditional diversity measures consider all species to be equally distinct from each other (Chao *et al.*, 2015). Naturally, species richness generally increases with the number of individuals found. To avoid biases, a comparison of such abundance of different samples needs a reduction to a standard size (n) (Hurlbert, 1971). Suggesting that rarefaction generates the expected number (E_S) of species in a smaller group of *n* individuals drawn randomly from the bigger pool of *N* individuals as means from the repeated re-sampling (ibid) (Table 1). Thus, a rarefaction calculation enabled a comparison of the number of species at a different level of the collection effort. The calculations were done by using R version 3.4.3 (R Core team, 2017).

Shannon Weaver index (H´)

In general, two logics of describing species diversity are identifiable: diversity as variance and diversity as information in which individual species act as a ´message´ of the sampled area (Maurer & McGill, 2011). As the latter is very commonly used across biodiversity literature and thus allows for comparison, it was used. Pielou (1975) called it the Shannon Weaver measure of species diversity (H´), and it is rather insensitive to rare species and focuses more on abundant species (Hurlbert, 1971; Chao *et al.*, 2014). Applied indices are displayed in Table 1.

Table 1. Indices used for the forest data analysis. Note: p_i is the proportion of individuals that belong to species i. S_{obs} is the general number of species, Q_1 represents the number of species with one individual and Q_2 the number of species with two individuals.

Index	Index category	Formula
Chao estimated richness (S_{Chao})	Richness	$S_{obs}+Q_1^2/(2Q_2)$
Rarefied diversity (E_S)	Diversity	$\sum(1-(N-Ni/N))$
Shannon´s diversity (H´)	Diversity	$-\sum P_i \ln(P_i)$

3.3 Social science data collection

For the analysis of local residents´ perspectives on their resource use, the IFRI Household (H), as well as IFRI User Group (U) forms were consulted. They address the forest users and their practices, their assessment of the forest´s condition as well as issues that they might encounter through the forest management. The purpose was to obtain comparable data, although later more open-ended questions were added to facilitate more detailed knowledge on the addressed issues. The data was collected in weeks 3-5 of the fieldwork in March 2018. This work was supported by Mr. Kasujja, a local opinion leader and very observant, reflective and expressive man who is encountered with great respect in the community presumably due to his various involvements in the local school, the CFM group, church, etc. He was also one of the few members, who managed to educate all his seven children to a higher degree. His involvement and guidance were particularly helpful as people seemed to both seek assistance and support from him as well as impose challenges and issues on him too. Towards the end of my time in the field it came to my attention that some individuals within the community including Mr. Kasujja, obtain payments from NFA in exchange for keeping an eye on people and their practices which has most likely influenced the responses received in his company. Mr. Kasujja initially organized meetings with members whom he maintained a certain level of trust with. This task was assumed by my assistant and me in the second week of field work. As he was present during three out of the four FGDs, some participants may have told us what they think that we wanted to know, such that their reputation in the village would not get tarnished. However, he was not present during the female-only FGD to be able to discuss sensitive issues.

In the process, I also introduced myself to numerous local leaders (religious leaders, opinion leader, local council, and former CFM members). As I would always be perceived as an outsider, I actively worked on being a familiar face in the community by repeatedly walking through the community, to make sure that my presence was not perceived as a threat.

The language barrier was, of course, a challenge. As most community members were more familiar with Luganda and Lusoga than with English. However, my interpreter and I had an excellent relationship and with her topic-related knowledge and her position as a member of the same ethnic group as most of the community members, these issues were largely overcome.

One limitation is that assessing changes in use over irregular periods throughout the year are tricky. Informants´ memories are biased towards recent activities that may not be representative for the entire year (Jagger *et al.*, 2012). Another limitation is one of presenting longitudinal effects, as my time in the field was limited to only four weeks which posed a constraint on identifying key members to interview and for detailed investigations.

3.3.1 Social science data collection methods

Household interviews

In total eighteen households were interviewed from various economic backgrounds. Four were previously interviewed in 2006 and 2012, whereas thirteen households were discovered by snowball sampling and convenience sampling through village walks. Four of these were identified after conducting a FGD due to their apparent interest in the topic or involvement within the village resource decisions. By using this type of purposive sampling, it was easier to reach people who are forest users, charcoal producers as well as those who are engaged in activities contrary to formal law. Five were targeted after being suggested by Mr. Kasujja as they were presumably heavy forest users or people with much knowledge of the area and finally, four households were interviewed merely out of convenience as they were home.

The household interviews were semi-structured with a guided questionnaire (Annex II) comprising questions on demography (age, sex, education) and open-ended questions about the forest, their use of it and their perception and usage of the paper mulberry tree. The interviews without exception were held in Luganda or Lusoga and were simultaneously translated in a summarized format. The presence of male family members challenged the attempt of being gender-sensitive throughout the interview process. As the possible period of approaching households was in the afternoon (2pm-6/6.30pm) after the garden work was done, most family members were merely home and available to talk. We mostly sat outside the houses in a circle to avoid the sense of being questioned. After every interview, each household received a small gift for their time and participation consisting of soap and salt packages.

Key-informant interviews

For the eleven key informant interviews, people relevant to the context of the two communities were chosen. Some of the informants were local figures of the community, whereas others where outsiders which may have limited the validity of their statements regarding local perspectives. Such people were: the village leader, a local politician, a traditional healer, the CBO MAFICO (Mabira Integrated Forest Community Organization) from another community bordering Mabira CFR, the NFA sector manager and the NFA forest supervisor, a charcoal trader, the land-title owner of the area as well as two school principals: one of the local primary school and one from the only secondary school in the area. Implementing these interviews provided a more contextual understanding of the study area without necessarily giving insights into how forest degradation impacts the local community at hand.

However, some indications for factors that inhibit ongoing reforestation efforts could be identified. As stated above, the communities presented themselves as substantially diverse in religion, background and ethnicity which in itself gives elites of each group less power (Rigon, 2014). It appeared that people within the communities where more concerned about the central government in Kampala and Jinja than with local power figures which might be related to the particular cultural mix of the area. There were, however, two exceptions: the guards and other NFA officials patrolling the area around the communities with the power to harm local residents by mostly physical punishment, but also by confiscating harvested goods or imposing fines. The second exception is the land-title owner of the area. He seemed to be generally liked by the community as he handles matters in a respectable way, yet, he was depicted as a figure of power able to halt claims of degazetting parts of the reserve to external actors.

Both community members as well as local power figures were interviewed. The interviews were conducted following a set of open-ended questions that differed according to the background of the interviewee (Annex II). Some of the discussions were conducted in English, where both me and my assistant took notes and later merged them. When the meeting was held in Luganda or Lusoga a summarized format was used.

Focus group discussions

FGDs are a frequently-used method to get an overview understanding of social issues, and in conservation research it is often used to gain in-depth knowledge from a selected set of respondents (O.Nyumba *et al.*, 2018). Also, to discuss results of interviews to be able to understand why people feel as they do about local practices and to get people talking by facilitating a discussion (Bernard, 2011). This way ethnographically rich data is generated. The groups were homogenous in the sense that they were all residents of the two communities relying on subsistence farming. Key figures such as village leaders and other strong institutional figures, were not invited to participate such that people would feel less threatened to share sensitive information about their daily activities and to prevent modifications in the answers given (ibid). The groups were heterogeneous in their age and gender (at least in two of the four FGDs) to provide a supportive environment for the respondents to open up more easily especially for women as they tend to speak less in group settings with male presence (Stewart *et al*., 2002). Care was taken to hold the females-only discussion in a private setting behind a house to overcome the issue of dominance of male household members and other key figures of the community. Male respondents seemed to not be affected by female's presence during the discussions. Biases regarding race and ethnicity were not considered as the respondents during the in-depth interviews did not constitute it as a barrier for collaboration in the community.

Figure 7. Focus group discussion 1. (Photo, own picture)

Figure 8. Focus group discussion 3. (Photo, own picture)

As the communities are rather small, most of the participants knew each other, which is usually not preferable, but my assistant and I were practically not known to them. The local guide did the recruitment and participation was at people´s discretion. Before starting the FGDs, participants were informed about the general study interest, the intend to record the session as well as the significance to participate to share their point of views. Two out of the four discussions were mixed in gender (1st group: five men, four women; 2nd group: six men, two women), the 3rd one was only with men (six participants), and the 4th one was only with women (eleven participants). In total, 34 people

participated. The goal of gender sensitivity evolved along the organizational process. The focus group discussions were based on a series of questions put together beforehand on the villagers' perception and usage of the paper mulberry tree, on CFM, on charcoal making and the condition of the villages and their livelihoods in general. Each participant received a small incentive consisting of a soda and salt for their participation.

3.3.2 Social science data analysis

By having conducted a rather small sample and by having used snowball- and convenience sampling as the chosen approach, the categorization of respondents may not be representative for the entirety of the communities at hand. Data from the interviews and FGDs were summarized in Excel sheets and then coded to categorize the information emerging from the data (Higginbottom & Lauridsen, 2014) based on Kathy Charmaz and her constructivist grounded theory. It is an approach to construct theory through analysing data by making assumptions and constructing categories (Charmaz, 2017).

Systematically discovering behaviour to describe a context and explain how things are, is at the basis of grounded theory dating back to Barney Glaser and Anslem Strauss (1967). Constructivist grounded theory from Charmaz (2013) is based in grounded theory, but it alternates from it as researcher and informants work together on creating data (Bernard, 2011). It touches upon how realities are made. By constructing categories and by comparing them, the pertinent from that which isn´t becomes clear, yet the process is undoubtedly affected by the researchers´ interactions and opinions and thus, the objective about the data (Charmaz, 2013). Even so, the process becomes replicable as results are analytically grounded in the data (Strauss & Corbin (1990) in Higginbottom & Lauridsen, 2014). The process follows the following steps: Coding, linking themes with other theoretical models to then be able to display and validate them (Bernard, 2011).

With the interview and FGD data in Excel format, after initial coding, focused coding followed as themes emerged from the interviews as I went along which then led to filtering out of categories (Bernard, 2011). This process is followed by formulating a memo in which thoughts and observations of the categories were further developed and noted down (ibid).

This facilitated creating a perspective of the local context of the two communities and its stakeholders. This process resulted in eight thematic categories: Conservation, Rules & rights, Conflicts, Responsibility, Corruption, Collaboration, Livelihood supply and Education. These categories were then used to synthesize prevalent data from the spread sheets representing the

described and perceived construction of my reality as well as the participants´ realities (Higginbottom & Lauridsen, 2014), to then be able to compare data with existing literature and to discuss them. The characteristics of the respondents in the household interviews and a graphical analysis of the such was applied in Excel 2016. A compilation of some explanatory text statements both from key - informants and respondents in FGDs and household interviews are attached in Annex II.

4 Results

Currently there is not one serious tree in the forest
(Man in FGD 1)

4.1 Characteristics of respondents

In the 18 household interviews, 36 females, 27 males and 93 children (5.2 children per household) were encountered with a rather small number of both males and females with primary and secondary education (Fig. 9). Very few men and women work outside the community. Only five males stated that they do and only one female, which contributes to the need of the households for assistance with household products of school fees from family members who live elsewhere and have jobs. Seven of the surveyed households receive support, whereas nine do not.

The most commonly mentioned cooking fuel mentioned was a combination of both firewood and charcoal (9 out of 18 households). 5 out of 18 families had never adopted any new technologies for cooking, such as energy-saving stoves. Eight mentioned that they previously had done so, but it is no longer functioning, and 4 out of 18 households cook with improved technology. Most families rely on agricultural production for subsistence which means they eat and use most of the products they harvest without considerable additional purchases.

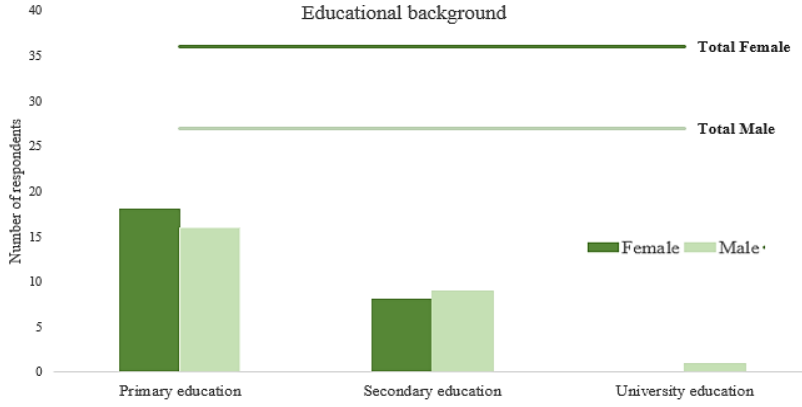


Figure 9. Educational background of conducted household interviews and total number of interviewed individuals separated by females and males

The sampled houses were located mostly near the forest reserve. More than half of households associated an economic value with the forest, whereas others saw it valuable for climate regulation, a source of medicine, food or fodder or cultural – sacred purposes. Most of the surveyed households named cultivation for subsistence as their most common livelihood activity on their own land (Fig. 10).

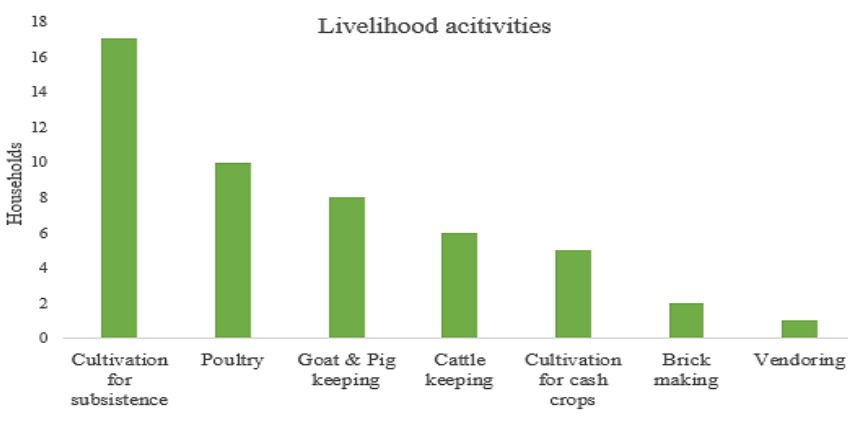


Figure 10. Livelihood activities of conducted household interviews on their land

4.2 Species abundance under the dominance of *B. papyrifera*

The species distribution in the sample plots across all categories (Seedlings, Shrubs, Saplings, and Trees) of woody species is displayed in Fig. 12 and shows an apparent abundance of indigenous species together with introduced species under the dominance of the paper mulberry. During the interviews, 14 out of 18 households, assessed the paper mulberry as a facilitator for the regeneration of native tree species. While participants also stated that under the paper mulberry there is no food as it does not nurse food crops.

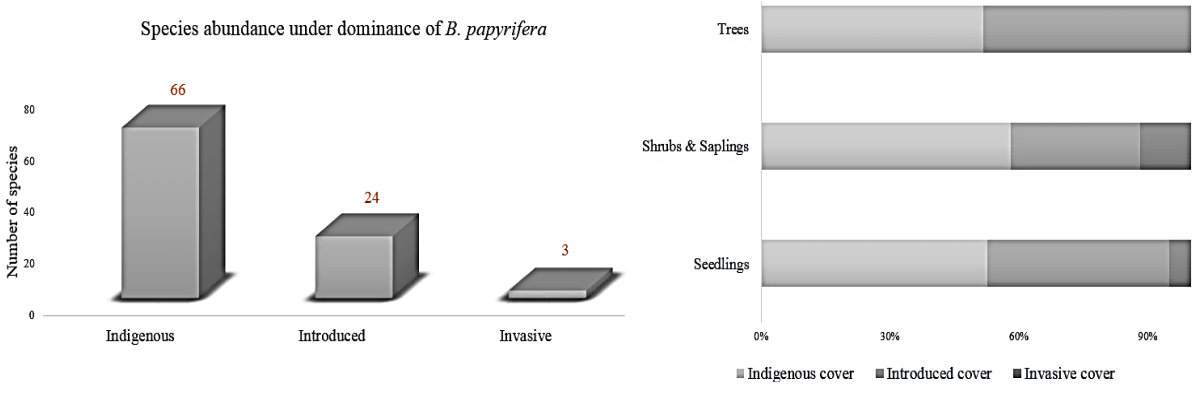


Figure 11. Species abundance across origins (indigenous, introduced & invasive) and species cover across origins and across different growth stages (seedlings, shrubs & saplings and trees)

Interestingly, most of FGD participants stated that *B.papyrifera* does not promote indigenous species which contradicts the observations reported in Fig. 11 as most species found were native ones. As people often focus on species which they can see growing fast, and which have many uses for them, indigenous species despite being seemingly highly valued won´t be incorporated as much. Often specific indigenous species which are not valued won´t be noticed either. Indigenous species tend to be slower-growing and hence less ´valuable´ for the short-term benefits (Eilu *et al.*, 2007). This effect is shown also in Figures 12 and 13, where the distribution across growth categories deviates from the abundance of species perceived to persevere under the paper mulberry by the respondents (indigenous species are coloured in green whereas species not mentioned at all are coloured in grey).

The most abundant shrubs recorded were *Lantana camara, Hibiscus callyphyllus and Vernonia. amygdalina*. *Lantana c.* being an evergreen shrub that is invasive and forms next to *B. papyrifera* the vegetation cover of many clear-cut spaces in the forest. *Hibiscus c.* behaves similarly, thriving on

roadsides and forest edges and in disturbed areas. Both species are also used as a food source (for humans and animals). *V. amygdalina* is regarded an important medicinal plant for the treatment of malaria.

In the tree stage category, 37 different species and 118 individuals were counted whereas the following three were the most abundant ones: *Ficus sur, Artocarpus heterophyllus* and *Ficus exasperata* (18, 16 and 15 stems respectively) whereas *B. papyrifera* recorded 116 individuals. It is evident that the composition of the different growth stages changes most substantially in the tree stage. Many species of the saplings and seedlings stage thus do not reach the tree stage or have not yet reached it in the measured plots.

When looking at the origin of the species throughout the various growth stages of seedlings, saplings and trees, the biggest group are the introduced species. Many of which are related to the native species pool (an example of vast inventory of *Ficus sur* adjacent to indigenous *Ficus sp.* with a smaller stock). Another significant group of species are fruit trees (such as *A. heterophyllus* and *Coffea canephora*.) that are of great use for the surrounding community. Interestingly, *Funtumia africana* (the ´bastard wild rubber´) was found both in the seedling and tree stage in small numbers whereas *Funtumia elastica* is the most important species in the strict nature zone of Mabira CFR (Weldemariam *et al.*, 2017), which is morphologically and distribution wise very similar to *F. Africana.*

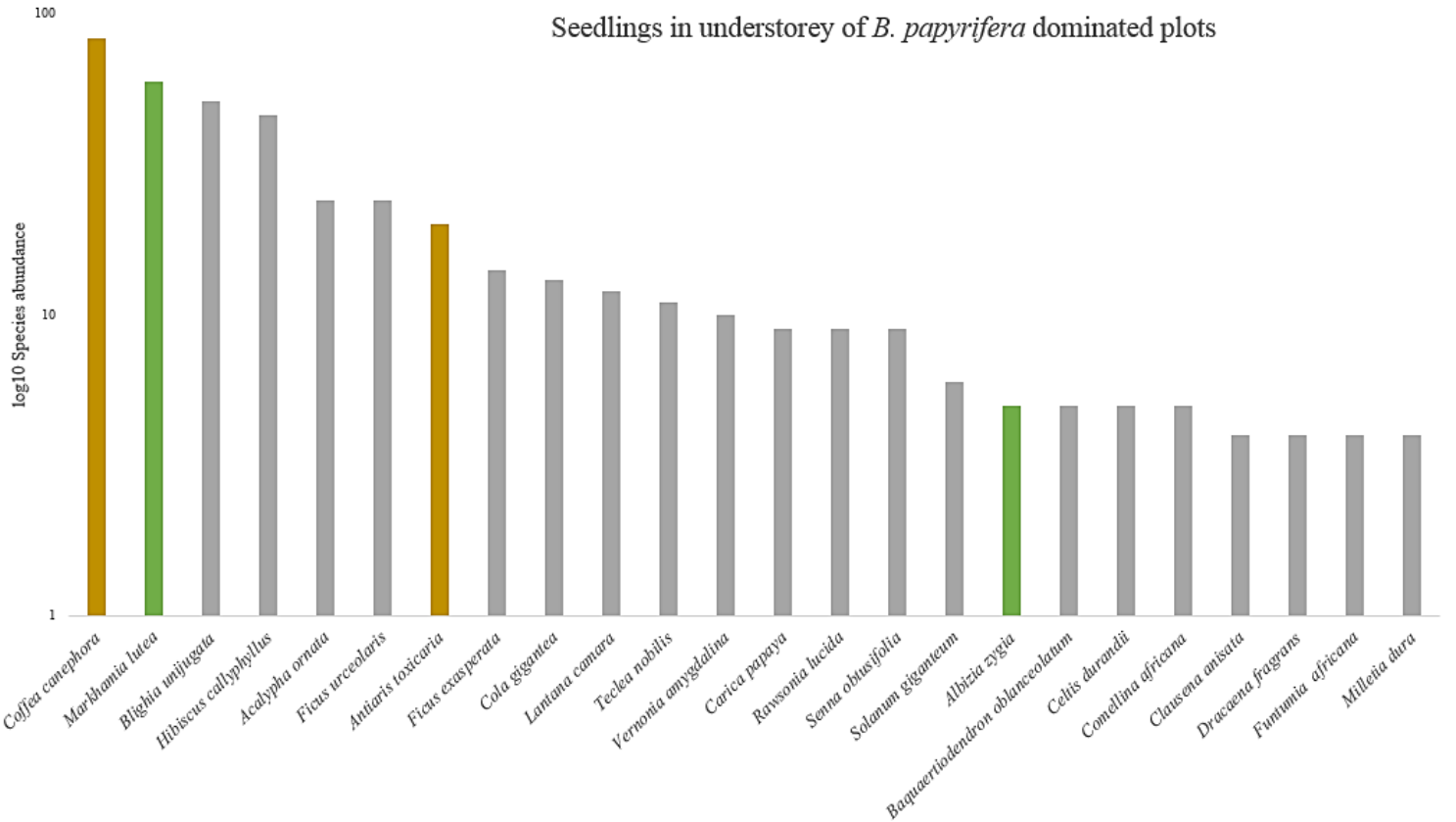


Figure 12. Seedlings abundance across sample years in understorey of the paper mulberry in the 1 m radius category. Recordings below 4 individuals are left out of this figure. Green are indigenous species and orange are introduced species that respondents reported to grow under the paper mulberry (372 seedlings of *B. papyrifera* encountered). The grey ones were not mentioned by the respondents.

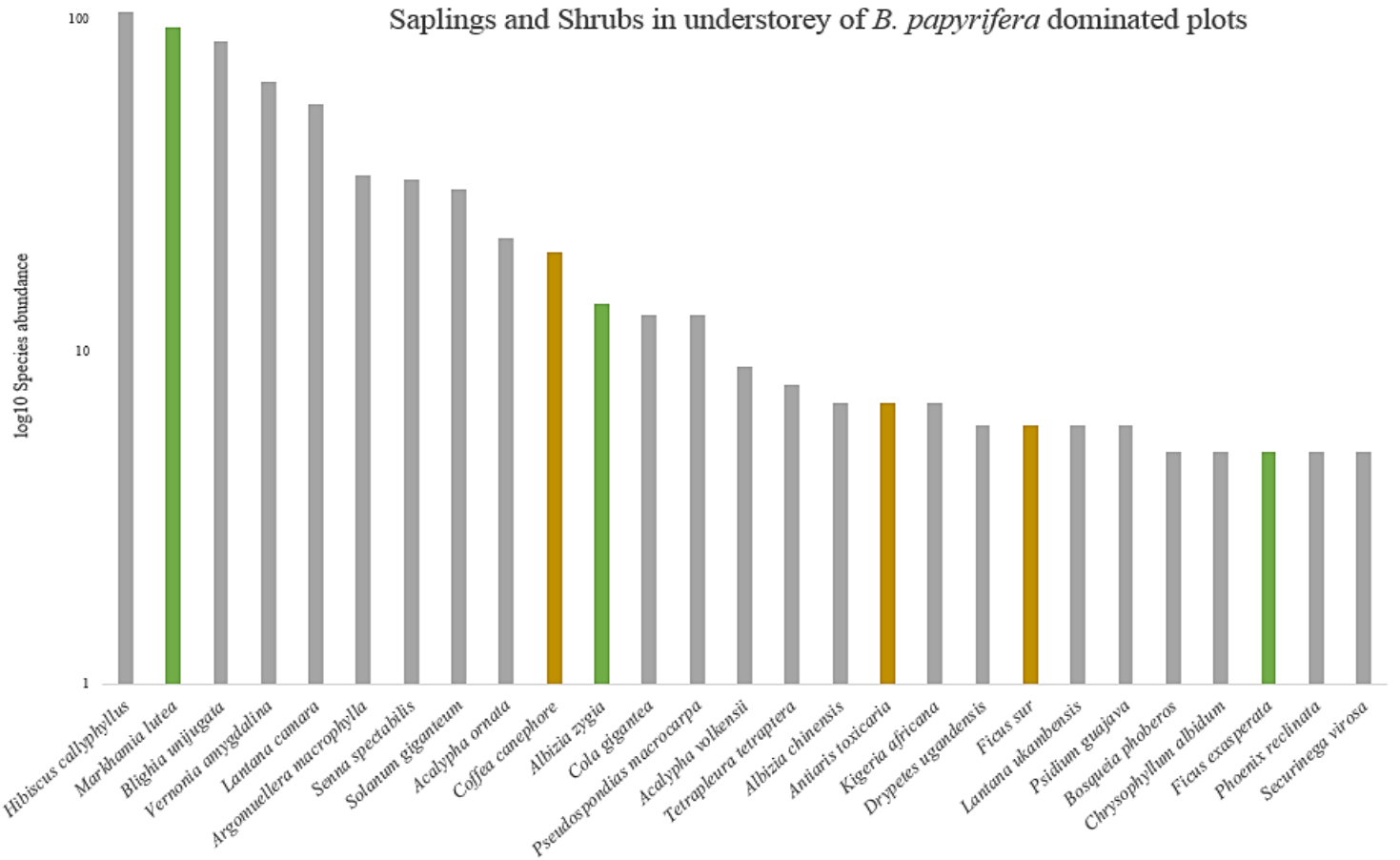


Figure 13. Saplings and Shrub abundance across sample years in understorey of the paper mulberry in the 3 m radius category. Recordings below 5 individuals are left out of this figure. Green are indigenous species and orange are introduced species that respondents reported to grow under the paper mulberry (880 saplings of *B. papyrifera* encountered). The grey ones were not mentioned by respondents.

4.3 Species abundance without *B. papyprifera*

Compared to the plots where *B. papyrifera* was not prevalent, the forest composition sample was considerably less varied and less densely populated. Only 76 individuals and 33 different species were recorded throughout the three sample years across all 31 plots, whereas the sample of 2018 did not contain one plot without paper mulberry. Seven out of ten plots without the presence of paper mulberry were from 2006. The plots that were found without the presence of the paper mulberry in 2006 and 2012, in 2018 showed clearings due to visible slash and burning and abandoned or prevalent cultivations of corn and banana on relatively dry soil. One plot was located on formerly settled land before people were evicted by the NFA such that forest had more time to establish (Fig. 14). Many of the plots showed signs of forced removal of seedlings, and evidence of movement of border stones that were put there by NFA, something noted by key-informant 10 during the forest inquiry.

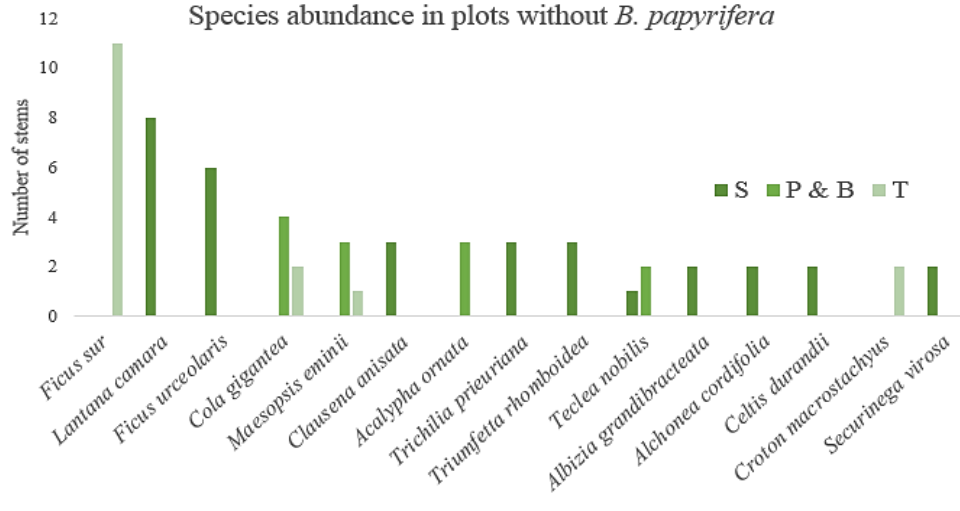


Figure 14. Species abundance in plots where no traces of *B. papyrifera* were found. S = Seedlings, P & B = Shrubs and Saplings, T= Trees. Single recordings are not included in this figure

4.4 Biodiversity indices

4.4.1 Results for woody species

The forest plots show that compared to previous years in 2018 more indigenous and introduced species were recorded while the number of invasive species remained constant. While the number of indigenous and introduced species increased, their relative cover decreased (Tab. 2). Although this could be an effect of moving the plots, the composition of a clear-cut area would not have given a sufficient set of data.

Table 2. *Cover of indigenous, introduced and invasive species across the three sample years*

	Relative cover indigenous species (%)	**Relative cover introduced species (%)**	**Relative cover invasive species (%)**
2006	36.28	24.77	38.86
2012	37.99	17.40	44.61
2018	28.31	18.24	53.44

The increase in the invasive species cover is linked to the dominance of the *B. papyrifera* that formed 36.01% of the woody species cover encountered in 2006, 41.18% of the woody species cover in 2012 and 48.56% in 2018 – an increase of 12.55% and 7.38% respectively.

Chao richness (S_{Chao})

The estimated species richness of the ecological sample in 2018 shows a slight decrease in the seedling stage (37 compared to 49 in 2006), a steep increase in the sapling and shrub stages (98 compared to 39 and 49 in 2012 and 2006 respectively), but an abrupt decrease in the tree stage (35 compared to 56 and 125 in 2012 and 2006 respectively). Such a development can be traced back to the practices of continuously harvesting trees, for example, for firewood. As a result, a J-shape pattern in distribution for the years 2006 and 2012 is given, while 2018 shows an inversed U-shape distribution (Fig. 15). For seedlings and trees over time this means that richness decreased, while the richness of shrubs and saplings peaks in 2018. Compared to the Nyabyeya forest estate, species richness in Mabira CFR across the growth stages is higher in sapling and shrub stage, and close to identical in the tree stage.

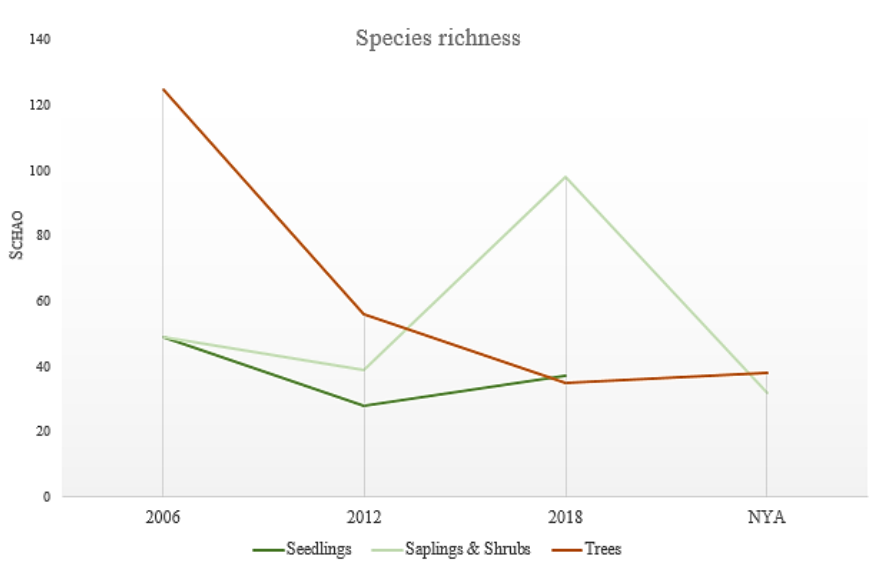


Figure 15. Estimated species richness (S_{Chao}) across sample years and growth stages

Shannon Weaver diversity (H´)

The Shannon Weaver index shows complex patterns of changes in diversity through different life stages within Mabira forest (Tab.3). Measured diversity in Nyabyeya, a relatively undisturbed forest (but still subject to illegal harvesting) was consistently higher.

Table 3. *Shannon Weaver diversity (H´) in Mabira CFR and Nyabyeya forest estate*

Sample code	**Sample years**	**Shannon Weaver diversity (H´)**		
		S1	**S3**	**S10**
MAB	***2006***	2.341	1.983	2.658
MAB	***2012***	2.974	2.003	1.953
MAB	***2018***	2.244	2.149	2.148
NYA	***2013***		*3.100*	*3.097*

Rarefied diversity

The rarefaction diversity calculations across the chosen 10,000 resamples of each year´s data, gave the pattern in Fig. 17. The number of species that were identified in a randomly defined sample of 20 individuals ranged between 5 and

14. In 2006 we would, therefore, expect to have 10.45 species (variance of +- 2.604), in 2012 7.53 species (variance of +- 1.988), and 2018 9.01 species (variance of +- 2.99)

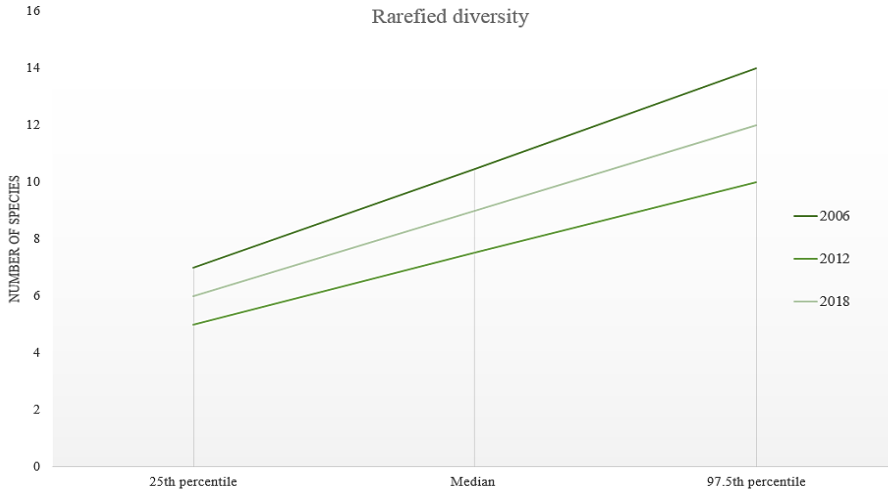


Figure 17. Sample of randomly chosen 20 individuals in a chosen resample of 10,000 of each year´s data

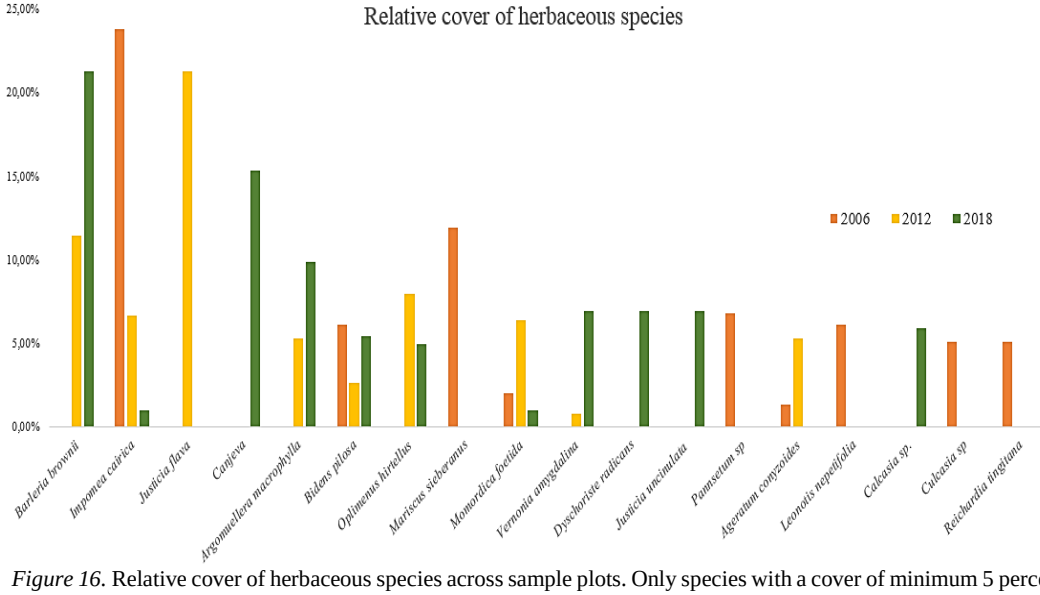


Figure 16. Relative cover of herbaceous species across sample plots. Only species with a cover of minimum 5 percent are represented in this figure

4.4.2 Results for non-woody species

The herbaceous cover in the sampled plots changed noticeably as very different species were identified as abundant in different sample years. Species with the highest relative cover in 2006 included: *I. cairica (*23.81%) *and M. sieberanus (*11.90%) and Pannsetum sp. (6.80%) in 2012*: J. flava (*21.28%), *B. brownie (*11.44%) *and O. hirtellus (*7.98%) and finally in 2018 a relative cover of*: B.brownie* (21.29%), *Canjeva* (15.35%) and *A. macrophylla* (9.90%). Such a distribution shows that the herbaceous cover has also changed throughout the sample years (Fig. 16).

4.5 Socio-economic impacts of *B. papyirfera* and factors that inhibit ongoing reforestation efforts

During the interviews and FGDs, people were asked an array of questions regarding their livelihood activities and their use and views on the paper mulberry. This is embedded in inhibiting factors of on-going reforestation efforts in the forest reserve. Through the coding process, the following five broad categories have been identified: Fuelwood supply; Educational background; Governance; Private tree planters; and Collaboration.

Fuelwood supply

People in the FGDs as well as in the household interviews characterized the forest as crucial for their livelihoods as they mostly associate economic benefits, subsistence farming and the supply of fuelwood (firewood and charcoal) with it, yet also other uses such as for fodder as one FGD participant stated:

> *I usually went there for fodder, but it was not used to be like that. I was not able to enter before in the past, because it was so dense.*

12 out of 18 of households mentioned that they would grow paper mulberry on their land to get by with their forest product needs. It is acceptable to get timber from Mabira to sell it off for some income if crops on their land have failed, according to many respondents. However, such quests are becoming increasingly more difficult as few timber trees are left to compensate such agricultural losses. The most significant restriction mentioned was the shortage of land regarding area to plant paper mulberry, although, repeatedly interviewees indicated that they would dedicate land to *B. papyrifera*, because of the various benefits that they would get from it: fodder for livestock, fuelwood, some

medicinal use, and fibre as potential income from its bark. One FGD participant described it as:

> *It is like a necessary evil. If you want to commit to the evil, it can easily occupy the whole land. So you don´t have land for cultivation. To the extent that as me who thinks of the future, with time it will use value when it is grown. Not because it has a long growing time, but because there will be an abundance of it, so its monetary value will go down.*

However, paper mulberry is currently not used for timber and furniture. The most significant benefit mentioned was its growth rate as well as the suitability as a soil fertilizer through its leaves as is claimed by many people as well as researchers. Although, many would not plant paper mulberry on their patches of land, they do see its benefits as a fertilizer on newly-cleared areas as well as its use for medicinal purposes. A female FGD participant mentioned:

> *I would also plant it to avoid going to the forest and as a measure to protect the environment*

For many of the interviewees from the community, *B. papyrifera* is not considered a valuable tree as many other indigenous species, but rather a means to support their livelihoods. NFA officials even acknowledged the species´ role in supporting the community and by that also the forest. As such *B. papyrifera* was described by the respondents to be a valuable resource, especially once other trees are cut down, and it is `left´ in the forest.

> *If they* [NFA] *would identify certain areas within the forest and have native tree species there, the remaining part of the forest could be saved for Nkulaido [*paper mulberry*] - so specific areas for Nkulaido and other native species [*as an alternative resource*]*

Educational background

Given the significant resource pool of *B. papyrifera,* people stated that it has brought children to attend school and it has facilitated access to healthcare for people as it pays the fees. A woman during the FGD mentioned that she uses its bark to stop blood loss which was supported by fellow FGD members and that

> *we would like to collect its [*paper mulberry*] bark and bring it to a pharmaceutical company for processing.*

Many respondents stated that the pressures from timber and other industries are the biggest issues for them as well as the forest. The key- informants from NFA recognized urban-rural sprawl, low-paid jobs and population pressure as the biggest issues. The aspect of urban- rural sprawl according to Lambin *et al.* (2001) is deepened as in many cases wages earned in cities often create ´remittance landscapes´ in rural communities as migrants leave and pay remittances, leading to an increase in dependency on the urban centres and a weakening of production-consumption relationships which is also a reality in the well-developed world.

Figure 18. Community member transporting fodder from *B. papyrifera* leaves. (Photo, own picture)

Considering the proximity of the two communities to the city of Jinja, increasing the tree cover on farms will be challenging for many reasons as people see most benefits in crops which give both fuel and income. Crops tend to do so much earlier than trees do, as exemplified by respondent 3:

> *There were some areas where trees are protected. The government could allow people to carry out a Taungya system* [form of reforestation*] to ensure that the enriched areas do better.*

The prevailing understanding of conservation from community members diverges from the image of conservation that NFA maintains. Indeed, the necessity for sensitization about forest laws is daunting as people officially are allowed to collect fallen dead wood, yet many are not aware of their rights to do so. Some respondents mentioned the wish to get further training on alternative uses and for knowledge building for other income generating activities. Smallholder farmers stated that they need to be given alternatives to leave the forest such as bee keeping, fish farming, growing of fruits, mushroom growing and cattle and poultry keeping, the forest officials see it as it is up to the community itself to alter their livelihoods. While one NFA official was of the impression that

> *the lacking educational levels are the most hazardous to the forest. Many people do not understand. Also, we need some practice in the natural resource management before it can work.*

Thus, there is a discrepancy between whom the forest laws are supposed to help and whom they are actually able to help (Welch Devine, 2004) and whom they actually reach. An example of such can be seen in the by-law that was established by NFA in 2003 which was described by an NFA official during the key-informant interview as follows:

> *So they* [community members] *can get as many headloads as needed out of forest. They are not allowed to bring them out with boda-bodas* [motorcycles] *or cars. The idea was that they can take their children too – when they are not in school – and to facilitate also that we have to do less patrolling in general.*

It shows how badly managed the patrols are as the officials sees their patrolling as counterproductive to people´s legal use of the reserve.

Governance

Most of the respondents stated that although they do see that the forest is in a bad condition, they will not stop producing charcoal if the government or any other entity from outside, won´t bring them businesses. So, bodies outside the community shall act. THEY shall stop the community from encroaching as well as pay members who engage in tree planting, which was previously discouraged due to providing habitat for the tsetse fly (Welch Devine, 2004).

> *No one is responsible for it* [the forest], *so no one fears entering it. It is now destructed. Those who are conserving it, are again the ones who cut the trees down*
>
> (Man 1, FGD 1).

The narrative that NFA is leaving people landless by moving borders of the reserve to the people´s disadvantage, leaves many people fearing violence from officials and mistreated for losing their property. Currently, based on the legal notice from 1932, when Mabira was first established as a CFR, NFA is in the process of re-establishing borders (Key-informant 5), despite the fact that borders moved substantially throughout various political regimes in the past. As such, boundaries often end up in the

Figure 19. Traditional charcoal kiln (burning site). (Photo, own picture)

middle of people´s gardens. Possible relocations are especially alarming as the population is continuously increasing.

Private tree planters

Forest management has failed to support both people and forest personnel in the field. In recent years projects such as the Kalagala Offset Project, sponsored by the World Bank have gained momentum. By creating a hydro power project close to Mabira, the agreement set out to also address reforestation in the Mabira Ecosystem (MWE, 2010). Since 2016 such a project on 11 km^2 is now paid for by the World Bank and is supposed to collaborate with the surrounding communities by agreeing on a price per ha of replanting, paid out once trees are actually planted. Often though such projects are not maintained in the long term due to difficulties in the preparation phase (lack of understanding what the agreements about and lack of agency to negotiate a fair price) (Key-informant 5 from NFA). The villagers did not mention this project or any participation whatsoever throughout the interviews. In general, NFA officials put much faith in the private tree planters, who *´can save many forests in Uganda´*.

Individual tree planters invest in government-owned reserves to establish plantations mostly consisting of *Pinus caribaea* and *Pinus oocarpa, Eucalyptus grandis* and *Terminalia* sp., which are labour-demanding during establishment and tending (Byakagaba & Muhiirwe, 2017) and are to be used for timber and poles in accordance with SFM standards (MWE, 2017b; Byakagaba & Muhiirwe, 2017).

Collaboration

Various community members described less collaboration compared to the past between forest users as they now tend to go to the forest more individually. In terms of collaboration with NFA, they describe it as poor as officials do not consult them, but rather they just come, and plant trees as mentioned by man 4 in FGD 2:

> *Conservation is very poor, because they* [NFA] *bring seedlings in the dry season, they do not irrigate them, and they do not have patrols for those seedlings and when they find us, they beat us up seriously. At least that is what I heard*.

However, the will for collaboration from many community members together with the forest supervisor was emphasized too, such as by respondent 6:

> *They should collaborate with us … to understand each other. Also, they should stop using armed people to patrol the forest. The government should stop letting its officials cut down trees which they do not replace with other trees.*

NFA is responsible for the planting of trees. One initial effort was the supply with shade-tolerant seedlings with better survival rates under the paper mulberry (Key-informant 4) which were then supposed to be planted and maintained together with community members. The initial attempt of a CFM group in Nakalanga and Kirugu failed, according to FGD participants and former CFM group members, due to bad leadership. A new group of CFM members elected a leader early 2018 and started with enrichment plantings alongside NFA (Key-informant 10). However, previous CFM group members mentioned that people did not have the agency to participate in the replanting – to ´*be at the table*´ as defined by Lyons *et al. (*2017, p.330).

Whereas key-informants from NFA stated that they do acknowledge community enhancement and awareness building as part of the conservation goal for Mabira, but that it is tremendously difficult. Further collaboration which some informants place great potential in lies in the `Twekembe Womens group´, an association of currently 28 members ranging from agricultural support to sensitization to business support etc. (key- informant 10), while further services are envisaged. The paper mulberry was mentioned here due to its variety of uses that could expand to matchbox making, use of construction poles and plywood. To wait for native species to grow is hampered by the growing resource pressure. Thus, the paper mulberry can be used for ´*timber, although, its wood is soft and weak but has a nice light colour*´ (key- informant 4).

5 Discussion

The results show that the species composition in the production zone of Mabira CFR is changing and that there is a diversity of both species as well as people living in the area. A number of factors have been described which inhibit land management that includes the surrounding communities into the management of the forest. Major discrepancies of what people are allowed to harvest from the forest for subsistence, and what NFA officials prescribe them have also been acknowledged and will be discussed in this chapter.

5.1 Ecological impacts of *B. papyrifera*

A transition is seen among herbaceous species moving towards a novel composition, for the shrub and sapling composition which increased in richness compared to previous years, as well as for the tree abundance which decreased due to ongoing exploitation. Furthermore, while the number of indigenous and introduced species increased, their relative cover decreased. Also, there was a discrepancy between observations and respondents´ recollections of what is regenerating under the paper mulberry. This aligns with findings from Tabuti et al. (2009) and Galabuzi *et al. (*2014) who described priority species of forest users as valuable species. Hence, the results suggest that biodiversity is changing regarding species composition, rather than being lost due to the dominance of the paper mulberry, which follows the trend across forests in central Uganda (Turyahabwe & Tweheyo, 2010).

The general species distribution in 2006 shows the highest tree count with lower richness of seedlings and saplings compared to later samples. In 2012, as depicted in Fig. 15, there was a rather low richness among growth stages which indicates adverse seedling and sapling existence. Such a survival is essential for

long-term forest maintenance (Weldemariam *et al.*, 2017). In comparison, the inverted U-shaped distribution pattern in 2018 shows an increase in richness in the sapling and shrub stage and the lowest abundance in trees (abundance for the ´young´ trees in the reference forest estate of Nyabyeya was far lower while trees had about the same abundance). Such results suggest that the forest is rather `young´ as it is continuously depleted of mature trees (MWE, 2017b). The high understory species richness contrasts with findings from Agyeman *et al.* (2016) and Malik & Husain (2007), who described *B. papyrifera* dominated gaps as species-poor. In Mabira CFR, the increase in richness occurred despite intensive timber and firewood harvesting, and despite an increase in *B. papyrifera* abundance, which could indicate a regeneration pattern of the forest that is at least so far successful. As discussed by Dornelas et al. (2014) this does not mean that many species are not at risk of local extinction or that critical ecosystems are not under threat. Also, the peak in the occurrence of saplings and shrubs remains unexplained and may be related to a difference in sampling effort.

5.1.1 Diversity indices

Emerging evidence shows that invasive species can facilitate natural regeneration in degraded landscapes (e.g., Agyeman *et al.*, 2016; Becerra & Montenegro, 2013). Rarefied diversity gave a comparable diversity to Kirika *et al.* (2010) in Mabira CFR of 7.53 – 10.45 species. The overall trend thus shows that the woody species composition across sample years within the production zone is considerable diverse as on average at least every second individual is of a different species.

The Shannon Weaver diversity (H´) results of Mabira suggest that it is doing better than average CFRs with a H´ value of 2.14 - 2.97 [usual values between 1.5 – 3.5 (Weldemariam et al. (2017)), yet it remains to be less diverse than the reference forest estate Nyabyeya and the Budongo forest reserve in which the estate is located (McLennan & Plumptre, 2012). A comparison of CFRs across Central Uganda gave lower values across growth stages (Turyahabwe & Tweheyo, 2010), and also a similar study in Ghana assessing tree regeneration under B. papyrifera got comparable results (H´= 2.59 ±0.91 (Agyeman et al., 2016)). A direct comparison though between the values is weak due to different approaches and ways of analysing forest data.

5.1.2 Species richness distribution

The analysis of the change of native vs. introduced richness shows that despite a substantial increase in species abundance of both invasive species in 2018 (*B. papyrifera* and *L. camara*), S_{Chao} estimated species richness increased by 69% and 15 % (relative to 2012 and 2006 respectively) for indigenous species and by 15% and 13.5% (2012 and 2006 respectively) for introduced species. Bernard-Verdier & Hulme (2015) in their analysis correlated an increase in introduced species richness with a decrease in indigenous species richness. Also, as assessed by MWE (2017b) according to growth rates species can be categorized into fast-, intermediate- and slow- growing species which are also of value for the present species composition. It would thus be worthy to assess species traits more in detail as species that are more functionally different to the native community are more likely to succeed (Ordonez, 2014) as they cover a specific functional niche or have certain ecological functions (Díaz & Cabido, 2001).

B. papyrifera is, without doubt, the most dominant colonizing species within the production zone of Mabira CFR and comes from the most abundant family of Moraceae. Across CFRs in Uganda this family accounts for about 15% of the species composition (Turyahabwe & Tweheyo, 2010). Paper mulberry leaves have high nutrient concentrations which explain the high levels of carbon, phosphorus, nitrogen and organic matter in the ground below the species, and it thus accumulates more soil micro-fauna than native species (Anning & Gyamfi, 2017). By such doing, the soil receives a rapid turnover of nutrients. As such it can mitigate soil conditions also for native species in times of disturbance (Rodriguez, 2006). As documented by Kyereh *et al.* (2014) the fruiting likelihood of paper mulberry increases with tree size, meaning that older trees are more likely to spread seeds. The prevailing situation of a declining tree stand in Mabira CFR might thus benefit more from the paper mulberry in the seedling and sapling stage, because of its soil enhancement properties as well as because it does not invade other areas through seeds.

The relative cover of herbaceous plant species was highest for *I. cairica* (in 2006), *J. flava* (in 2012) *and B. brownie* (in 2018). The first are introduced species whereas *B. brownie* is indigenous. When compared to a report by MWE (2017), which analysed the vegetation across different sample sites in Mabira CFR, *P. conjugatum* (11.4%), *Panicum sp*. (5.7%) and *B. pilosa* (5.7% - 5.5% in 2018) were the ones with the highest relative cover, whereas the latter is an

invasive weed that thrives in disturbed areas and has proven to outcompete native species (Fern, 2014).

Furthermore, as stated by Rodriguez (2006) invasive species often reduce the abundance of indigenous species, which is the case in Mabira CFR across sample years (in 2018 three invasive species account for 1040 individuals compared to 554 individuals from 32 native species). In *B. papyrifera* dominated plots, the number of indigenous species was higher than the introduced species abundance across different growth stages. As suggested by Rodriguez (2006), attention should be paid to the facilitative impacts of invasive species as they may support biological control and forest restoration. This in turn results in an indirect positive effect in restoring indigenous communities by, e.g. facilitating a high number of native seedlings. Arguably, in the case of paper mulberry, natural regeneration may be too slow to reshape the disturbed forest cover (Bosu *et al.*, 2013). Malik & Husain (2007) stated that in Pakistan the paper mulberry must be reduced as it is not being used, and it takes over the vegetation cover. The results of this work though suggest for Mabira CFR that both biodiversity, as well as species richness under the dominance of *B. papyrifera*, are considerably high. Following this reasoning, Kyereh *et al.* (2014) suggested that management measures for reforestation should promote non-pioneer indigenous species under mature stands of the paper mulberry rather than clearing such areas before replanting to have a balances forest composition

5.2 Socio-economic impacts of *B. papyrifera*

Natural resources are central for the survival, security, and freedom of rural local livelihoods (Ribot *et al.*, 2016) while also being the basis for subsistence to reduce poverty. By denying poor households' access to nature reserves, they are pushed even deeper into poverty (Diriba, 2014). The line of thought that most tropical deforestation occurs by an impoverished rural population is misleading as deforestation according to Lambin et al. (2001) is largely induced by growing economic opportunities influenced by social, political and infrastructural changes and increasingly by global forces that trickle down to the local scale. In the study area, such political pressures towards the privatization of land through globalized companies is visible as well as social challenges of population growth. A solution according to Lambin et al. (2001) must include changing consumption and behavioural patterns in such overpopulated communities rather than only a limitation in the number of people. At this moment, much land is used in ways, such that readily available natural resources are increasing in value for local livelihoods.

In the two communities the paper mulberry is deeply embedded in the local livelihoods. Many community members view this species as a holistic ´provider´. Nevertheless, it is often not considered as a good and worthy tree, but rather as a ´bundle of uses´, many of which of rather poor quality, yet it seems to help the community to overcome or cope with poverty. In this context, having a *Taungya* system seems to be crucial for people as it provides a source of income and can thus support conservation efforts. Yet, such a system is restricted in Mabira as the survival rates of tree seedlings during and after cultivation are one of the biggest challenges of reforestation.

Some potential uses of the paper mulberry which could be of importance for future policies as well as for forthcoming exploitation have not been mentioned either by the respondents or by other informants. For instance, that it has a strong, fibrous bark used for centuries for paper and textiles in its native range in Southeast Asia (Whistler & Elevitch, 2006) which could be of use as a supplement for the rapidly growing rattan cane industry in Uganda. In addition, as suggested by the Ministry of Water and Environment it could cover the demand for sticks for roasting meat sold in markets near the Mabira CFR (estimated use of 18,000 sticks) (MWE, 2017b) and it may be able to supply local paper producing plants to support the country´s paper production. Having soft wood, elsewhere it is often used for making match sticks, packing boxes, plywood, builing boards, high-quality paper as well as cheap furniture (FAO, 1980; CABI, 2018). Furthermore, research suggests that its leaf powder can be used as a pesticide as it contains antifungal substances (CABI, 2018). Thus, a concerted policy effort is needed to diversify the use of species, such as the paper mulberry, for rural livelihoods and to then be able to improve living standards (Diriba, 2014). Concurrently, here the aspect of elite capture needs to be considered once *B. papyrifera* becomes a more valued-added product.

5.3 Factors Inhibiting ongoing reforestation efforts

As stated above the chosen sample was rather small and with snowball- and convenience sampling the following categorization may not be representative for the entire community. With the available data however, five broad categories of impediments to restoration in Mabira CFR are presented in Chapter 4.5: *Fuelwood supply*, *Collaboration, Educational background*, *Private tree planters* and *Governance*. The information from each category suggests certain conclusions about inhibiting factors for land management. As local people depend largely on natural resources, overexploitation of such by any actor,

pushes people deeper into poverty and deeper into inequality which encompasses life opportunities, income and other capabilities of people (Rist *et al.*, 2015), while also inhibiting well managed land policies. In the study area this became apparent through the pressures hailing from the sugarcane and tea estates that prioritize different services that the people living in this area do.

The diversity of people in the two communities revealed a high level of adaptability and openness to activities able to sustain people´s livelihoods. Yet, weak institutions, pressures from neighbouring commercial actors and ruling authorities and the lack of economic opportunities that do not rely on the forest, inhibit the diversification of livelihoods. As population increases – on average 5.2 children per household (5.8 children on the national level (Uganda Bureau of Statistics, 2017)), the demand for biomass will most likely increase in the immediate future too. However, in the far future, this demand might decrease with rural electrification to meet the necessary energy demand. Hence, investments in electricity infrastructure are described as significant (Lee, 2013) to facilitate additional alternative sources of income. As described by Oput *et al.* (2018), the government of Uganda is currently (since 2013) executing an *´aggressive infrastructural development campaign´* supported by IGN France International (FI) and the World Bank to improve electricity and telecommunications. The project aims at establishing a Land Information System (LIS) called DeSINLISoR (Design, Supply, Installation, Implementation of the Land Information System and Securing of Land Records) in the country. The second phase between 2015 – 2020 should continue the initiated decentralization process. This project should also generate alternative sources of income to make use of available species such as the paper mulberry as well as establishing a distribution chain for its uses.

However, as maintaining energy infrastructure is challenging even in wealthy countries, it will likely be challenging in a developing economy such as in Uganda. Furthermore, rural electrification is often associated with more degradation (Trac, 2011) as people with access to cheaper electricity might be more likely to engage in more exploitation as their agricultural productivity and profitability may be improved (Tanner & Johnston, 2017). This effect in the area of Mabira CFR might be further intensified as the timber and charcoal industries are already now putting pressures on the forest (Welch Devine, 2004). The main limiting factor for such changes is the availability of land to grow and sell firewood from, as people in the two communities use most of its products for subsistence which again is not likely to change in the immediate future.

Nevertheless, there is clearly not enough room to plant more trees, and people do not have the money to purchase seedlings to do so.

Repeatedly, people of the community stated that due to population expansion and due to NFA, who they view as taking land away from residents for forest boundary adjustments, community members are increasingly left landless:

> *People were not there then, but the population increased a lot … We don´t have even where to cultivate because the forest land survey is simply not accurate anymore when population was still much smaller* (Man 2, FGD 1)

Simultaneously, there seems to be widespread disappointment in forest governance practices as degradation continues due to a lack of alternatives available. Time and again, respondents discussed that such alternatives should be provided by the authorities as it is their responsibility. Education is a crucial part of ´human capital´ which also entails the potential of a person to engage in labour work. In times of conflict and overuse of resources such capital is reduced and needs strengthening to improve security (Ellis, 2000). The notion of ongoing overexploitation was repeatedly related by critical informants from both NFA as well as the local NGO to a lack of education being hazardous to the forest, aside from some respondents from the community that stated a similar view too. The lack of education may also act as a barrier for collaborative effort to restore the forest and to increase the propensity for households to move up from the bottom (Lee, 2013). However, this thesis argues that in the context of the two communities, higher educational levels did not decrease charcoal production. A clear correlation however cannot be drawn from the data available which indicates that educational levels are a driver for further exploitation. This may relate to the importance of charcoal as a cash income for the livelihoods, despite people´s awareness that it is harmful for the forest.

In response to strengthen their human capital, community members saw collaboration between themselves as well as collaboration with NFA officials on the ground as one way to strengthen their position. Only then, local governance efforts will be able to move past some strong individual actors. However, there is currently the tendency to enter the production zone of the forest individually, partially out of fear for the remaining scarce resources, and possibly due to the poor experiences of the previous CFM efforts in the area:

> *We no longer have user groups because we don´t go in the forest in groups anymore – we enter the forest individually* (Man 4, FGD 1)

> *Education is poor, so individuals go in forest to get charcoal and firewood, so they get enough school fees … This ends up in the cycle of more and more encroachment* (Man 3, FGD 1)

According to many interviewees the community is beaten up or punished by NFA personnel or their guards no matter what, as they act as *´forest dictators´* (Man 4, FGD 2). Although CFM might offer many benefits such as high membership (thus high reachability for sensitization), strong commitment by its members, growth of local markets, and infrastructure improvements, it also has its drawbacks: insecure access rights, weak leadership in organization (Johansson *et al.*, 2013). As described by Nel (2014), many CFM groups across Uganda fail due to poor integration of local people´s agendas and short- lived institutional support. Some of these drawbacks were experienced in the two communities some years back, and portrayed also by an informant from MAFICO, who attributed them to a mismatch of envisioned aims in previous collaboration between local people and NFA. Forest management has failed the as officials in the field too according to key-informant 5 from NFA. Also, the revised management plan from MWE (2017b) claims that tree plantation development to provide firewood and construction material for livelihoods improved through the scaling up of CFM arrangements. Such scaling up should also address policy and legislation issues, as there are, for example no clear policies guiding reforestation activities for selecting well-suited species for a degraded forest (Galabuzi *et al.*, 2015). I conclude that if only community members would feel included in forest governance, the forest status would improve.

An effective governance environment to maintain a sustainable resource exploitation within forest reserves in Uganda has been lacking in recent years (Jagger & Shively, 2015), such that the government has been giving reserve land to private tree planters for reforestation (Key- informant 5; Child, 2009). As such, owners have security of tenure over these planted trees as they are free to use land according to the Land Act (1998). This tenure category of ´leasehold ownership´ is also open to foreign investors, whereby land is leased for a period of up to 99 years (MWE, 2016) with its own chain of impacts. According to Turyahabwe & Tweheyo (2010), private forest tenure of Mpigi forests located in Central Uganda during the last 50 to 60 years show a better forest composition

and diversity than government agencies do. This is described as being the case both in CFRs, but also in LFRs (Local Forest reserves) as improvements in monitoring and in regulation for harvesting through governmental bodies are required. However, as has been documented by MWE (2016), the forest cover under private tenure recorded most significant losses of 56% between 1990 and 2015 in Uganda which in turn does not necessarily maintain diversity. This development is only somewhat compensated by an increasing gain in forest cover on private plantations on NFA land. In spite of the growing pressure on forest resources, the importance of planting trees on private land will increase in the future (Buyinza & Teera, 2008) as became apparent also in my study area. Although the long-term benefits of such a plantation value-chain remain unknown (Byakagaba & Muhiirwe, 2017) and criticized, much of land in the process is cleared to establish monocultures of mostly pine and eucalyptus (Lyons *et al.*, 2017). Nevertheless, the forest authorities and its employees two of which were also interviewed, seem to hold on to the idea of private plantations as sources for local employment, economic prosperity, saviours of natural forests and providers of raw materials for small-scale industries (Turyahabwe & Banana, 2008). The valuable contribution of establishing plantations was pinpointed by the interviewed NFA officials to the fact that current FM does not account enough for the existing tremendous firewood demand (Buyinza & Teera, 2008). Literature suggest, that there is also a timber deficit as most of the soft-wood plantations established in the past in Uganda will soon be harvested (Mwima *et al.*, 2006).

In Uganda, forest governance increasingly interacts with non-state actors to legitimize its doings, rather than meaningfully decentralising control. As a result, the private sector is increasingly perceived to be able to fuel conservation and forestry through funding and co-ordination with external actors (Nel, 2014). Previously, when decentralization efforts started and during colonial times, exploitation of woody species was better contained, and tree planting on public land encouraged (Tabuti et al., 2009). The trend nowadays of privatization of natural resources, denies people their customary rights over access to lands and further minimizes available land areas for crop production (Byakagaba & Muhiirwe, 2017). Furthermore, it leads to a bottleneck in charcoal production, which is detrimental for the preservation of local livelihoods. These circumstances may escalate and create additional local conflicts (Byakagaba & Muhiirwe, 2017) by giving rise to social, economic and ecological repercussions (Lyons *et al.*, 2017). Current forest estate structures under the multiple land tenure system, often result in ownership by none or all, which also falls back to

colonial times and justifies large-scale commercial exploitation (Geisler, 2012). In this narrative, communities with their utilisation of resources are mainly described as the actors of concern. Such structures are magnified in a system of unstable political leadership.

Such instability peaked in Mabira CFR during the intended sale for sugarcane growing in 2007, and leaves people in fear for their land from their own president (Child, 2009). The struggles to save Mabira CFR became a symbol for civil society action based on an environmental issue which was unheard of in Uganda before. This may have given some hope to accelerate a more responsive government structure and more democratic management (ibid). Furthermore, slowly, due to efforts of the Land Administration Reform (2013), land ownership in Uganda is supposed to be further clarified by obtaining legal land titles (World Bank, 2018b). Only, once land title structures are settled, smallholder tree plantations may provide an additional source of income (Oduro *et al.*, 2018; Tabuti *et al.*, 2009), and act as a supply for firewood to alleviate the rural energy demand (Buyinza & Teera, 2008) assuming that biomass remains the single most important primary energy in coming years (Lee, 2013).

6 Conclusions

No one wins by exhausting the forest. Yet, some actors profit while others are disadvantaged. By having protected forest areas, both legal and illegal benefits are created. Despite the right of local people to benefit through subsistence resource use such as in Mabira CFR, immediate pressures from outside through for example sugarcane plantations are imperative. As in other parts of Uganda, also in Mabira CFR especially the hidden costs of conservation were observed to be increasingly born locally stemming from national or international interest (Adams & Hutton, 2007). In the process, rural people whose livelihoods are based on forest resources are depicted as ´villains´. Nevertheless, overexploitation of forests remains of great concern. Thus, forest management in the study area undoubtedly goes beyond ´simple´ conservation as various structural problems such as poverty, unequal land and resource allocation are unquestionably present too. Such a situation, for instance, gives room for authorities to act as ´forest dictators´ and to use force in the name of conservation to protect the forest reserve.

Regenerating forests can be significant sinks for GHG emissions and are thus frontlines and essential assets for the mitigation of climate change effects. On one side, mitigating climate change effects requires funds, stable governance and strong leadership. On the other, as was shown within the study area of this thesis, the situation would likely be much worse for GHG emissions, if people were cutting deeper into the native forest as rural households highly depend on firewood. As was shown, despite people´s right to harvest for subsistence use, people´s actual right to harvest was represented to be, mostly by NFA officials, at their good graces. Many respondents stated that their interest to maintain indigenous species does not degrade the forest composition as care is taken which species are harvested, however, that external actors continue to

overexploit all varieties of species. A readily available species in the production zone of the reserve enables such a supply. However, it needs a diverse forest cover that both promotes forest productivity to mitigate climate change effects, but also provides essential services to improve food security and reduce rural poverty.

Much of the natural resource demand on the eastern margin of the Mabira CFR is supplied by the invasive tree species, *B. papyrifera*. As has been discussed in this thesis, the forest composition in the production zone of the reserve is considerably diverse and a vast number of indigenous species have been shown to survive under the dominance of the paper mulberry. *B. papyrifera is* a species that is readily available without additional planting efforts. As was shown in this report the forest composition has changed noticeably: from the herbaceous cover, through the seedling cover to the tree abundance, showing a rather diverse ecosystem. Also, local people have shown great diversity with the potential to adapt to the multiple uses of the paper mulberry which can thus act as a ´gap-filler´ and provider of resources. As such this might only marginally tackle the systematic problem that continues to push people into using natural resources (Simberloff *et al.*, 2013), but it feeds the supply chain of local livelihoods in the present. In times of land degradation and soil erosion a species, such as the paper mulberry might even be more useful from the perspective of being a soil fertilizer. Whereas the long-term effects on the soil chemistry under the paper mulberry needs to be explored further.

Private tree planters have been mentioned as one way forward for Ugandans forests by NFA officials. However, as mentioned above, they bring several issues with them concerning the loss of customary rights and access to land. On-farm planting of trees is recognized by community members as being useful and beneficial, although, it has various constraints too as land is limited and access rights of members are rickety.

To conclude, there is a need to further examine the benefits and trade-offs from the paper mulberry within the concrete context of the two communities. The species feeds into a system that would otherwise have even bigger difficulties to secure a sufficient energy supply, and it thus requires further policy responses to allow additional uses of this available resource. Furthermore, the presented factors all, in one way or another, impede successful reforestation of degraded forest patches. More research is needed to explore alternative uses and silvicultural use of the paper mulberry, to control its invasiveness rather than eradicate it and to develop forest-based industries that may be supplied by it.

Overall, the diverse area around and in Mabira CFR offers a variety of ways forward with a defined need of promoting conservation planning that moves beyond simple conservation and incorporates communities within the reserve.

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Annex I

Overall objective: To explore the mutual impacts of conservation, livelihoods, and forest governance on the communities and the forest, using the example of two communities bordering Mabira CFR

Specific objective	Data required	Data collection method
1. To describe forest harvesting practices in the communities under study around Mabira CFR	1.1 Data from previous studies on firewood & charcoal production in Uganda	1.1.1 Literature review of previous studies & identifying common practice
	1.2 Data on use & production of firewood and charcoal in the communities under study	1.2.1 Implementation of household interviews & FGs in the two communities
		1.2.2 Comparison of data from previous studies with new data
	1.3 Data on the perception of the previously mentioned production & the community´s feasibility for adaptation to introduced and invasive species	1.3.1 Implementation of household interviews & FGs
	1.4 Information on the historic & policy background that directs current harvesting practices in the communities under study	1.4.1 Literature review of the legal framework in the forestry sector & other such data sources
		1.4.2 Key informant interviews with forest officials from NFA & community leaders
2. To explore evidence that *B. papyrifera* facilitates the regeneration of native tree species	2.1 Data on the ecological factors of *B. papyrifera*	2.1.1 Literature review of previous studies on the species & data from interviews & FGs
	2.2 Data on the dominance of woody species & their distribution	2.2.1 Quantitative sampling in revisited forest plots based on IFRI methodology with circular plots. Supported by information gathered from the household interviews & FGs
	2.3 Data on species composition within the forest plots under *B. papyrifera*	2.3.1 (same as 2.2.1)
	2.4 Data on species abundance throughout the growth stages within the circular plots	2.4.1 (same as 2.2.1)
3. To analyse biodiversity of the production zone of Mabira CFR	3.1 Data on species richness & evenness in plots of 2006, 2012 & 2018	3.1.1 Quantitative sampling in revisited forest plots based on IFRI methodology with circular plots to calculate various biodiversity indexes
	3.2 Data on diversity in plots of 2006, 2012 and 2018	3.2.1 (same as 3.1.1)
4. To assess factors that oppress reforestation factors	4.1 Data on prevailing issues that direct current practices in the communities under study	4.1.1 Key-informant, household and discussions to filter out oppressing factors

Annex II

The following table contains a compilation of citations from the **Key-informant interviews** sorted by Category after coding.

Category	Overlap in category	Text
CONSERVATION	RESPONSILITY	´Yes it appears that force is needed to control the harvest situation´
		`People do not seem to know the importance of the forest or how to maintain it´
		´People can earn their living from it, as it does not take very long to grow´
	CONFLICTS	´The challenge is the limited land for growing trees, lack of seedlings for indigenous species and there is a lack of money to buy the species´
	COLLABORATION	´The leaders in the community are collaborative with the NFA, but there are still some stubborn people´
	LIVELIHOOD	´Without it he would not know what the communities would live from, because without the paper mulberry there would not be any trees left´
COLLABORATION	LIVELIHOOD	´People who refused [to be part of CFM] are still struggling and rather poor´
	CONFLICTS	´But people are not eager to listen although they participate in meetings´
		´Because before it was difficult to determine if someone was met in the forest, what they were about to collect, now they at least have the by-law to refer back to´
RULES & RIGHTS		´People do not know the rules or laws, but they know the by-laws´
		´We are also advocating such that the Forest Act is reviewed, because it does not represent the real situation of headloads and penalties´
	EDUCATION	´There is a lack of sensitisation, there is low education levels and the ignorance about and of the laws is also a problem´
RESPONSIBILITY		´… There is no money allocated from the World Bank for maintenance work, so NFA would have to pay for it themselves´
		´If the government would be serious to protect its natural resources ... government should invest in enlarging the power network such that factories as well as households overall are incentivized to switch from firewood usage to electricity´

		´After the survey results many residents were found in the forest and they complained. We stopped the placing of the boundary stones to settle the conflicts first´ ´Management of forests has been so poor, that government has been given out reserves to private owners to do the replanting´ ´The NFA advocate is `to be present in the forest although the management has failed many of us in the field´ ´We can reverse the situation! We just need the majority´
	EDUCATION	
CONFLICTS		´The guards perceive the communities to be rather aggressive, so they have to act sometimes´ ´the community is very hostile, so the issue is the openness for violence´ ´NFA is doing a good job, but the politicians are causing a lot of conflict in the forest as they are fighting for territory and political influence´
	EDUCATION	
CORRUPTION		´Sensitization of people would be necessary to make them aware that bribing and paying guards is not a good option for them´ ´The demand for timber is high on the markets, but there is a lot of corruption and bribery going on with the army guards´
LIVELIHOOD		´Mabira is affected a lot by the urban-rural sprawl, which affects also other forests ... many people who work in the city in sometimes very badly paid jobs, so they go to the forest in the evening and harvest some charcoal to enrich their income´ ´Some people have now actually left the forest and started other activities´ *´Someone cannot stay with no food, while there are still trees there´* ´Paper mulberry serves like a protector and it helps Mabira to survive after it has been degraded so much in the 80´s and supply people with firewood and fruits´
EDUCATION		´The lacking educational levels within the community are the most hazardous to the forest. Many people do not understand´ ´People deliberatively refuse to educate their children. So, sensitization is highly needed in the community´ ´NFA is a bit behind on sensitization as there has not been one meeting in last 5 years´

The following table contains a compilation of citations from the **Household interviews** sorted by Category after coding.

Category	Overlap in category	Text
CONSERVATION		´No money that is there, protects from further destruction´
		´The forest is in bad conditions because the economic situation of the community´
		´The Nkulaido (paper mulberry) fertilizes the soil with its leaves, if it is big it is difficult for other species to come up´
		´It grows so fast that it is good for enrichment, because after 5 months it is a forest already´ [paper mulberry]
		´Apparently the enrichment is done by the government. His request is that also the community plants trees as well as they should be given trees to plant on their land in order to protect the forest´
	COLLABORATION	
		´Those who protect and should conserve the forest are its neighbours, not the people of other end of the country but rather the people who are nearby´
	RESPONSIBILITY	
		´We committed to take care for them, but they (NFA) did not give them the opportunity, so the trees just died. Those they cared for are there´
	CONFLICTS	
		´It (paper mulberry) is like a necessary evil. If you want to commit to the evil, it can easily occupy the whole land. So, you don´t have land for cultivation´
		´NFA has the responsibility of encouraging those companies to respect restoration´
	RESPONSIBILITY	
		´They once had a conservation group that was enriching the forest, but that group was not given the opportunity to carry out their responsibilities´
	RULES & RIGHTS	
COLLABORATION		´We enter the forest individually´
		´They [NFA] should collaborate with the local community and understand each other´
		´Also, the government does not invest back into the communities e.g. bad road infrastructure. They would need a good relationship with the community to protect the forest and stop using it destructively, so that it is protected by the people who are native here´
	CONFLICTS	

	EDUCATION	´They don´t listen to people´s advice and they do not follow the rules given in the constitution and the forest act - **they are forest dictators**´ ´Yes, they agree that participation will make the FM easier, but besides that also sensitization is necessary´
RULES & RIGHTS		´but our situation forces us to do so´
	CONFLICTS	´The forest officials sensitize us that if they are not satisfied with the survey, we can always discuss about it, but over and over they told us that they cannot change it´ ´CFM has challenges with registration and some other issues´ ´We don´t have even where to cultivate … because the forest land survey is simply not accurate anymore when population was still much smaller´
RESPONSIBILITY		´ … the government should invest in projects and bring in capital for them to stop using the forest´ ´It is a bad thing, but there is no alternative to get income. So, government should bring in some projects´ ´This should come from outside from the government or from other organizations who should support us´
	CONFLICTS	´The problem is also that they beat up people when trees do not survive as they blame the residents´
CONFLICTS		´When they meet the supervisor, he tells us that they are destroying the forest` ´Currently there is not one serious tree in the forest´ ´People lost what they thought was their property, yet they had their families and children there. That is the reason, why people keep on cutting or harvesting from forest. As a revenge due to the lack of alternatives´ ´They should also stop cutting trees themselves or at least they should stop collaborating with the bad people´
EDUCATION		´Education is a major challenge here in the community. Connected with that is also how to treat the forest´ ´Education is poor, so individuals go in forest to get charcoal and firewood, so they get enough school fees´
CORRUPTION		´When CFM started the government got to know that there is money here on the ground, so instead of letting people on the ground work they came and took over´

LIVELIHOOD		´Yes, it grows fast and burns fast and well (paper mulberry)´ ´No it is of no use [paper mulberry]. You cannot get timber, no furniture, no match boxes … it is always available´ ´It is also fast growing and ´it helps the community to overcome poverty´ ´I would be interested to grow it, because it is a valuable species´[paper mulberry] ´It is bad because it destroys nature, but it is necessary´[paper mulberry] ´Education is poor, so individuals go in forest to get charcoal and firewood, so they get enough school fees. When they reach secondary school they need to pay more and cut down more forest´
	EDUCATION	
EDUCATION		´Families with lower educational levels treat the forest differently´

Annex III

The questionnaire used for conducting the **household interviews**.

Section 1 - About individual or households

How many people live in hh?

How old are you?

Do indivuals work outside the community?

How many individuals work outside the settlement? Gender?

How many attended primary school? How many secondary? How many universities?

How many of individuals are employed full time?
Do you receive any assistance from a family member or hh member who does not live locally? And what? (Send remittances to members, help members finding jobs, help through other means)

For how many months a year do you or your hh consume your own food crops?

What type of fuel do you utilize for cooking?
During past 5 years have you adopted any technologies that reduce need for forest products? (more efficient burning stoves, pressure cookers, others)

Were these integrated well in the everyday life?

During last 2 years have you faced any issues or conflicts that have endangered you or your hh? Did conflicts increase?

Section 2 - Forest

How far is your house away from the forest?
Are there other user groups who harvest from this forest? If so, do they have the right to harvest?

What percentage of the needs does this forest supply? For fuelwood, timber, fodder- or do you have to move somewhere else?

What land use activities do you carry out on your land? Like what proportions of their own land are farmers, vendors?

How do you feel about the type of conservation measures adopted in relation to this forest?

What opportunities do to those managing the forest have now? And in the future?

What cultural views do you have about this forest? (sacred, economic resource, both) and in what ways do they affect the use of the forest?

Are the forest management guidelines in policies clear? Why not?

Would degradation of forest be minimised if policy formulation process was participatory through all stages?

What do you think about type of conservation measures adopted in relation to forest area? (restrictive, right level, loose-lax)

Section 3- Broussonettia papyrifera

Do you see B.p. as a valuable species for this area? Why?
What are some of the products that are made out of B.p.?
How do you see its potential to facilitate regeneration of native tree species?

Do you prefer planting/having exotic species to indigenous tree/shrub species? Why? (reasons only economic?)

Section 4 - Products (specifically Charcoal)

What do you harvest from the forest? Of these which ones do you have the right to harvest?

Please rank the products in order of their importance.

If fuelwood is the most important, is it used for subsistence?

If charcoal is the most important, is it used for subsistence? Or more for commercial use?

For how long is forest product available for harvest or accessible for use in a year?
When do you actually harvest or use this forest product? Which months mostly? Which season?

Is the quantity always available throughout the year?
How much did you harvest last year? This year? (units of headload, sack, jerrican)
How important is **charcoal** for income? Do you gain most of livelihood from cutting wood or charcoal?
Do you gain your livelihood through charcoal commercial operations?

What is your perception about charcoal making?

What would be a solution for the charcoal dilemma? Regarding policy response to use? Investments necessary?
What land improvements have you made on your farm? Or pasture? How did you finance this work?

The questionnaire used to conduct the **focus group discussions**.

Section – About group
How do individuals rank the conditions of forest?
Have there been any major changes in relationship between user groups of the forest and others since last visit if so what? What do you think the forest managers can do to conserve the forest? (opportunities/challenges) In the future? How do you feel about type of conservation measures adopted in relation to this forest? What kind of values do you see in the forest? (cultural, economic, sacred, all)
In what ways do they impact your use of the forest?
When and how do individuals interact? (all year, seasonally, occasionally) within or outside forest in cooperative harvesting, processing, marketing/sales, financial contracts, monitoring/sanctioning/maintenance) Has any individual acted as leader trying to work out coordinated strategies within group concerning maintenance, investment, upgrading the forests? What kind of activities? What are the land use activities of hh in the community?
Would degradation of the forest be minimised if policy formulation process was participatory through all stages?
Has density of trees on forest land changed in past 5 years? Why? Has density of shrubs and bushes changed in past 5 years? Why?
Section 2- Broussonettia papyrifera
Do you see B.p. as a valuable species for this area? Multiple uses?
Would you consider using it for other uses too? (softwood, paper)
Would you be interested to grow B.p. on your land? If yes, no why?
What is the species potential to facilitate regeneration of native tree species?
What is the challenge with promoting more indigenous species?
There is the belief that B.p. negatively affects soil health. What do you see? Did it affect the farmland? What is growing there different to before?
Section 3 - Products
What percentage of the needs does this forest supply? For fuelwood, timber, fodder? Or do you have to move somewhere else further away? When you harvest/collect this product, do you clear the product from the forest or you collect part of it?
Do you think that people who are doing charcoal production have a higher income than those not producing charcoal?
What is your perception about charcoal making?
How does the charcoal making process take place? (how many people involved? Time? Whole tree? (Maybe let them draw)-more towards end What would be a solution for the charcoal dilemma? Investments, Plans necessary? The policy permits you to harvest a certain amount. What changes would you suggest to be made in the policy?

What challenges do you face in charcoal production? (during production and distribution)

Section 5- CFM

What do you think about Collaborative forest management?

What are main constraints of CFM in your view?

How could CFM operate? Is it operational even? When did it start?

What impacts does CFM have on conservation and management?

What are the shortcomings of CFM? Opportunities?

The questionnaire used to conduct the **forest official interviews**.

Please give some information about the Forest and its structure

What is the current situation of the FM? What are they currently doing?

Section 1- Forest

Have they undertaken any of following management or **regeneration activities** and how frequently? (planted trees, seeds, built fences, cleared undergrowth, removed leaf or needle litter from floor of forest, sought help from external authorities to improve vegetation?)

Have there been any reforestation improvement projects related to this project?

What are most serious problems of forest users currently and during next years?

What are most serious problems for those responsible for this forest currently and during next years?

What are the perspectives for the forest management?

Have restrictions on total quantity to be harvested changed to previous visit?

Is enforcement by outsiders still most important method of forest control?

Section 2- Broussonettia papyrifera

Do you see B.p. as a valuable species for this area? Why?

Would you consider using it for other uses too? (softwood, paper)

Would you be interested to grow B.p. on your land? If yes, no why?

Do you see that local people prefer using the B.p. to indigenous tree species?

What is the challenge of promoting more indigenous species?

Literature suggests that the B.p. supports the growth of other shade-tolerant species. What do you see within the community? In terms of soil improvement, diversification?

Section 3 - Products

What kind of forest products are harvested? (wood, tree shoots, food crops, charcoal)

What species are they? And what are most important for commercial and wood use (firewood, charcoal)

Are there rules that are used in practice similar to rules recognized by the community?

Have there been any major changes in rules (mostly informal) about products since last visit and if what where they? What about permits?

What types of penalties are likely to be imposed if they break the harvesting rule for first time? 2nd time? Several?

Who decides what kind of penalty is appropriate when rule is broken? Who collects? What types of records are kept concerning penalties imposed? Are records accessible to all? What alternatives to fines are there?

What kind of solution could be found for the situation in Mabira?

The questionnaire used to conduct relevant **key-informant interviews** (partially adapted to background)

Section 1 - About user groups

2. How many people live in this community?
3.Did the community change much in the last years since the last visit? House type, land use?
4. During last 2 year have individuals faced any issues that have endangered conflict within user group? Did conflicts increase?
5. How do people define poverty, wealth?
6. Given the local definition is there a great difference in wealth among hhs? How has this developed?

Section 2 - Forest

1. Have there been any changes in the forest in the last 5 years? If so, what are they?
2. Has the forest been divided into FM units for the use of the community? Is there any informal structure?
3. Are there any points in the forest where main flows of products can be controlled? Paths etc.?
4. What percentage of the livelihood needs wtihin the community does this forest supply? And what are the most common products? (Fuelwood, charcoal, fodder?
5. Who can enter the forest and when?
6. Are harvesters from different user groups readily observed by each other while harvesting?
7. Do the forest managers need to be more engaged in rational collaboration with stakeholders with local people?
8. Is enforcement by outsiders considered an important method of forest control?

Section 3- Broussonettia papyrifera

1. Do you see B.p. as a valuable species for this area? Why?
2. Would you consider using it for other uses too? (softwood, paper)
3. Would you be interested to grow B.p. on your land? If yes, no why?
4. Do you see that local people prefer using the B.p. to indigenous tree species? What is the challenge of promoting more the indigenous ones?

Section 4 - Products

1. Are there rules that are used in practice similar to rules recognized by the community? What about the by-laws?
2. Have there been any major changes in rules (mostly informal) about products since last visit and if what where they?
3. How much is one unit of charcoal sold for? Where do they mostly sell it?
4. Is there a substitute for this product? Or what are closest substitutes? Other energy alternatives - how can they be more distributed?
5. How are the permits distributed and organized within the community? What are the restrictions on? (quantity?) How often do they renew the permits?
6. Have restrictions on total quantity to be harvested changed to previous visit?

7. What types of penalties are likely to be imposed if they break the harvesting rule for first time? 2nd time? Several? Who collects?

8. What types of records are kept concerncing penalties imposed? Are records accessible to all? What alternatives to fines are there?

9. Is there a cash fine imposed who collects it? How is it used and what records are kept about it?

10. Further comments