University of Zurich[UZH]

The Potential of On-Farm Trees for Sustainable Charcoal Production Challenges, opportunities and human and social capital implications of charcoal production from on-farm trees in Kilosa District, Tanzania

GEO 511 Master's Thesis

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02.12.2020
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Acknowledgements

First and foremost, I would like to thank my supervisors Prof. Dr. Norman Backhaus, Prof. Dr. Maria J. Santos and Hanneke van't Veen. I'm sincerely grateful for your continuous support and guidance, for all the invaluable feedback and your flexibility whenever plans needed to be adjusted. You kept me motivated and on task, despite the many logistical and administrative challenges encountered along the way. A most special thank you also goes to our Tanzanian research team. Dr. Vincent Gerald Vyamana, thank you for leading the team during the data collection and for contributing with your expertise and experience. Moshi Salehe Mpembela and Jamal Hatib Jengo, thank you for making not only data collection but also its processing possible, for answering my countless questions, for being my binoculars into the world of charcoal producers in the case study villages and allowing me to still be part of this journey. Chenny Saira Magafu, thank you for all your help with data processing, which allowed me to include all the relevant interviews from village and district governments.

My sincerest gratitude also goes out to all the charcoal producers in the case study villages for entrusting us with their stories, their knowledge and perceptions and to the village and district government members for sharing their side of the story. A special thank you also goes to the five academic experts for imparting their profound knowledge and expertise about the field and the research topics to me.

Thomas Fischer, you are incredible, thank you for "staying up all night" to proofread my thesis and for your dedication and attention to detail while doing so. Your notes and comments helped me to state more precisely what I wanted to say, improving both grammar and content, and for that I am very grateful. I'm also thankful to all the other master students from Y25-G10 who worked, suffered and laughed with me through these past few months. I wish you all the best in finishing your theses and for whatever comes next. Last but not least a huge thank you goes to my partner for your love, patience, understanding and insight, for believing in me when I had doubts and for inspiring me to push myself further and reach higher than I ever thought I could.

Nimenifunza sana kupitia nyinyi – I have learned so much thanks to all of you
Asanteni sana – Thank you very much

Summary

Charcoal production is an important source of income for many rural households in Tanzania. At the same time, current mostly unsustainable production practices are threatening the forest ecosystems along with the livelihoods of the rural people dependent on its products and ecosystem services. Incoherent policy frameworks and insufficient capacity of formal governing institutions further complicate governance of the charcoal sector and enforcement of sustainable practices. Hence, alternative production, income and governance strategies are urgently needed. One option to reduce pressure on the forest could be to shift production to the farm by planting and utilizing on-farm trees. The present study investigates current practices, challenges and opportunities of on-farm tree utilization. A special focus is given to aspects of producers' human and social capital and how these affect on-farm charcoal production. Empirical data was gathered through survey interviews in Kilosa district, Tanzania, including participants form villages, which were part of a project promoting sustainable charcoal production, and from non-project villages. Further interviews were held with members of village and district governments in order to account for the local, formal institutional context. Additionally, academic experts on core research topics – i.e. charcoal production, producers' livelihoods and agroforestry – were interviewed. A qualitative content analysis was conducted, applying inductive-deductive coding to 20 interviews with charcoal producers, eight and three with members of village and district government, respectively, as well as to five expert interviews. In the research area, charcoal production is a predominant activity and its environmental consequences are starting to be felt. Since on-farm production practices are mostly a result of permanent land clearing for agricultural purposes, current practices are environmentally highly unsustainable. Due to the lack of alternative income generating opportunities in the region, however, many will continue to depend on charcoal production in the future. In order to increase its sustainability – on- and off-farm – new trees need to be planted. However, tree planting involves a number of opportunities and challenges in general and concerning human and social capital. Major hindrances for producers to plant trees on their land are land size and tenure security. These issues are further complicated by land conflicts between villages and with large landowners as well as by disputes between farmers and pastoralists. Additionally, in project villages, current by-laws forbid any charcoal production outside of a designated forest section. Interest in planting trees for charcoal production and other purposes is generally high, especially if seedlings and training are provided. In regard to human capital, participants' lack of information and knowledge about current regulations is hindering their compliance. Producers' awareness of the environmental effects of charcoal production, on the other hand, could be an opportunity to introduce more sustainable practices, which has already led to some success in project villages. Social capital between producers is important for production and is especially high in project villages, through the charcoal producers' association. It has proven to be a supportive institution for a more efficient governance of the village forest and charcoal production within it. Social capital in the form of linking to members of government, however, is largely absent, especially with the district government. This lack of linking social capital further impairs the information flow about regulations and their implementation to producers, and about the implications thereof back to the district government. District officials admit, that due to forest issues not being a priority, they are lacking human and financial resources to adequately address them and support the villages. These results suggest that the social capital within a village holds potential for more if not the most efficient governance of charcoal production and other harvesting activities in the village forest under the current policy circumstances. In order to introduce different, more sustainable practices and more efficient governance, investments should be made into building on and further developing existing human and social capital, especially through local capacity building – including education and training on sustaining such efforts beyond a project's lifespan.

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List of Abbreviations

AF	Agroforestry
AFTP	Agroforestry Tree Products
CBFM	Community-Based Forest Management
CBNRM	Community-Based Natural Resource Management
CIFOR	Center for International Forest Research
DRC	Democratic Republic of the Congo
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GHG	Green House Gas(es)
LPG	Liquid Petroleum Gas
MAFSC	Ministry of Agriculture, Food Security and Cooperatives
MJUMITA	Tanzania Community Forest Conservation Network
MNRT	Ministry of Natural Resources and Tourism
NASCO	National Agroforestry Steering Committee
NBS	National Bureau of Statistics
NGO	Non-Governmental Organization
NTFP	Non-Timber Forest Products
PAH	Polycyclic Aromatic Hydrocarbons
PES	Payments for Ecosystem Services
QCA	Qualitative Content Analysis
SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable Development Goals
SLA	Sustainable Livelihoods Approach
SSA	Sub-Saharan Africa
TaTEDO	Tanzania Traditional Energy Development Organization
TFCG	Tanzania Forest Conservation Group
TFS	Tanzania Forest Service
TTCS	Transforming Tanzania's Charcoal Sector
TZS	Tanzania Shilling
UN-REDD+	United Nation’s Collaborative Program on Reducing Emissions from Deforestation and Forest Degradation
UNDP	United Nations Development Programme
USD	United States Dollar
VNRC	Village Natural Resource Committee

1 Introduction

Worldwide, 2.4 billion people rely on woodfuel as an energy source, especially for cooking in rural households and for small enterprises (FAO, 2017). It is estimated that woodfuels account for 50% of the wood globally harvested from forests (FAO, 2017). Across sub-Saharan Africa (SSA), 73% of the fast growing population is reliant on biomass fuels, with implications for the environment and about 700 million livelihoods by 2030 (Ahrends *et al.*, 2010). Biomass fuels, i.e. fuel directly or indirectly derived from biomass, include dung, agricultural residues and woodfuels; in SSA mostly firewood and charcoal (Bailis, Ezzati and Kammen, 2005). Due to rapid population growth (Doggart and Meshack, 2017; Hoffmann *et al.*, 2018) of 114% predicted for SSA from 2009 until 2050 (FAO, 2009) and particularly as a result of increasing urbanization (Iiyama *et al.*, 2014; Doggart and Meshack, 2017) woodfuel demand is projected to rise in the foreseeable future, especially the demand for charcoal (World Bank, 2009; Doggart and Meshack, 2017). This increasing demand is further boosted by the slow fuel-switching rates to modern energy sources (i.e. electricity, kerosene, liquified petroleum gas (LPG)) due to the lack of infrastructure, unreliability and lower affordability of these fuels (Mwampamba, 2007; Jamnadass *et al.*, 2015). For example, in Lusaka and Dar es Salaam, the biggest cities within the respective countries Kenya and the United Republic of Tanzania (hereafter referred to as Tanzania), charcoal consumption grew by 80% between 1990 and 2000. In the latter city, the proportion of households stating that charcoal is their primary fuel rose from 50 to 70% in the same period (Zulu and Richardson, 2013). By 2030, charcoal demand in SSA is estimated to double from its amount of 23 million tons in 2000 (Arnold, Köhlin and Persson, 2006).

Charcoal is predominantly used for cooking and heating in urban areas, whereas production takes place in rural regions in the proximity of accessible forests and wood resources (Malimbwi and Zahabu, 2009). On a local level, charcoal production is an essential cash income generating activity and livelihood diversification strategy for many rural households in SSA. Many of them combine charcoal production with smallholder subsistence agriculture (Malimbwi and Zahabu, 2008), where income from charcoal can be invested to improve the livelihoods of the family or to purchase farming inputs (Smith, Hudson and Schreckenberg, 2017).

It is estimated that, worldwide, over 800 million people live in or heavily rely on tropical forest and savannas to access fuel, food and income supplied by these ecosystems (Chomitz, 2007). However, satisfying the persistently rising demand for charcoal comes at a high environmental cost. Locally, current mostly unregulated methods of charcoal production have severe environmental consequences, putting pressure on the very ecosystems from which charcoal as well as a wide array of other ecosystem services and non-timber forest products (NTFPs) including firewood, fruits, medicinal plants etc., are derived (Robinson *et al.*, 2014). In Africa, degradation of these ecosystems is therefore a major factor in increasing vulnerability of the households reliant on them (Butz, 2013), threatening the sustainability of the environment and local livelihood strategies that depend on those services and on charcoal production.

Both the number of people involved in the charcoal value chain and the amount of revenue generated by the charcoal sector are in the millions across SSA. However, despite its major economic relevance, most charcoal-dependent developing countries do not have sufficient or adequate policies and regulations to effectively govern this sector (Mwampamba *et al.*, 2013; Neufeldt *et al.*, 2015). Governance of the charcoal sector is further complicated by its overlapping of several sectors, including forestry and energy (Bergmann, Roden and Nüsser, 2017). Even less attention is given to the sector's potential for national development strategies, as charcoal is mainly portrayed as an environmental problem (Butz, 2013; Ghilardi, Mwampamba and Dutt, 2013).

Different efforts have been taken to make charcoal production and consumption more sustainable through policy interventions and projects. At the consumer end for instance, improved cooking stove projects have been implemented to reduce charcoal demand (Hoffmann *et al.*, 2018). At the production end, these efforts include more efficient kilns to improve wood-to-charcoal conversion (Schure *et al.*, 2019), permit and licensing schemes (Sola *et al.*, 2019) as well as promotion of on-farm tree planting (i.e. agroforestry) (Githiomi and Oduor, 2012).

Some of these interventions have adverse effects, especially, when access to forests, their resources and services becomes restricted (Mutune *et al.*, 2017). One such example are community-based natural resource management (CBNRM) projects, where the decision-making process is often dominated by majority groups and are therefore exclusionary to minorities and other already marginalized groups, including women (Ellis and Allison, 2004). Hence, such interventions may interfere with livelihood strategies and can have severe effects on households with a high dependency on natural (forest) resources, especially on the poor (Arnold, Köhlin and Persson, 2006, p. 608), which is the case for most households of rural SSA (Ellis and Allison, 2004).

While there is a lot of research conducted on the (un-)sustainability of the charcoal value chain, consumption patterns, the effects of the above mentioned interventions and livelihood implications along the value chain (e.g. Arnold, Köhlin and Persson, 2006; Schure *et al.*, 2015; Sola *et al.*, 2017), there is very little literature on how wood for charcoal production can be sourced through sustainable harvesting, especially in regard to on-farm trees. Agroforestry could serve to counter some of the negative environmental impacts of charcoal production, namely deforestation and forest degradation and thereby relieve pressure on these ecosystems (Leakey 1996). Agroforestry, or the purposeful integration of trees on farmland, represents a resilient land use practice (Leakey, 1996). Aside from a variety of livelihood benefits and adaptation and mitigation opportunities when facing climate change, agroforestry systems could potentially decrease pressure on forests by reducing their degradation and deforestation (Kitalyi *et al.*, 2010). Intercropping trees with crops for the production of fuelwood has been shown to be more ecologically and financially beneficial than monocultures of either product (Kürsten, 2000). Agroforestry has many environmental benefits such as increasing soil fertility, regulating services for soil erosion and water retention (Njenga *et al.*, 2017), increased biodiversity and habitat connectivity (Asare *et al.*, 2014). Through these benefits, it is able to counter the main negative environmental effects of charcoal production, namely ecosystem degradation, reduced soil fertility and biodiversity and watershed deterioration (Iiyama *et al.*, 2017). Meanwhile, the benefits could exceed to also improve the livelihoods of smallholder farmers by reducing their dependence on forests and potentially increasing their households' food security (Sanchez, Buresh and Leakey, 1997; Garrity *et al.*, 2010; Jerneck and Olsson, 2013). Therefore, agroforestry could, at least in theory, provide an adequate system for the production of wood for charcoal, while reducing environmental degradation and producing (additional) livelihood benefits. Agroforestry and on-farm tree utilization, however, are subject to similar governance issues as charcoal production, since it neither fully falls under the agriculture nor the forestry sector (Dawson *et al.*, 2014). Therefore, explicit support and guidelines in high-level policy papers, as well as institutional, infrastructural and human capacity for its development are lacking (Msuya and Kideghesho, 2012). Moreover, agroforestry systems must be tailored specifically to local environmental and cultural conditions, local knowledge and social practices for successful implementation and adoption of this new technology (Isaac, Dawoe and Sieciechowicz, 2009)

1.1 Problem Statement and Research Questions

Charcoal production is both an essential source of energy for urban households and an essential source of income and livelihood diversification strategy for rural households (Iiyama *et al.*, 2017), which has severe environmental implications (Chidumayo and Gumbo, 2013). Utilization of agroforestry systems and on-farm trees could be an alternative and complementary way to mitigate the restricted access (e.g.

through harvesting restrictions or reduced resource availability) while enhancing rural livelihoods and reducing pressure on the forest at the same time (Iiyama *et al.*, 2014). However, making use of the potential synergies between agroforestry or on-farm trees and charcoal production is not quite as simple. Firstly, the factors determining a farmer's reasons and motivation to plant trees are manifold, including farm size, distance and access to natural forests and its products, household socio-economic situation and market access. Hence, these factors must first be understood before agroforestry systems can be promoted (Ndayambaje, Heijman and Mohren, 2013). Secondly, the ecological, social and economic potential of agroforestry is highly context specific, depending on local tenure systems, trade-offs and opportunity costs, markets, etc. (Iiyama *et al.*, 2017).

There is a lot of literature on agroforestry as an agricultural practice and on forest conservation. Yet there is a lack of research on both the potential synergies between (agroforestry) agriculture and woodlands, as well as on the context-specific determinants for the successful implementation of a synergetic strategy (Dawson *et al.*, 2014; Iiyama *et al.*, 2017). Important dimensions for the potential of such strategies for woodland conservation include knowledge, education, cultural aspects and rural institutions (Graef *et al.*, 2015). Hence, especially aspects of social capital and human capital including knowledge, education, social interaction, local culture and practices need to be investigated in order to determine potential opportunities and challenges of using agroforestry and on-farm trees for sustainable charcoal production (see section 4). Other, rather neglected aspects in literature addressed in this thesis include the role of local institutions (e.g. government agencies, customary regulations and practices, local groups) with regard to sustainability and governance of charcoal production (Luoga, Witkowski and Balkwill, 2000; Iiyama *et al.*, 2017) and exclusionary dynamics (e.g. access and land rights) (Ellis and Allison, 2004).

Based on these environmental and socio-economic issues, which are further explored in the subsequent sections, the goal of this thesis is to investigate the following research questions:

1. How are agroforestry and on-farm trees utilized for charcoal production in the research area?

2. What are the challenges and opportunities for using agroforestry and on-farm trees as a wood source for charcoal production?

3. How does human capital and social capital influence these barriers and opportunities?

Based on the literature review, I expect to find that agroforestry and on farm trees are used for charcoal production and other purposes (Ndayambaje, Heijman and Mohren, 2013). I further expect that, among others, farmland size and ownership (Faße and Grote, 2013), direct (financial) benefits and farmers' individual perceptions could serve as challenges. Contrarily, increasing scarcity and restricted forest access could provide an opportunity for on-farm tree planting and/or utilization (Beyene and Koch, 2013). In terms of human capital, higher education, better knowledge and awareness of sustainable practices for charcoal production and or farming are expected to lead to increasing willingness to plant trees on-farm (Mercer, 2004; Faße and Grote, 2013). Regarding social capital, interaction and knowledge exchange with others might have a positive effect on farmers' interest in on-farm tree planting and utilization for charcoal production.

To answer these research questions, empirical data was gathered through survey interviews with charcoal producers in six case study villages in Kilosa district, Morogoro region, Tanzania. Additionally, structured interviews with members of village and district government were conducted to determine their views and influence on charcoal production. A subsample of 20 interviews from four villages was chosen and analyzed by conducting a Qualitative Content Analysis. A subsample of the relevant

interviews with members of village and district government was analyzed as well. Further background information was gathered through five expert interviews as well as secondary literature.

The thesis at hand is linked to a larger research project by the University of Zurich's University Research Priority Program in Global Change and Biodiversity on 'the effect of harvest for charcoal on tropical biomes', which focuses on livelihood implications of charcoal production and its impacts on biodiversity, in the Kilosa District of Tanzania. This thesis contributes to this research with its focus on human and social capital. Moreover, it brings in an additional element by focusing also on agroforestry and on-farm trees.

The structure of this thesis is as follows: Section 2 gives a detailed overview on charcoal production in SSA and especially in Tanzania, including its relevance and challenges. Section 3 focuses on agroforestry; namely its benefits, potential synergies with charcoal production and implementation challenges. The applied theoretical framework – human and social capital – is elaborated on in section 4, followed by a description of the research area in section 5. The methodological approach for data collection and analysis is explained in section 6, including challenges and limitations encountered throughout this thesis. Section 7 includes a description of the results of the analysis, which are discussed and positioned within the wider context in section 8. Concluding remarks are given in section 9.

2 Charcoal Production and its Implications in Sub-Saharan Africa

Millions of households in SSA depend on woodfuels for energy, which put pressure on the environment through their production and consumption (Arnold, Köhlin and Persson, 2006). In urban and peri-urban areas, where direct access and availability of fuelwood is slim since forests and tree stands had to make way for urbanization, charcoal is the preferred source of energy as compared to fuelwood (Hiemstra-van der Horst and Hovorka, 2008). The rising demand for charcoal through urbanization is further increased by the lacking infrastructure, affordability and reliability of alternative modern energy sources such as electricity, kerosene or liquified petroleum gas (LPG) (Mwampamba, 2007; Zulu, 2010; Jamnadass *et al.*, 2015).

Despite the emphasis on promoting modern energy under the United Nations Development Programme's (UNDP) Sustainable Development Goal (SDG) 7, aiming at universal access to modern energy by 2030 (Bergmann, Roden and Nüsser, 2017; UNDP, 2020b), transition away from traditional energy sources is progressing slowly due to unreliable supply, much higher costs and bureaucratic hurdles for grid access and supply, economies of scale and lacking information and awareness of these modern energy sources (Kojima, 2011). Compared to firewood, charcoal has a higher energy density per weight unit and therefore involves lower transportation costs, it is easily storable and perceived as cleaner because it produces less smoke (Iiyama *et al.*, 2014). Furthermore, it is affordable at mostly stable prices, readily available, accessible and reliable (FAO, 2017). With the compilation of the aforementioned aspects leading to a slow adoption of modern energy sources and charcoal being the preferred form of (transition) fuel, traditional energy sources, such as fuelwood and charcoal, will therefore remain the most significant in SSA for decades to come (Dagnachew *et al.*, 2020).

Providing clean and modern energy to all (SDG 7) would be the preferred development intervention (Bergmann, Roden and Nüsser, 2017). However, it has two major weaknesses. By focusing on the need for modern energy sources for the poor, global policy debates on the matter have mostly disregarded the significance of woodfuels (Iiyama *et al.*, 2014) which has led to i) ignoring the importance of woodfuel for the energy supply of urban population for decades to come until the transition to modern fuels is accomplished (Arnold, Köhlin and Persson, 2006; Ghilardi, Mwampamba and Dutt, 2013) and ii) a complete neglect of the implications for the livelihoods of tens of thousands of stakeholders across the woodfuel value chain and the lack of alternative income opportunities (Arnold, Köhlin and Persson, 2006). The latter aspect is dominated by an incoherent policy and regulation landscape, which leads to substantial losses in tax revenues and foregone development opportunities (Butz, 2013; Ghilardi, Mwampamba and Dutt, 2013; Schure *et al.*, 2013; FAO, 2017) and in turn, has adverse livelihood implications for the rural communities (Zulu, 2010; Mutune *et al.*, 2017).

2.1 Economic Aspects of the Charcoal Sector and Value Chain

Across SSA, an estimated 7 million people are involved in the charcoal value chain as producers, transporters, merchants, wholesalers or retailers, which are expected to increase with the rising demand to 12 million by 2030 (Mwampamba *et al.*, 2013), generating over USD 8 billion in 2007 and an estimated USD 12 billion by 2030 (Iiyama *et al.*, 2014). Figure 1 shows the different actors of the charcoal value chain. Annual revenues generated by the charcoal sector in Kenya alone are estimated between USD 450 million and USD 1.6 billion, which is commensurate or largely exceeding to the country's well-established tea industry (Bergmann, Roden and Nüsser, 2017). In Malawi, the charcoal sector provides 3.5% of the GDP (gross domestic product) with revenues of USD 40 million (Kambewa *et al.*, 2007). These numbers manifest the economic importance of charcoal for the millions of people dependent on the income provided by their involvement in the value chain.

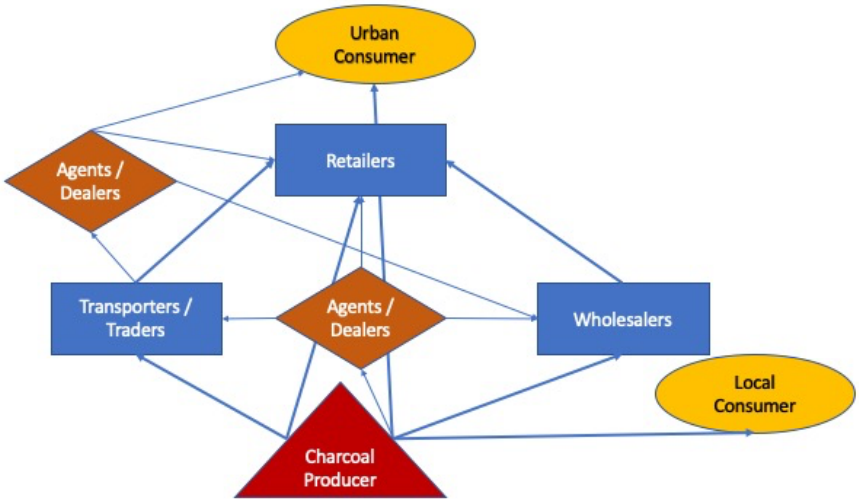

Figure 1: Charcoal Value Chain. (Source: adapted from Sola et al (2019))

Profit distribution along the value chain, however, is very uneven, depending on a person's function and the scale of production and or trade (Baumert *et al.*, 2016). Large-scale commercial enterprises have the highest profit margins as they can cover different levels of the chain themselves, from production over transportation to wholesale, thus also earning the profit at all covered levels (ibid). The largest group in the value chain, the rural-based small-scale producers, on which this master project is focused, make the lowest profits (Baumert *et al.*, 2016; Ndegwa *et al.*, 2016). Nevertheless, producing charcoal provides a vital opportunity to source income for these households (Malimbwi and Zahabu, 2009; Smith, Hudson and Schreckenberg, 2017). As they usually have access to forest resources that is easy, close by, and often open, charcoal can be produced with low entry investments and opportunity costs for labor since alternative income-generating or formal employment opportunities are largely missing (Luoga, Witkowski and Balkwill, 2000; Zulu and Richardson, 2013; Baumert *et al.*, 2016).

With low entry and input costs and relatively high returns compared to uncertain and highly variable income from subsistence farming, charcoal production provides a lucrative way to supplement farming (Iiyama *et al.*, 2017). This ease of entry, on the other hand, also leads to strong competition, which further explains the relatively low returns for producers (Arnold, Köhlin and Persson, 2006), especially when large-scale operators dominate local production (Baumert *et al.*, 2016). The uneven distribution of profits along the charcoal value chain is symptomatic of the unregulated nature of the entire charcoal sector (Schure *et al.*, 2013; Baumert *et al.*, 2016) as further discussed in section 2.5.

2.2 Charcoal Production Process

The charcoal production process involves harvesting and preparing (e.g. cutting and drying) wood, clearing the kiln site and constructing the kiln, pyrolysis of the wood in the kiln and observation of the process. Afterwards, the kilns are emptied, the charcoal is cooled and then packaged for transport and sale (Ndegwa *et al.*, 2016; Schure *et al.*, 2019). Wood for charcoal production is mostly sourced from natural forests on public or private land or forest areas with unclear tenure, though in some cases also from protected areas or forest reserves. Trees outside of forests (on roadsides, in towns, scrubs and hedges) and on-farm trees, i.e. from agroforestry, are harvested as well. Thereby, either whole trees or pruned or trimmed branches are harvested. Other sources of wood for charcoal production include plantations and harvest residue (FAO, 2010). Wood harvesting for charcoal production is often highly selective for certain tree species, which allow the production of high-quality charcoal (Zorrilla-Miras *et al.*, 2018; Kiruki *et al.*, 2019) such as *Acacia* species, for example (Oduor, Ngugi and wa Gathui, 2012). The tree is cut at the base of the trunk with machetes, axes or chainsaws. The basal portion of the trunk is left for "stumping" or coppicing, i.e. natural regeneration of the tree through vegetative sprouting. The trunk and bigger branches are then cut into smaller logs, small branches are removed and either left as waste or used as firewood (Chidumayo and Gumbo, 2013; FAO, 2017). For more energy efficient carbonization, the wood is ideally laid out to reduce the moisture content before pyrolysis (FAO, 2017).

Most producers build a pit kiln or an earth mound kiln. For the former a hole is dug in the ground, the wood is placed inside and then covered with soil (Chidumayo and Gumbo, 2013). For the latter, wood is stacked on the ground and then covered with soil. The soil cover cuts off oxygen supply during pyrolysis and thus prevents combustion of the wood (Demirbas *et al.*, 2016; Schure *et al.*, 2019). Conversion efficiency of the kilns varies greatly between 8% and over 20% (Chidumayo and Gumbo, 2013). In modern kilns producing 1kg of charcoal requires as little as 3kg of wood, whereas traditional kilns require up to 12kg (FAO, 2017). Hence, the lower the kiln efficiency the larger the amount of raw materials needed and thereby more pressure is put on wood resources (Abdallah and Monela, 2007; FAO, 2017). Gmünder et al. (2014) compared different scenarios for typical charcoal value chains and conclude that apart from improved cooking stoves at the consumer end, more efficient kilns at the production end have a major impact on the sustainability of the value chain.

2.3 Environmental Implications of Charcoal Production

The extent to which charcoal production is responsible for forest degradation and deforestation is difficult to quantify due to challenges regarding monitoring, separating charcoal production from other drivers (Ahrends *et al.*, 2010) and variations depending on scale and geographic location (Mwampamba *et al.*, 2013; Kiruki *et al.*, 2019). To what extent deforestation is driven by charcoal production is disputed in literature (Chidumayo and Gumbo, 2013; Mwampamba *et al.*, 2013). Deforestation, defined as the long-term clearing of forest area and conversion into non-forest land use (Watson *et al.*, 2000), has, in many cases, been found to be the result of clearing land for agricultural expansion. In this case, production of charcoal from the cleared forest is more of a by-product rather than the underlying motive (Mwampamba *et al.*, 2013; Bergmann, Roden and Nüsser, 2017; Kiruki *et al.*, 2019).

Selective tree cutting practices as described above, on the other hand, are changing the composition of the ecosystem and thus leading to degraded forests rather than complete and permanent deforestation (Chidumayo and Gumbo, 2013). Various studies have concluded that selective tree harvesting can lead to losses in biodiversity, forest cover loss, changes in the hydrology and soil fertility and reducing carbon storage capacity in and of these ecosystems (Monela *et al.*, 1999; Chidumayo and Gumbo, 2013; Mwampamba *et al.*, 2013; Iiyama *et al.*, 2014).

The sustainability of harvesting practices also depends on the amount harvested and the (natural) regrowth rate. Sustainability in general is defined as satisfying "the needs of the present without compromising the ability of future generations to meet their own needs"(WCED, 1987, p. 40), meaning that a given capital stock is maintained (Pearce and Atkinson, 1998). Accordingly, sustainable wood harvesting is defined and limited to less than or equal to natural tree growth in the harvesting area per time unit, whereas harvesting exceeding the natural growth rates would be deemed unsustainable (Soltani *et al.*, 2012). Depending on forest stock, regrowth and production amount (i.e. harvesting), kiln efficiency has an influence on how much pressure is exerted on the ecosystem where wood is harvested from (Santos *et al.*, 2017).

Degradation of ecosystems not only reduces their resilience but also the resilience of the livelihoods dependent on its services (Chidumayo and Gumbo, 2013). Hence, it is vital to ensure environmentally sustainable practices for charcoal production in order to sustain the livelihoods of the charcoal producers as well as those of the non-producing community members. However, based on current trends and projections for future demand, even greater pressure will be put on a declining forest resource base, which in turn will increase both environmental and (socio-)economic stressors (Khundi *et al.*, 2011).

2.4 Livelihood Implications of Charcoal Production

Charcoal is often produced as a casual, seasonal activity rather than a full-time occupation by rural households, mainly subsistence farmers, in the agricultural off-season (Malimbwi and Zahabu, 2009; Wiskerke *et al.*, 2010), which coincides with the dry season (Jones, Ryan and Fisher, 2016). At this time of year, demand and thus prices for charcoal are higher whereas food and income supply from farming are generally low (Zulu and Richardson, 2013; Smith, Hudson and Schreckenberg, 2017).

Rural households mostly use fuelwood for their own consumption but produce charcoal as an income generating activity for various reasons, ranging from a safety-net or coping strategy to supplement income, a buffer for yield losses from farming or to cope with shocks and stressors (environmental, political, etc.), as a seasonal gap-filler during the agricultural off-season, and as an income diversification strategy (Arnold, Köhlin and Persson, 2006; Malimbwi and Zahabu, 2009; Jones, Ryan and Fisher, 2016). The proceeds from selling the produced charcoal can be reinvested into sustaining the livelihoods (see section 4) of the household members by paying for school fees, health care or to buy farming inputs such as seeds or fertilizer (Butz, 2013; Smith, Hudson and Schreckenberg, 2017). Income from charcoal production has also been found to be an important contribution to households' food security when the money is used to buy food to supplement subsistence production and/or if production failed (Hoffmann *et al.*, 2017).

Involvement in charcoal production has also shown to possibly enable poverty alleviation or at least keeping rural households out of poverty (Butz, 2013; Zulu and Richardson, 2013). However, this potential highly depends on the scale of production. Very small-scale charcoal production generally only covers subsistence needs, not providing enough surplus to allow producers to expand production capacity and raise households out of poverty. For some producers, charcoal has therefore also been described as a poverty trap rather than a way out (Luoga, Witkowski and Balkwill, 2000; Arnold, Köhlin and Persson, 2006; Ndegwa *et al.*, 2016).

As charcoal production is physically demanding, time consuming and labor intensive, family members and other producers often help each other (Malimbwi and Zahabu, 2008). One common practice is labor groups, generally mostly men, where the group builds one producer's kiln first and everyone is compensated with food and drinks. Labor is reciprocated when they move on to the next producer to construct that person's kiln and so on (Schure, 2012). Thus, many charcoal producers rely on their social

network for production. The exchange with other producers is also how many producers learn the trade, by observing and learning from others since there's no formal education or training available (Butz, 2013; Schure *et al.*, 2015). Hence, knowledge about charcoal production as human capital is closely linked to producers' social capital (see section 4. for further explanation).

2.5 Policies and Regulations

Policy interventions and regulations have targeted different stages of the charcoal value chain, from the different stages of production to consumption, in order to reduce its environmental burden as well as the health risks associated with charcoal consumption (FAO, 2017). However, there is no overall policy to govern production, trade and consumption, but rather multiple policies from different sectors (Doggart and Meshack, 2017). Moreover, political support and general interest in these interventions are rather low throughout SSA (Hoffmann *et al.*, 2018). Widespread adoption has in some cases also been hindered as the intervention failed to adequately account for the socio-economic and cultural context (Arnold, Köhlin and Persson, 2006).

Policies relevant for sustainable charcoal production are spread across different sectors including energy, forestry, environment and agriculture (Sola *et al.*, 2019). Relevant policies regarding charcoal production in Tanzania are discussed in section 5.5. While some of them recognize the importance of charcoal they do not include explicit statements or guidance for it. Instead, many of them focus on sustainable forest management in general and/or timber (Doggart, 2016). Moreover, energy strategies in many SSA countries largely neglect woodfuels altogether and rather focus on switching to more modern energy sources (Sola *et al.*, 2019). In Kenya, Tanzania, and Malawi, among others, bans on charcoal production and transportation have been imposed. These bans sometimes did not include selling and consumption, thus production and transportation continued illegally (ibid).

The most comprehensive policies and related instruments (laws, regulations, guidelines and strategies) influencing charcoal production are generally found in forest policies (Doggart and Meshack, 2017). Several of them include permit and licensing schemes for the extraction and trade of forest products (Sola *et al.*, 2019). However, the process of applying for a permit is rather opaque, involves bureaucratic hurdles and high costs (Baumert *et al.*, 2016). Therefore, the majority of charcoal is produced outside of these regulations, rendering them largely ineffective (Ndegwa *et al.*, 2016).

Furthermore, efforts to produce charcoal legally are undermined by competing with informal or illegal production. By evading taxes and permit fees, illegally sourced charcoal is cheaper than that from formal production (Robinson and Lokina, 2011; Cavanagh, Vedeld and Trædal, 2015; FAO, 2017, p. 83). In many SSA countries, taxing the transportation of charcoal has de facto replaced licensing of charcoal producers, due to lacking enforcement capacity of the regulatory authorities (Ihalainen, Schure and Sola, 2020). Moreover, taxation schemes tend to penalize smallholder production compared to large-scale production with proportionally lower taxes for the latter (Ellis and Allison, 2004).

Formalizing and regulating forest products can also have other adverse effects, including marginalizing and criminalizing the mostly informal practices of charcoal production (Bergmann, Roden and Nüsser, 2017) and harvesters of forest products in general (Schure *et al.*, 2013). This particularly effects the rural poor whose livelihoods considerably depend on the consumption and/or income of these products (Jumbe and Angelsen, 2011; Robinson and Lokina, 2011). One emerging intervention bearing these risks is community-based forest management (CBFM), where a community owns and manages forests on village land through a Village Natural Resource Committee (VNRC) (Vyamana, 2009). During its establishment, a major step is to formalize land use plans and demarcate the forest area to be turned into a reserve, with restricted access and extraction. However, this formalization process often clashes with existing informal customary laws (Schure *et al.*, 2013), for example contesting tenure and

ownership rights (Cavanagh, Vedeld and Trædal, 2015), which, especially in remote areas, dominate compared to formal laws (Baumert *et al.*, 2016). Additionally, depending on village power structures, CBFM (and CBNRM in general) harbors the risk of elite capture and reproduction of income inequalities (Vyamana, 2009). Especially richer and/or male headed households tend to profit unevenly more than poorer households and/or those headed by women, especially when the focus of the resource management lies on forest products for sale rather than on subsistence use for the community (Arnold, Köhlin and Persson, 2006, p. 608). Furthermore, if other forested areas are accessible nearby, the pressure on these other forests might be rather diverted instead of reduced completely through the establishment of forest reserves (Jumbe and Angelsen, 2011). Examples of successful implementation of CBFM, where the local community benefits from revenues and can either invest those in developing infrastructure such as schools or improve producers' incomes, can be seen in west Africa (Niger, Burkina Faso, Mali, Senegal) (Schure *et al.*, 2013). From a conservation perspective, CBFM has generally shown to improve forest conditions (Vyamana, 2009). However, despite the formalization through legal frameworks, the much higher consumption levels compared to the licensed production amounts of charcoal reflect the still largely informal and often illegal production. Combined with weak capacities of forestry services, incomplete implementation of taxation and corruption throughout the value chain, it undermines the potential revenues for local communities (Schure *et al.*, 2013).

Overall, policies and regulations for the charcoal sector have been found to currently be insufficient and mostly ineffective as in most cases, they are either barely acknowledged, lack enforcement capacity, are conflicting and incoherent across different government sectors, or render charcoal illegal (Kambewa *et al.*, 2007; Neufeldt *et al.*, 2015). Where policies and instruments are technically in place, implementation on the ground often fails due to lacking human, financial and technical capacity of the enforcing governmental and communal institutions (FAO, 2017, pp. 108–110; Zorrilla-Miras *et al.*, 2018). Reflecting the fact that charcoal is one of the most commercialized yet least regulated commodities, the large losses in tax revenues from the charcoal sector are a common theme throughout SSA (Bailis, Ezzati and Kammen, 2005). Annually foregone tax revenues from charcoal licensing and taxation for Kenya are estimated at USD 65 million, for Mozambique at USD 50 million and for Tanzania at USD 100 million (FAO, 2017). The unregulated and/or unenforced nature of the policy and regulations landscape surrounding charcoal production also leave leeway for corruption and bribery (Schure *et al.*, 2013; Cavanagh, Vedeld and Trædal, 2015). In Malawi and Kenya, it is estimated that bribes account for 12% and 20-30% of the retail price of charcoal, respectively (FAO, 2017, p. 111).

Iiyama et al. (2017) suggest that cross-sector approaches are needed for the successful implementation of charcoal governing policies, especially in regard to reducing forest degradation and deforestation without adversely impacting rural livelihood strategies. This is especially important since agriculture and charcoal production are both associated with deforestation and depend on the same ecosystem services (ibid). One option might be to address charcoal production in agriculture and forestry (and energy) cross-sector policies, through promoting sustainable agricultural intensification or agroforestry (Cavanagh, Vedeld and Trædal, 2015).

3 Charcoal Production and Agroforestry

3.1 Agroforestry Definition

Agroforestry is, in very broad terms, a multi-production system that combines the production of crops and tree products (Leakey *et al.*, 2005). As Leakey (1996, p. 956) defines it, agroforestry is "a dynamic, ecologically based, natural resource management system that, through the integration of trees in farmland and rangeland, diversifies and sustains production for increased social, economic and environmental benefits". According to the definition of the Food and Agricultural Organization (FAO), which defines it as agricultural land with tree cover of more than 10% (FAO 2010: 6), agroforestry nowadays covers over 43% of total agricultural land area worldwide (Zomer *et al.*, 2016) providing for approximately 560 million people (Dawson *et al.*, 2014). The combination of trees with crops and livestock can follow certain spatial arrangements and/or temporal sequencing (Quandt, Neufeldt and McCabe, 2019). Aside from the benefits described below, trees in agroforestry systems serve specific uses, including as boundary demarcation or live fences. The trees can be intercropped with food or cash crops (agri-silviculture), on livestock pastures (silvipastoral), or they can be grown in woodlots – farmland specifically set aside for growing trees, usually for woodfuel or timber production (Kitalyi *et al.*, 2010; Njenga *et al.*, 2017). In considering the particular use of trees and the utilization of certain characteristics of specific tree species, agroforestry includes the intentional management of trees, including planting new trees (Ndayambaje, Heijman and Mohren, 2013). Since the 1990s, being a low-input and species-rich agricultural technique, agroforestry has received increasing attention as an initiative to address both the SDGs and environmental conservation efforts at the same time (Plieninger *et al.*, 2020). The premise is that tree cultivation for agroforestry tree products (AFTPs) and their commercialization could motivate farmers to plant trees on their farms. The consumption and sale of these AFTPs in turn could help reducing poverty, improving food and nutritional security, increasing health and enhancing environmental sustainability (Leakey *et al.*, 2005).

3.2 Benefits of Agroforestry

Based on Leakey's definition, agroforestry systems can be beneficial to both the livelihoods of farmers and the ecosystems they depend on. In well-established agroforestry systems, this resilient land use practice can further help to mitigate the effects of climate change, reduce or even reverse land degradation and preserve on-farm biodiversity (Kitalyi *et al.*, 2010). Agroforestry also aids with biodiversity conservation in general by providing corridors for connectivity to other systems, including forests (Asare *et al.*, 2014; Dawson *et al.*, 2014; Harvey *et al.*, 2014).

More specifically, benefits of agroforestry can be divided into three main categories: direct biological products (direct benefits), ecosystem services and cultural services. Products provided by agroforestry include i) woodfuel, ii) construction material, iii) edible products such as fruits, vegetables and nuts, iv) medicinal plants, v) natural pesticides and vi) leaves and pods as fodder for livestock (Kürsten, 2000; Njenga *et al.*, 2017; Reppin *et al.*, 2020). Local knowledge about the nutritional benefits of certain cultivated tree products like vitamin- or protein-rich fruits and crops, which also contain high amounts of carbohydrates, fats and minerals, can improve the family members' health (Leakey *et al.*, 2005; Njenga *et al.*, 2017). Consuming a variety of indigenous fruits and vegetables supports a diversified diet and promotes a healthy immune system. Additionally, medicinal herbs can be grown in the shade of trees in agroforestry systems (Leaky et al. 2005). Financial benefits can be derived by selling these products. Profits from fuelwood production in tree-crop systems are higher than in monocultures of either and the same goes for the ecological benefits (Kürsten, 2000). These profits can then be used to be reinvested into improving the household members' livelihoods (e.g. school fees) or in agricultural inputs (e.g. fertilizer). Moreover, expenditures on food are lower due to enhanced on-farm production (Leakey *et*

al., 2005). Hence, agroforestry and its products can have direct livelihood benefits for the farmer and her*his household.

Ecosystem services provided by on-farm trees include i) soil fertility improvement through fertilizer trees, such as nitrogen-fixing species (Sanchez and Jama, 2009), ii) (agro-)biodiversity conservation (Bhagwat *et al.*, 2008), and iii) regulating services including control of soil erosion, water retention or in the form of windbreaks (Njenga *et al.*, 2017). Other than these uses, trees can also have cultural and social purposes when they provide shade for gatherings (Quandt, Neufeldt and McCabe, 2019, p. 497), as sites for religious or spiritual functions (Akinnifesi *et al.*, 2008, p. 77) or by strengthening ties to other community members when products are exchanged between households (Maroyi, 2009). Selling of NTFPs and AFTPs is often done by women. Promoting marketing and value-adding options, such as processing, could therefore additionally strengthen the role and independence of women (Leaky et al 2005). The high species diversity furthermore allows for year-round production, contributing to food security by reducing the repercussions of crop failure of one crop (Maroyi, 2009) and it lowers dependence on just one commodity by diversifying income from on-farm products (Leakey *et al.*, 2005).

3.3 Synergies of Agroforestry and Charcoal Production

Agroforestry has the potential to counteract some of the negative environmental impacts of charcoal production, namely forest degradation and deforestation, through its manifold ecological services (Hoffmann *et al.*, 2017). As shown in a restoration project in northern Tanzania, for example, the promotion of agroforestry can help degraded ecosystems to recover and reduce pressure on them, while also providing woodfuels (Duguma *et al.*, 2019). When access to forest resources is limited through deforestation and degradation (Akinnifesi *et al.*, 2008) or through CBNRM/CBFM, which restricts access (Jumbe and Angelsen, 2011), households are forced to seek alternative strategies for subsistence needs, like planting on-farm trees. For woodfuel shortages specifically, woodlots could serve as an alternative solution (ibid). Encouraging communities and individuals to plant woodlots could also reduce pressure on customarily used forests in areas with no established forest reserves (Jumbe and Angelsen, 2011). Moreover, the implementation of agroforestry systems can be connected to the energy sector or financial incentives can be provided through payments for ecosystem services (PES), for instance for carbon sequestration (Kürsten, 2000), together with highlighting pro-social and pro-environmental benefits of conservation (Jones *et al.*, 2020).

Table 1 gives an overview of benefits as well as challenges (see next sub-section, 3.4) regarding livelihood and ecological aspects of agroforestry and charcoal production. If implemented successfully, the benefits of agroforestry could counter or even exceed the detrimental effects of charcoal production. The list includes the most relevant aspects for the purpose of this thesis.

Table 1: Potential livelihood and ecological benefits and challenges of agroforestry and charcoal production (Source: own representation)

		Benefits	**Challenges/ trade-offs**
Agroforestry	*Livelihood*	• Improved & diversified food production (food security)[20, 25] • Medicine[3] • Shade[3] • Construction material, Timber[36] • Woodfuel[12, 16, 44] • Boundary trees for demarcation, fencing and protection[36] • Increased income from selling tree products[13]	• Competition between trees and crops [39] • Long-term investment and relatively long establishment period[21] • Insecure tenure, land rights[2, 27] • Size of land holdings[2, 27] • Lack of established markets for AFTP[13, 38]

Table 1: continued.

		Benefits	Challenges/ trade-offs
	Ecological	• Reduction of deforestation[15, 41] • (Agro-)Biodiversity conservation[6] • Soil fertility improvements[22, 35, 40] • Erosion control[24] • Watershed and water retention improvements[45] • Climate change mitigation[9, 34] • Carbon sequestration[43] • Habitat and habitat connectivity[4, 11]	• Invasive, exotic species[19, 28] • Climatic feasibility and conformability[30] • Limited performance on degraded soils[19] • Pests[19]
Charcoal Production	*Livelihood*	• Income diversification[42] • Safety net[45] • Poverty alleviation[7, 46] • Large and well-established market[18, 23]	• Production often illegal[8, 37] • High fees for license, taxes, bribes [5, 31] • Low profit margins for producers [5, 31] • Labor intensive and time consuming[26]
	Ecological	• Sustainable production[10, 14] • Integration in CBFM[47] • Soil amendments[1]	• Forest/ Ecosystem degradation • (Deforestation)[18] • Reduced soil fertility and water retention capacity[29] • Loss of biodiversity and fragmentation of habitats[2] • Carbon emissions[32]

Sources: Abiven, Schmidt, and Lehmann (2014)[1]; Ahrends et al. (2010)[2]; Akinnifesi et al. (2010)[3]; Asare et al. (2014)[4]; Baumert et al. (2016)[5]; Bhagwat et al. (2008)[6]; Butz (2013)[7]; Cavanagh, Vedeld, and Trædal (2015)[8]; Charles, Munishi, and Nzunda (2013)[9]; Chesterman et al. (2018)[10]; Dawson et al. (2014)[11]; Faße, Winter, and Grote (2014)[12]; Garrity et al. (2010)[13]; Githiomi and Oduor (2012)[14]; Harvey et al. (2014)[15]; Iiyama et al. (2014)[16], (2017)[17]; Ishengoma and Abdallah (2016)[18]; Jama, Amadou, and Kwesiga (2006)[19]; Jamnadass et al. (2015)[20]; Jumbe and Angelsen (2011)[21]; Kitalyi et al. (2010)[22]; Kürsten (2000)[23]; Kuyah et al. (2019)[24]; Leakey et al. (2005)[25]; Malimbwi and Zahabu (2008)[26]; Molebatsi et al. (2010)[27]; Msuya, Masanja, and Temu (2011)[28]; Ndayambaje and Mohren (2011)[29]; Ndegwa et al. (2016)[30]; Okoko et al. (2017)[31]; Pennise et al. (2001)[32]; Quandt, Neufeldt, and McCabe (2017)[33]; Rao, Verchot, and Laarman (2007)[34]; Reppin et al. (2020)[35]; Robinson and Lokina (2011)[36]; Russell and Franzel (2004)[37]; Sanchez (1995)[38]; Sanchez and Jama (2009)[39]; Sanchez, Buresh, and Leakey (1997)[40]; Smith, Hudson, and Schreckenberg (2017)[41]; Stavi and Lal (2013)[42]; Wiskerke et al. (2010)[43]; Zhu et al. (2019)[44]; Leo C. Zulu and Richardson (2013)[45]; Leo Charles Zulu (2010)[46]

3.4 Challenges for Implementing Agroforestry

Characteristically, agroforestry landscapes are complex dynamic systems involving various interacting institutions, actors and networks across different governance, spatial and temporal scales (Plieninger *et al.*, 2020). Hence, while the potential benefits of agroforestry are evident and well researched, the implementation of agroforestry systems is faced with a number of challenges across these scales.

As is the case with charcoal production, governance of agroforestry and on-farm trees is spread across different government sectors, primarily forestry and agriculture (Msuya and Kideghesho, 2012). Acknowledgement of the potential of agroforestry is lacking in high-up policies and instruments (NASCO, 2010). Thus, the inherent interdisciplinary nature of agroforestry is challenging its adoption in current governance and policy landscapes (Place *et al.*, 2012). To overcome this implementation hurdle, the disaggregation of agroforestry between agricultural, forestry and other related sectorial policies such as land use and environmental policies needs to be eliminated and coherent policies must be realized (Plieninger *et al.*, 2020).

At the individual or farm level, small farm size can be a major hindrance for farmers to plant trees on their farm (Jumbe and Angelsen, 2011). Small landholdings and long waiting periods until full productivity of on-farm trees are often reasons why farmers are reluctant to plant trees on their farm (ibid). While large landholdings can be an opportunity because there is space for trials, they can also be a hindrance in that environmental pressures, i.e. declining tree resources or soil fertility, are not felt as acutely (Mercer, 2004). Land tenure systems and local traditional institutions governing land use and rights are another crucial components for agroforestry adoption (Mercer, 2004). Farmers are more reluctant to invest in tree planting if land tenure is insecure, especially so when combined with small farm size (Akinnifesi *et al.*, 2010). Willingness to plant on-farm trees has further been shown to be connected to farmers' education levels as well as their knowledge and awareness about ecological sustainability and degradation of their environment: The higher these aspects of human capital, the higher farmers' willingness (Mercer, 2004; Faße and Grote, 2013).

Another key challenge with promoting agroforestry is connecting farmers to markets or even establish new markets for its products (Garrity, 2004; Russell and Franzel, 2004). Establishing links between markets and producers of tree products, including charcoal and firewood, is often hindered by tree protection policies dating back to the colonial era, which prohibit the cutting and transportation of tree products (Russell and Franzel, 2004; Zulu, 2010). For successful and beneficial marketization, favorable social and human capital, including being well informed about the markets, and well organized as well as establishing networked groups are crucial (Leakey *et al.*, 2005).

The promotion of certain tree species for their specific function should include careful assessment of the properties and suitability of different genetic varieties of a species in order to fit the specific climatic environment and utilization context (Ndayambaje and Mohren, 2011). Accordingly, it is important to promote indigenous species, as exotic ones could be invasive and threaten natural forests and their endemic species (Dawson et al 2014). Relatedly, it is crucial to include indigenous knowledge (Duguma *et al.*, 2019) and customary practices and traditions (Kimaro, Isaac and Chamshama, 2011; Altieri, Funes-Monzote and Petersen, 2012) to connect new agroforestry initiatives and technologies to and further build on existing human and social capital.

4 Theoretical Framework – Human and Social Capital

In this section, the central theoretical concepts used in this thesis are introduced and put into relation with charcoal producers' livelihoods. Livelihood in this case is defined according to Carswell (1997, p. 3): "A livelihood comprises the capabilities, assets and activities required as a means to a living. A livelihood is sustainable if it can cope with, and recover from, stresses and shocks, maintain or enhance its capabilities and assets and provide net benefits to other livelihoods locally and more widely, both now and in the future, without undermining the natural resource base." The assets or capitals include both material and social resources, namely natural, financial, physical, human and social capital (Carney, 2002). These capitals can be utilized through different strategies to produce desired livelihood outcomes. These strategies and outcomes, in turn, are set in a specific context with external influences "such as policies, institutions, laws, culture and individual preferences and priorities"(Soini, 2005, p. 312). The main focus of this thesis is on the human and social capital of charcoal producers. These two capitals are defined in detail in the following sections (4.1 and 4.2).

4.1 Human Capital

Today, the value of human capital as well as its development and enhancement through health care and education is reflected in numerous development programs and investments, especially in developing countries (Dao, 2008). This is, for instance, evident in the UNDP's SDGs where at least five of the seventeen goals directly or indirectly address health and education. These are: 2: zero hunger (incl. improved nutrition); 3: good health and well-being; 4: quality education; 5: gender equality (education for women, equality of opportunity); and 6: clean water and sanitation (UNDP, 2020a). While enhancement of human capital can lead to (national) economic development, the lack of human capital – especially bad health (Dao, 2008; Kinabo *et al.*, 2011) and a low education level (Beach, 2009) – have been shown to correlate with a higher risk of poverty on an individual level.

What is now known as modern human capital theory roots back to Adam Smith's "the wealth of nations" in 1779 and in the following two centuries has then been developed into an economist theory (Fitzsimons, 1999). As Schultz (1961) argued, the more educated laborers are, the more valuable they become and their knowledge and skills thus represent a form of capital, namely human capital. De la Fuente and Ciccone (2003) use a similar but more specific definition focusing on to value of human capital for production (i.e. of certain goods such as charcoal or agricultural products) and the means through which human capital can be developed. They define human capital as the "knowledge and skills embodied in people and accumulated through schooling, training and experience that are useful in the production of goods, services and further knowledge" (De la Fuente and Ciccone, 2003, p. 7).

In its modern, neoliberal definition, all individual human behavior is determined by economic self-interest and operates within a freely competitive market (Fitzsimons, 1999). According to this logic, increasing individual human capital is therefore an inherent goal, as more human capital ensures higher economic gain (i.e. wage or general growth) and is hence desirable from an individual as well as a national perspective. More recently, this has led to a re-theorization of education and training as key determinants for individual participation in economic performance and, consequently, for national economic growth (Fitzsimons, 1999; Beach, 2009). Education has thus been re-conceptualized from a consumption good into an asset worthy of investment for governments, companies and individuals (Au, Altman and Roussel, 2008). From a national governmental or a company's perspective, human capital can be referred to as its human resources or the labor force and the skills and knowledge they inhabit. In this context, human capital development means the establishment and promotion of an educated, skilled and experienced work force in order to boost economic growth and advancement of a national economy (Eigbiremolen and Anaduaka, 2014). Through this recognition of the economic

relevance of education, it has received ample attention in development and poverty alleviation programs as well as policy reforms over the past few decades. Among its promoters were also the OECD and the World Bank (De la Fuente and Ciccone, 2003). It also led to the emergence of an academic field and framework to assess the returns on the investments made in such programs (Au, Altman and Roussel, 2008). Most of these studies focus on the correlation between investments in educational programs and national economic growth rates by assessing literacy rates, school enrollment years, rates of higher education degrees and un-/employment rates (Kwon, 2009; Eigbiremolen and Anaduaka, 2014). For charcoal production and producers, however, these are not very useful indicators. As described in section 2.1 there is a rather low entry cost required to participate in charcoal production, which does not only concern the equipment for building the kiln or the wood to be transformed but also the entry level skills required, notwithstanding quality and quantity constraints. There is no formal education requirement or training available specifically for charcoal production (Malimbwi and Zahabu, 2009), possibly explaining the mostly informal household participation. In fact, Ndegwa et al. (2016) found that education levels among charcoal producers in Kenya are generally lower than among non-producers. They reason that many resort to charcoal production because their low education limits their options for alternative income generation, whereas higher educated people have other, more lucrative opportunities.

Learning from others is how most producers acquire their charcoal production skills in the DRC (Schure *et al.*, 2015). That charcoal production can be learned through watching others and learning by doing has also been observed in a village in northern Tanzania, where Maasai women are thought to have learned from observing non-Maasai producers outside the village. The women are expected to have learned without any direct, first-hand instructions as Maasai women usually have no contact with non-Maasai males, yet in the rest of the country charcoal production is predominantly a male activity (Butz, 2013). Similar evidence is reported in agricultural research regarding the adoption of new technologies and practices (e.g. agroforestry practices). Skills and knowledge (i.e. experience) of farmers are important for learning by doing and spillover effects. Farmers are more likely to adopt and achieve profitable results when their own or their neighbor's experience with a new technology is more advanced (Foster and Rosenzweig, 1995).

In addition to education, training, skills, knowledge and experience, health has also been recognized as an important dimension of human capital, especially for its influence on development, economic growth and productivity, since bad health generally lowers a person's productiveness and income (Young P. Hong and Pandey, 2007; Dao, 2008). De la Fuente and Ciccone (2003) for instance mention (yet do not evaluate) the importance of health and nutrition in enabling – or rather the lack thereof limiting – people to participate in productive activities, especially in developing countries. A case study from Tanzania shows that health issues such as nutritional status including underweight, anemia, iodine deficiency, and diseases, such as malaria and bilharzia, pose serious constraints on agricultural productivity and thus directly affect people's self-sufficiency in food production and their livelihood overall (Kinabo *et al.*, 2011).

Empirical assessments of health aspects of human capital have mainly included surveying indicators such as mortality rates of infants and children and maternal health (Dao 2008). Studies specifically on woodfuel consumption have estimated that it causes up to 400'000 deaths annually in SSA due to the air pollutants emitted indoors during use (e.g. for cooking and heating). Women and children are much more likely to be affected since they tend to spend more time indoors and in close proximity to the stoves (Bailis, Ezzati and Kammen, 2005). Compared to firewood, burning charcoal produces less particulate matter, of which high exposure can lead to respiratory issues. However, charcoal emits more carbon monoxide (Maes and Verbist, 2012), a taste- and odorless gas, which is highly toxic and can cause headaches, dizziness, nausea and in severe cases brain and heart damage and, ultimately, death (Prockop and Chichkova, 2007). Research on charcoal related health issues has been focusing mainly on

the consumer end of the value chain. Overall, little is known to date about health implications during the production stage (FAO, 2017, p. 34). A study on polycyclic aromatic hydrocarbons (PAH) emissions during the charcoal production process found genotoxic, carcinogenic PAH in particulate matter. Chronic exposure to these emissions, which is hardly avoidable for charcoal producers, can cause tumors and lung cancer (Mara dos Santos Barbosa, Ré-Poppi and Santiago-Silva, 2006). A study in Liberia revealed work related injuries such as burns and lacerations, with a 75% injury rate among participating producers (Alfaro and Jones, 2018). As for charcoal producers and farmers alike, health in the sense of being well-nourished, able-bodied and fit to work ultimately determining their labor-ability, is prerequisite as both activities are physically challenging work. Hence, health is included in the definition used in this thesis but focuses only on the health and health constraints of the charcoal producers (and their households) which influence, or are caused by, charcoal production.

A prominent voice among scholars on human capital and capabilities literature, especially in development and in connection with poverty reduction, is Amartya Sen (Hunt, Durham and Menke, 2015). He describes the vital importance of human capital and capabilities for (economic) development as follows:

> "While economic prosperity helps people to lead freer and more fulfilling lives, so do more education, health care, medical attention, and other factors that causally influence the effective freedoms that people actually enjoy. These "social developments" must directly count as "developmental" since they help us to lead longer, freer, and more fruitful lives, in addition to the role they have in promoting productivity or economic growth or individual incomes." (Sen, 1997, p. 1960)

He defines human capital as skills, knowledge and effort which determine a human being's agency to augment production possibilities. Human capital is indirectly valuable, as it contributes to the production of goods. However, he argues that this definition often focuses solely on human capital's indirect value to economic productivity. Therefore, Sen's extrapolated human capability approach also includes the direct values of human capital to the individual, which enable said individual to lead a live s*he finds valuable and gives her*him the (cap)ability to augment her*his fundamental choices to lead such a valued live (Sen, 1997). This approach also accounts for the criticism held against human capital concepts which solely focus on the eventual economic returns of human capital. In doing so, they neglect how social (capital) and structural barriers, and discrimination can limit peoples (cap)ability to enhance their human capital in educational landscapes and eventually in the labor market (Beach, 2009).

What is also not included in any of the commonly used human capital definitions, yet very closely linked to a person's ability to achieve her*his full human capital potential, are often culturally determined aspects of ethnicity and gender (Beach 2009). The domination of one ethnic group by claiming power as first-commers especially over land allocation within the village severely restricts the ability of other, later arriving ethnic groups in accessing land and negotiating land rights within recent CBRM (Mabele, 2019). Access to and increase of physical capital is closely related to accessing and increasing human capital (Grier, 2005). Moreover, ethnic diversity can make it difficult to find consensus over human capital investments (e.g. education) in a community (ibid). Regarding gender, a case study in north-western Tanzania found that when financially constrained, a family chooses based on cultural reasons and social values, such as gender roles, which child(ren) (male or female) can go to school. This form of human capital investment is usually made in a son, as he can thereafter have a better income which he is expected to partially use for taking care of his parents when they are old, thus returning their investment. A daughter on the other hand, once married, is obligated to do the same for her

parents-in-law, thus the investment of her original family would be lost to the in-laws. It would, however, raise her chances of marrying into a better-off family and daughters tend to still take care of their own parents as well, while many young men often leave rural areas in search of better job opportunities (Lilleør, 2008). Sen (1997) argues that promoting education for women could reduce gender inequality and thereby contribute to social development.

In connection with charcoal production various gender aspects and differences can be found in literature. For instance, Jones, Ryan, and Fisher (2016) found in their case study that female producers in central Mozambique practice charcoal production to gain more financial independence from their husbands. Other gender differences include the (ir)regularity and amounts of production (ibid.), as well as differing access to wood as the basic natural resource needed for production (Zorrilla-Miras *et al.*, 2018; Kiruki *et al.*, 2019). In a Maasai village in northern Tanzania some women, especially from female-headed households, are driven to charcoal production because of lacking alternative income providing activities and the absence of social systems provided by the village government. They are not just economically but also socially marginalized since charcoal production is frowned upon by other village members because of its environmentally degrading consequences (e.g. increasing dust storms). Although aware of the environmental impact of their practice, the women (are forced to) choose income, which they can invest in the health and education of their family, over the protection of the environment and social acceptance (Butz, 2013). In this thesis, these aspects and their effects on human capital (and social capital) will be carefully considered.

As indicated above by Beach (2009) and illustrated by these studies, an individual's human capital and the opportunities to augment it are highly influenced by the cultural and social context (Fitzsimons, 1999). For instance, human capital is closely linked to social capital (see section 4.2) and vice versa. As described above, a neighbor's human capital (knowledge and experience) can have an influence on farmers (or charcoal producers) to adopt new technologies and their profitability through spillover and learning from others (Foster and Rosenzweig, 1995). Hence, the social connections to the neighbors determine how easily this spillover effect of knowledge, experience and information can take place. A long-term panel study found that bridging and bonding social capital (see section 4.2 for further elaboration) has positive effects on income and employment security. The same was found for cultural aspects such as social, family and economic life goals (e.g. importance of friends, importance of partner and children, professional success, ability to afford certain things etc.), which also influence life satisfaction (Muffels and Headey, 2013). Coleman (1988) showed that social capital of and within the family strongly influences children's education. Within the family, social capital can be seen as the time and effort spent by a parent to support the child in its education. This support is potentially enhanced by the parents' own human capital (i.e. years of schooling), it is, however, of no use to the child if the social capital is not invested to pass it on. Community social capital, i.e. the parents' connections within the community, also have a strong effect on the outcomes of children. The stronger the parents are embedded in the community and with other parents the more influential are the shared values and expectations of specific educational outcomes of a community (ibid.). Apart from explicit formal educational learning, social and cultural learning through practices such as rituals, games, competition and everyday life is a precondition for and also a form of social membership (Alkemeyer and Buschmann, 2017, p. 13).

In conclusion, human capital is here defined as the skills, knowledge, experience and health of charcoal producers and/or agroforestry farmers. This thesis will not assess the economic value of human capital in charcoal production but qualitatively inquire how charcoal producers' skills, knowledge, experience and health influence the production process and the potential for utilizing and planting on-farm trees. Aspects of the social and cultural context along with ethnicity and gender and how they influence the human capital and capabilities of charcoal producers will be carefully considered. Additionally, the

benefits of charcoal production on human capital (e.g. if revenue is used for school tuition or health care) along the lines of Sen's capability approach are explored.

4.2 Social Capital

Social capital is crucial to sustain livelihoods, especially for natural-resource dependent rural households, as it provides access to a number of other assets (i.e. human and natural capital assets); access which can otherwise be limited when social capital is lacking (Carney 2003). Furthermore, it is a key resource for managing vulnerability and risk (Hunt, Durham and Menke, 2015). Social capital consists of a bundle of resources, which are captured in social relations and social structures (Lin, 2002). These resources can be utilized to facilitate actions in order to achieve certain goals or interests. Social capital also comprises various entities (i.e. resources), where one entity might be useful or even indispensable in facilitating and achieving a certain goal or activity, yet irreplaceable, and useless or even harmful for another activity. Social capital can be combined with other capitals and resources to produce different outcomes for individuals. While being a capital made up of different resources itself, its main objective and value lie in providing access to resources of other capitals (i.e. human, financial, natural and physical capital) (Carney, 2002).

The concept of social capital is originally rooted in Hanifan's: a metaphor for non-economic aspects such as goodwill or fellowship in a family, which can improve life (Hanifan, 1916; Fulkerson and Thompson, 2008). To these intimate and strong ties, Granovetter (1973) later added the importance of weak ties, since people we are weakly acquainted to usually have a more diverse set of connections and networks and hence opening up access to other resources and information than family members or other close ties could provide with their similar network to one's own. Both Granovetter and Hanifan focus their definition of social capital on the individual or household level. Putnam, on the other hand, focuses on the strong, more closed ties and their implication for a society's efficiency. At least for the effects and general outcomes of social capital, his perspective focuses on the community level. He defines social capital as the networks, norms and trust of a society, which promote its efficiency by enabling collective action. By engaging in social networks and associations, a framework of shared values emerges, building the basis for mutual trust and norms of reciprocity. These shared values, norms and mutual trust provide individuals with a sense of accountability for maintaining collective benefits of common resources (i.e. community forests) for the common good. They also allow for social sanctions if these benefits are threatened by individual actions defecting the shared values and interests (i.e. overexploitation) (Putnam, 1993, 1995). The more closed a network is, the easier and the more effective the sanctioning (Coleman 1988).

The value of social capital according to Coleman (1988) lies in (i) the number of obligations another person owes to reciprocate previous favors, which can be called in when needed, (ii) the potentially useful information a social relation might provide or (iii) the form of an effective norm, allowing for sanctions for social members who do not follow it. Others have added partially overlapping indicators. Flap (1999) focuses on the number and the strength of relations, as a notion of number of obligations, and closedness of a network (Coleman) vs. weak ties (Granovetter). He also includes the resources (e.g. information) these relations could provide. Lin (2002) names information as well, and social credentials, which resonates with Putnam's conditions of shared norms and trust and Coleman's idea of closedness. Lin, however, also adds influence and reinforcement, which resonate more with Bourdieu's aspects of power and the reproduction of the social context through practice.

The widely applied Sustainable Livelihoods Approach (SLA) includes its own definition of social capital and highlights its major relevance to livelihoods, especially for rural poor individuals and households (DFID, 1999; Carney, 2002). The SLA definition sees social capital as "the social resources upon which people draw in pursuit of their livelihood objectives" (DFID, 1999, sec. 2.3.2). These resources can be

acquired through "networks and connectedness" (vertically and horizontally), "membership of more formalized groups" (including shared rules, norms and sanctions) and "relationships of trust, reciprocity and exchange" which could serve as an "informal safety net among the poor" (ibid). This further highlights the importance of social capital in increasing other capital assets (DFID, 1999, sec. 2.3.2). It acknowledges mutual construction and possibly self-reinforcement of social capital and its inherent structures and processes (DFID, 1999, sec. 2.3.2), albeit rather vaguely with its very open definition of social capital (Stirrat, 2005).

Putnam's definition focuses on the community level outcomes of social capital, thus it includes institutional performance and a society's efficiency as a result of social capital (Fulkerson and Thompson, 2008). This resonates with Coleman's definition that social structure (or organization through networks) facilitates (collective) action (Coleman, 1988). This could be applied, for instance on the safeguarding of natural resources in and through communities. On the community level, social capital in this context is therefore a valuable resource and starting point for collective and community-based efforts to manage common natural resources (i.e. forests, water resources, etc.). The identification of local institutions, their values and their influence on people's livelihoods and access to resources is therefore paramount, as is the identification of lacks thereof. In connection with the natural environment, institutions can be defined as "regularized patterns of behavior between individuals and groups in society" (Leach, Mearns and Scoones, 1999, p. 226). "Diverse institutions, both formal and informal, and often acting in combination, shape the ways in which differentiated actors access, use and derive well-being from environmental resources and services, and in so doing, influence the course of ecological change" (Leach, Mearns and Scoones, 1999, p. 240). Formal institutions are considered as formally regulated through rules determined by outside factors such as policies and laws. Informal institutions, on the other hand, are bound by unwritten rules and influenced by shared norms and values. They are socially accepted, (re)produced and reinforced through individual social action (Leach, Mearns and Scoones, 1999; Schure *et al.*, 2013). Hence informal institutions are created and reinforced through social practice within social networks, through the formation and utilization of individuals' social capital.

Social capital can be formed and utilized across different hierarchical and geographical scales. Bonding social capital emerges when individuals interact in solidarity with people with a similar background (i.e. belonging to the same community/ intracommunity). When that solidarity is extended to people with different backgrounds (i.e. across different communities within or across geographical locations), it is considered bridging social capital. Linking social capital involves relations across vertical arrangements in a society to more powerful and influential persons such as government or public administration officials (Hunt, Durham, Menke 2015). In connection with the poverty alleviation and development discourse, linking social capital is especially important since there is a correlation between poverty and people's inability to access people in power (Bebbington 1999).

The concept of social capital enjoys wide popularity among scholars and in literature about poverty reduction and development. However, it is not without criticism (Stirrat, 2005; Fulkerson and Thompson, 2008). The SLA's definition is criticized for being too broad and too vague (Stirrat, 2005). Moreover, if social capital within a community is dominated by tightly bonded and homogenous groups, the lack of diversity can hinder change and innovation (Newman and Dale, 2005; Edwards and Onyx, 2007; Rydin and Holman, 2007). Furthermore, the common assumption of Putnam's and other definitions indicates that more social capital is better. However, this position disregards power dynamics and inequality, which are reflected and reinforced through social networks and institutions (Fulkerson and Thompson, 2008). They define and reproduce the boundaries of social groups, reinforcing mechanisms of inclusion and exclusion. While potentially benefitting its members, social capital can be discriminatory for non-members. This more Bourdieuan view is key in order to give more attention to the context in which social capital is set (Bebbington, 2007). Investigating bridging and

linking social capital as described above can provide a starting point to identify and address such issues (e.g. see Hunt, Durham and Menke, 2015).

A particular focus of this thesis is how human and social capital influence the utilization of on-farm trees or agroforestry as a potential source for charcoal, in order to reduce environmental pressure and degradation of natural forest resources, as their integrity is vital for environmental as well as livelihood sustainability of the local community. Thus, for its community dimension, the working definition of social capital applied in this thesis is mostly based on Putnam. Such a normative approach to social capital, however, also has the weakness of disregarding power dynamics. In order to accommodate this criticism, Putnam's definition is extended to include Bourdieu's focus of social capital for explaining the unequal distribution of power and privilege among individuals. In effect, social capital is here seen as the social ties, relations and networks an individual or household can utilize for access to information or other resources in order to sustain or even enhance their livelihoods. Thus, inquiry will be made on who people know, how and how well they know them (family, friends, neighbors, religious groups, associations etc.), what their interactions are about (occupational, professional, formal, informal, leisure etc.) and what information and resources they share with these (groups of) people. Along a continuum, these relations and networks can consist of strong ties with rather closed societies and institutions and regular and frequent interactions (bonding), or be weaker but more open and wider, with less frequent interaction (bridging). They can also be either horizontal (bonding and bridging) or vertical in nature(linking). The latter refers to ties to people in power, such as village committee members or the village chief. The general basis for these relations and networks is mutual trust and a shared norm of reciprocity. The value of a social relation lies in the information or resources it could potentially provide. Social capital, however, is not only positive. Besides its potential to improve livelihoods, social capital also inherits the risk of producing inequality and conflict by (re-)producing power structures and mechanisms of inclusion and exclusion. Meaning, it is important to determine who has disadvantages because of their social capital, or lack thereof, and why. As with human capital, the focus and use of the concept of social capital in this thesis is not to quantify its economic value. The aim is rather to qualitatively assess which and how formal and informal social relations (e.g. with family members, neighbors, village council members, etc.) and networks (e.g. charcoal producers' and other community organizations) influence charcoal production practice and on-farm tree utilization of producers, who they know, rely on and how that helps or limits them.

On a community level, groups, networks and institutions can be an important asset for (re-)shaping communal action regarding natural resource management. Social capital, namely its shared rules, norms and sanctions, reciprocal relationships, the inherent information and knowledge, and the networks and institutions that create it and are reinforced by it, can be of high value for environmental and agricultural conservation efforts of local natural resources. New ideas and technologies (e.g. agroforestry) can be spread quickly through social learning in communities with strong networks and are capable of transforming these norms and institutions (Pretty and Smith, 2004). Many policy interventions, however, have focused directly on individual behavior rather than a community by, for instance, looking into the local context (i.e. local institutions) that shapes individual behavior (ibid). Attempts to reduce the negative effects of charcoal production on the environment, which have targeted institutions, have focused on implementing formal institutions (Schure *et al.*, 2013). These interventions have involved permit schemes (World Bank, 2009; Minten, Sander and Stifel, 2013), banning charcoal production altogether (FAO, 2017; Smith, Hudson and Schreckenberg, 2017) or turning forest areas into protected areas (i.e. forest reserves) with limited or no access for local communities (Robinson *et al.*, 2014). Thereby, livelihoods of charcoal producers, consumers and non-producing rural community members have been implicated. Compliance would require adaption of livelihood strategies, which may not be feasible within the local context or when disobeyed, these interventions and regulations render practices illegal, thus criminalizing them (Zulu, 2010; Schure *et al.*, 2013; Bergmann, Roden and Nüsser, 2017). The (in)effectiveness of such interventions and regulations is further impaired due to

insufficient capacities of forest officials and other formal institutions for their enforcement (Mabele, 2019). Moreover, charcoal production is largely governed (i.e. overruled) by informal institutions and common law (Schure *et al.*, 2013). Understanding these locally deeply embedded informal institutions and the social capital within a community in general is therefore crucial in order to find the right entry point for sensible and effective interventions. Involving local communities and making use of their social capital could enable the development of interventions that are sensible to producers' and non-producers' livelihoods. Their very own networks could help promoting sustainable farming and charcoal production practices.

5 Research Area

Tanzania is the fifth largest charcoal producer in Africa (Sola *et al.*, 2017; Doggart *et al.*, 2020). It is one of the many SSA countries facing the challenges of the charcoal sector in the field of tension between sustainability of both the environment and the livelihoods of its citizens, and the development thereof (e.g. Beukering *et al.*, 2007). Equally, the country has a large potential to expand existing or implement new agroforestry and on-farm tree utilization practices, particularly in rural areas, to improve livelihoods, food security, and serve as a major energy source (Msuya and Kideghesho, 2012).

5.1 Geographical Location and Demography

The research area is located in the Morogoro region, one of Tanzania's largest regions with an area of 72'939 km^2. The villages studied are in Kilosa district, one of six districts in Morogoro. Located in east central Tanzania, Kilosa district stretches between latitudes of 5°55' and 7°53' south and longitudes from 36°30' to 37°30' east, covering 12'394 km^2 (Ishengoma *et al.*, 2015). According to the 2012 population and housing census by the National Bureau of Statistics (NBS), the population of Kilosa district counted 438'175 people, corresponding to roughly 20% of the population of Morogoro region. The average household size is 4.2 people (NBS, 2013, p. 95). The case study villages of the overall study are located to the north and south of Kilosa City as illustrated in the map below (Figure 2), with project villages in the south and non-project villages in the north (see section 5.5.2 for more information on the TFCG-project). The data analyzed in this thesis stems from villages A, B, C, and D (see section 6.1.1.1 on the sampling strategy).

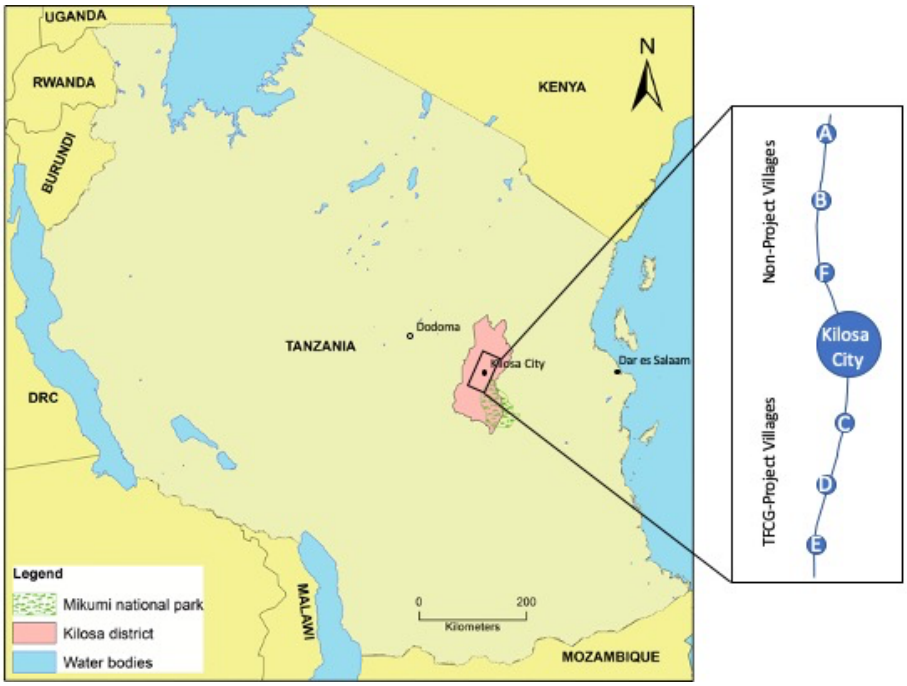

Figure 2: Map of the Research Area. (Source: adapted from Chipwaza et al. (2015))

5.2 Culture

The population in Kilosa district is composed of many different ethnic groups, which include Kaguru, Sagara, Vidunda, Maasai, Barabaig, Gogo and Sukuma (Benjaminsen, Maganga and Abdallah, 2009). These ethnic groups follow different livelihood strategies encompassing farming, settled agro-pastoralism (Sukuma, Gogo and Kaguru) and pure pastoralism (e.g. Maasai and Barabaig) (Saruni, Urassa and Kajembe, 2018). Depending on land allocation, land use and planning thereof, these different strategies have been coexisting and even mutually beneficial. However, due to increasing

competition over land, non-violent and violent conflicts have emerged in Kilosa district, especially between farmers and pastoralists (Benjaminsen, Maganga and Abdallah, 2009). During harvesting season, which coincides with the dry season, pastoralists are in need of access to watering places. Yet, access to water sources has become scarce due to agricultural expansion. In their search for water, cattle often have to cross cultivated areas, especially where farms are located along traditional livestock routes. While "trespassing", the herds destroy the crops that have not been harvested, leading to conflicts between farmers and pastoralists (Saruni, Urassa and Kajembe, 2018). As Benjaminsen, Maganga and Abdallah (2009) argue, these conflicts are rooted in land use policies and reforms, which favor (modern) agricultural activities over pastoralist ways of living, providing pastoralist communities with insufficient land and limiting other necessary resources.

5.3 Climate and Agriculture

Annual rainfall in Kilosa district follows a bimodal pattern with short rains between November and January and long rains between March and May peaking in April and it can vary considerably from year to year (Benjaminsen, Maganga and Abdallah, 2009). Average annual rainfall also varies between ecological zones, from 800-1'100mm in the northern part and 1'000-1'400mm in the southern plains. Temperatures vary between 19°C in July and 30°C in March with a mean annual temperature of 25°C (Ishengoma *et al.*, 2015). Climate change predictions for Tanzania estimate temperatures to rise +2-4°C. The Temperature increase will possibly lower the water volume of some of the major rivers, thereby severely reducing maize yields, one of the major food crops in Tanzania (Paavola, 2008, p. 647).

Elevation above sea level varies between the southern and central plains and the Ukaguru, Rubeho and Vidunda mountains in the western part of the district from 400m to 2'200m, respectively (Ishengoma *et al.*, 2015). Vegetation is dominated by Miombo woodlands, which are mostly found along the Rubeho Mountains of the Eastern Arc Mountain range in the western part of the district (Gmünder *et al.*, 2014). Miombo woodlands include a number of *Brachystegia*, *Julbernardia* and *Isoberlinia* species, timber species and numerous edible plants (Ruffo, Birnie and Tenganäs, 2002). Local livelihood strategies, including charcoal making, are complexly interlinked with and highly dependent on the miombo woodlands (Mabele, 2020).

The main economic activity in the region is farming, on which 80% of the people in the district depend. Over 90% thereof consists of rain-fed, smallholder subsistence farming (Gmünder *et al.*, 2014) with an average farm size of 0.8ha (Ishengoma *et al.*, 2015). Of the total district area, 536'590 ha are arable land. These lands can be divided into three agroecological zones, namely the mountains and uplands, medium altitudes and central and southern flood plains, each with characteristic cultivation. The well drained, loamy soils of the mountains and uplands are cultivated with maize, beans and horticultural crops. The poorly drained, black loamy soils of the medium altitude are mainly used for sugarcane and crop cultivation such as maize and rice, but also onions and sisal. The central and southern floodplains consist of poorly drained black clay, which is mainly occupied by Maasai pastoralists. Other land uses include the cultivation of sorghum, coffee, bananas, mangoes, oranges, lemons, cabbage, carrots, eggplant, peppers, sunflower, sesame and cotton (Ishengoma *et al.*, 2015).

Subsistence production is usually not enough to cover household needs throughout the year. Therefore, rural households resort to other economic activities, most commonly charcoal production (Gmünder *et al.*, 2014) as a secondary, income generating livelihood strategy (Mabele, 2019). Other significant economic activities in the district are livestock keeping, fishing, trade and tourism (Ishengoma *et al.*, 2015). The proximity to the major highways of Morogoro-Dodoma in the North and Morogoro-Iringa in the South provides access to transportation of products and to the urban markets of some of Tanzania's biggest cities: Dar es Salaam, Dodoma, Morogoro and Iringa (ibid).

5.4 Charcoal Production

After agriculture, charcoal production is the second most important economic activity in Kilosa district and is mainly practiced by smallholder farmers to supplement farming income (Gmünder *et al.*, 2014). Charcoal production mainly takes place in public, open access woodlands with little harvest control. Thus, on the one hand, it is leading to overexploitation of specific slow-growing tree species, which produce high quality charcoal, and resulting in forest degradation (Mwampamba, 2007). In combination with rapid urbanization causing increasing charcoal demand, inefficient management and regulation of forests and the value chain, environmental impacts of charcoal production are becoming a serious threat (ibid). The effects of the current wood extraction and charcoal production practices have already severely transformed the forests around Dar es Salaam (Ahrends *et al.*, 2010). The research of Msuya, Masanja and Temu (2011: 1368) projects that forest degradation and deforestation will affect 2.8 million ha to meet the charcoal demand of Dar es Salaam alone between 2010-2030. The forest along the Uluguru Mountains in Morogoro district, which are part of the Eastern Arc Mountains and had once covered 500 km^2, was reduced to 230 km^2 by 2001 (Paavola, 2008, p. 648).

On the other hand, participation in charcoal production requires no formal education and very low entry costs, yet on average yields more income than minimum wage in the private or government sector (Malimbwi and Zahabu, 2008). Hence, charcoal production is an attractive activity, especially when alternative income generating opportunities are lacking (ibid). The charcoal sector provides income opportunities for several hundred thousand people in the Dar es Salaam market alone. Annual revenues from charcoal in the same market are estimated at USD 350 million, which exceeds the national annual revenues of the coffee and tea sectors more than five-fold (Mwampamba *et al.*, 2013). Yet unlike the charcoal sector, the latter two are recognized as drivers of national economic development (ibid).

Morogoro region is one of the major charcoal producing areas for the Dar es Salaam market (Msuya, Masanja, and Temu 2011) and the top charcoal producing region in Tanzania (Chesterman *et al.*, 2018). The majority of households in the region participate in charcoal production in varying degrees, from occasionally to year-around (Monela *et al.*, 1999). The preferred and most widespread method of production in this region is using traditional earth mound kilns, which are highly inefficient, causing losses of up to 70% of caloric value of wood (Abdallah and Monela, 2007). Furthermore, according to the study of Schaafsma et al. (2012: 55, 60) up to 60% of charcoal producing households in Tanzania's Eastern Arc Mountain region use wood from protected forests, woodlands and reserves for charcoal production. Thus, the forest ecosystems of this region are under increasing pressure and more environmentally and socio-economically sustainable charcoal production practices are needed.

5.5 Governance Structure

Governance of the Tanzanian charcoal sector currently creates a paradox between conservation and development. Present policies, on the one hand, acknowledge its economic importance and favor revenue collection, but, on the other hand, ban charcoal production because of its environmental impacts (Mabele, 2020). Governance of charcoal production is further complicated as it is addressed in varying degrees across policies regarding forestry, environment, energy, land tenure and agriculture (Doggart, 2016). In a study on how energy policy influences charcoal consumption, respondents from local government and from the Ministry of Energy said that woodfuel supply falls under the authority of the Ministry of Natural Resources and Tourism (MNRT), which includes the Tanzania Forest Service Agency (TFS; see section 5.5.1) and the Forestry and Beekeeping Division (Doggart *et al.*, 2020, p. 206). The latter two see their responsibility with regard to the governance of charcoal to include policy development, trade management and collection of tax revenue (ibid). Figure 3 gives an overview of how policy, instruments and different governing levels and agencies interact depending on the forest management type.

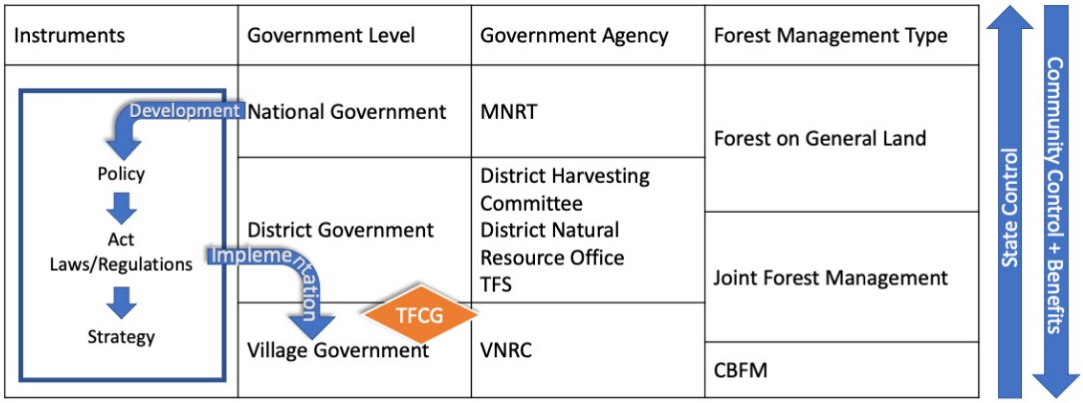

Figure 3: Instruments, Levels and Agencies of Government Involved in the Governance of Different Forest Management Types. (Source: adapted from Duguma et al. (2018))

The current National Forest Policy of 1998 supports sustainable harvesting of forest products; however, the focus is mainly on timber. It can be extrapolated to sustainable charcoal production, but it is not explicitly mentioned, supported or opposed. The policy does bolster joint forest management and CBFM (Doggart, 2016). Policy statement 3 articulates: "To enable participation of all stakeholders in forest management and conservation, joint management agreements, with appropriate user rights and benefits, will be established. The agreement will be between the central government, specialized executive agencies, private sector or local government, as appropriate in each case, and organized local communities or other organizations of people living adjacent to the forest" (Mugasha and Katani, 2016, p. 16). It further allows for forests on village land and village forest reserves to be governed by the village government (Doggart, 2016). The Final Draft for the revised National Forest Policy 2014 explicitly mentions charcoal and acknowledges its relevance as an energy source and source of livelihood. While not explicitly mentioning it, the draft policy is supportive of sustainable charcoal production mainly by promoting woodlot and plantation establishment and the planting of trees on farm specifically for woodfuel production, hence shifting charcoal production from forests to private land (Doggart, 2016, p. 7).

In turn, policy instruments, i.e. acts, regulations and public notices, include more specific guidelines on how to regulate charcoal production, albeit without specifically focusing on sustainable charcoal production (Doggart, 2016). Forest Act No. 14 of 2002 includes, among others, directives and guidance regarding the establishment of forest management plans, procedures for licensing and issuing permits in forest reserves, trade of forest products and restriction thereof, and penalties for prohibited activities (Mugasha and Katani, 2016). The Forest Regulations of 2006 appoint responsibilities between the District Harvesting Committee (which includes the Village Executive Officer) and village council, whereby the former oversees all harvesting activities (of logs, timber, poles, firewood and charcoal) in the forests within the district by coordinating harvesting plans and handling applications for harvesting licenses. For village land forest reserves and community forest reserves, which can be established through CBFM, the village council is the main authority, having to provide a harvesting plan in line with the one of the district (Doggart, 2016). Since the establishment of such plans involves technically and bureaucratically complex procedures, for which villages are not equipped, they depend on higher level authorities and/or a third party (e.g. an NGO) with this kind of expertise for assistance (Scheba and Mustalahti, 2015). The harvesting plan should include areas set aside for specific uses and harvesting activities of forest products, including charcoal. Charcoal must only be produced from designated areas and only produced, transported and or traded when in possession of a respective license or permit (Doggart, 2016).

The most comprehensive guidance towards sustainable charcoal can be found in the "Guidelines on sustainable harvesting and trade in forest products harvested in natural Forests 2015" which state:

> - "Charcoal traders and harvesters should be licensed and registered;
> - Villages should maintain a register of charcoal producers and should record the number of sacks produced by each registered producer;
> - Efficient kilns such as half-orange or Casamance kilns should be used;
> - Charcoal producers must pay royalties in accordance with government regulations and must contributed 5 % of the royalty to the Tanzania Forest Fund for tree planting;
> - The village council are responsible for ensuring that charcoal production is conducted in a way that does not damage the environment. "
>
> (Doggart, 2016, pp. 12–13)

Aside from the forest policy and instruments, the environmental policy supports sustainable forest management but does not contain explicit statements on sustainable charcoal production, whereas the energy strategy does not mention sustainable production at all. Both policies deem the nation's dependence on charcoal as a national problem and focus on fuel switching and reforestation to counter the environmental effects of charcoal production (Doggart, 2016). Meanwhile, the National Agricultural Policy does not mention charcoal or woodfuels at all (URT, 2013). Land tenure regulations and agricultural policies even tend to induce the opposite and rather lead to deforestation by promoting agricultural expansion and intensification, contradicting sustainable forest management principles (Doggart, 2016).

5.5.1 Tanzania Forest Service Agency (TFS)

The Tanzania Forest Service Agency or just Tanzania Forest Service (TFS) is a semi-autonomous executive agency, which was established in 2010 as part of the revision of the National Forest Policy, transferring forest management responsibilities from the Forestry and Beekeeping Division to TFS (Doggart and Meshack, 2017). TFS now has the mandates over the management of forests on general land, covering any non-village land (Doggart, 2016). In this capacity, TFS also collects revenue for the whole forest sector through royalties of all forest products, including for charcoal stemming from general forest land. At the zonal level, revenues from charcoal contribute between 10-70% of total revenues from all forest products (Doggart and Meshack, 2017). However, where the authority of TFS ends and where the one of the village government starts, in the case forest on village land, is unclear due to conflicting policy statements. The draft of the National Forest Policy categorizes most village land as general land which would fall under TFS authority. The village land act, however, clearly authorizes village government to directly manage village land forest (Doggart, 2016). With potentially high revenues from charcoal, TFS's interest in overseeing forest harvesting activities even on village land themselves is obvious.

5.5.2 Tanzania Forest Conservation Group (TFCG)

The Tanzania Forest Conservation Group (TFCG) is a national non-governmental organization (NGO), established in 1985, which focuses on forest conservation issues in Tanzania. TFCG advocates improving forest management and reducing deforestation through five programs, namely advocacy, participatory forest management, environmental education, community development and research (Mugasha and Katani, 2016).

Two of the four villages examined in this thesis are part of the "Transforming Tanzania's Charcoal Sector" (TTCS) Project (here referred to as the TFCG-project), which was initiated and financed by the Swiss Agency for Development and Cooperation (SDC) and implemented and managed by TFCG in cooperation with the Tanzania Community Forest Conservation Network (MJUMITA) and the Tanzania Traditional Energy Development Organization (TaTEDO). The project piloted in 30 villages in three districts of Morogoro Region (Kilosa, Mvomero and Morogoro Rural Districts). Its goal is to establish a sustainable and well-governed charcoal value chain, which supports pro-poor development and environmental sustainability. The project ended in March 2020 with results from the second phase pending. Preliminary results from the first phase (January 2011 – March 2016) include the establishment of village land forest reserves, land use plans and forest management plans under CBFM in eight of the 30 project villages. Each village land forest reserve contains a designated block for charcoal production, covering about 10% of the total forest reserve, with harvesting guidelines for 24 harvesting units relating to a 24-year rotation scheme (Schweizer Eidgenossenschaft, 2020).

5.6 Agroforestry in Tanzania

Tanzania is home to a variety of traditional agroforestry systems, which include the silvipastoral "Ngitili" system in central and western Tanzania, the multistrata systems of the "Chagga home gardens" in the northern parts, the Maize-Faidherbia systems in southern and the spice systems in eastern Tanzania, respectively (Kitalyi *et al.*, 2013). Agroforestry systems in Kilosa district include mixed intercropping, boundary planting and home gardens. Agroforestry technologies include agri-silvicultural (woody perennials and herbaceous crops) and agri-silvipastoral systems (same as the former, but in combination with animal husbandry) (Luumi *et al.*, 2016).

As for linking it to the charcoal sector, supportive policies and policy instruments for agroforestry are, if at all mentioned, rather vague and scarce. The policy draft for the National Forest Policy 2014 promotes agroforestry systems such as woodlots and on-farm tree planting for woodfuel production in general and intends to encourage and support such efforts through research, financial incentives and extension services (Doggart, 2016, p. 7). The National Agriculture Policy of 2013, on the other hand, does not mention agroforestry, trees or on-farm trees even once. Sustainable agriculture specifically is only mentioned on one occasion in connection with environmentally friendly crop husbandry (URT, 2013; Doggart, 2016, p. 29). Under "3.4 Specific objectives", the policy does, however, state to "strengthen inter-sectoral coordination and linkages to increase efficiency and effectiveness; protect and promote integrated and of cross cutting issues in agricultural undertakings" (Doggart, 2016, p. 10). The policy identifies inherent insecurity of land tenure in the current system as a major inhibitor for long-term investments and hence as a major driver of unsustainable practices responsible for deterioration, especially soil erosion and soil degradation. Raising public awareness and the enforcement of laws and legislation, including detailed district and village land use plans, are among the policy statements to improve the situation (Doggart, 2016, p. 16). These aspects would also be crucial to the promotion of agroforestry systems and on-farm tree planting as a long-term investment.

In regard to governance of on-farm tree utilization (e.g. for charcoal production), the Forest (Sustainable Utilization of Logs, Timber, Withies, Poles or Charcoal) Regulations, 2019 include the following: Tree harvesting on private land for commercial uses requires a permit from the District Forest Manager and is only issued with a letter from the Village Executive Officer verifying ownership of the trees (§13), tree felling for farm preparation (farm clearing) also requires a permit, but from the District Forest Manager after approval from the District Forest Harvesting Committee (§15) (URT, 2019).

One initiative with a potentially high impact on agroforestry development in Tanzania is the revised National Agroforestry Strategy (NAS). The first NAS of 2004 was partially implemented by the National Agroforestry Steering Committee (NASCO). However, its implementation was stunted by lacking

coordination with, integration in and support from relevant ministries and government structures and programs on both national and district level, combined with insufficient funding, human resources and networking. The revised NAS of 2010 builds on these lessons learned by integrating agroforestry into existing and future sectoral programs and policies, namely agriculture, forestry, environment, land, water, energy and livestock. Secondly, it institutionalizes NASCO within existing governance structures, mainly the Ministry of Agriculture, Food Security and Cooperatives (MAFSC) and the Ministry of Natural Resources and Tourism (MNRT). The goal is that by 2025, at least 6 million households will have adopted agroforestry technologies. Depending on the agro-ecological zone, promising technologies include fertilizer tree systems for improved soil fertility and conservation, rotational woodlots for woodfuel production, fodder production for livestock production, and indigenous trees for fruits, forest products and other services such as carbon sequestration. At the household level, i.e. considering livelihood impacts, benefits should include poverty alleviation through improved income from tree products and services, improved food security, nutrition and health, shelter, and sustainable energy resources. At the landscape level, impacts should benefit environmental sustainability through biodiversity and upland watershed conservation, land rehabilitation of forests and agricultural land, as well as climate change adaptation and mitigation. (NASCO, 2010)

Especially in connection with promoting sustainable energy resources, for example through rotational woodlots, the strategy holds the potential to support on-farm firewood and charcoal production. As shown in a study by Kimaro et al. (2011) in Morogoro, rotational woodlot agroforestry systems with fast growing, indigenous and exotic *Acacia* species could serve as a sustainable source for woodfuels, due to their growth and regeneration capacity. Moreover, woodlots with exotic species have the potential to reduce pressure and CO_2 emissions from deforestation in the miombo forest, accumulate carbon in their biomass and enrich soil organic carbon comparable to levels in natural miombo forests. In combining this agroforestry technology synergistically with the United Nation's Collaborative Program on Reducing Emissions from Deforestation and Forest Degradation (UN-REDD+)[1] efforts, payments for carbon sequestration and avoided emissions could serve as an (additional) incentive for its adoption by smallholder farmers (Kimaro, Isaac and Chamshama, 2011). Both agroforestry and UN-REDD+ are also supported by the TFCG-Project. Their implementation and benefits for project villagers are among the expected outcomes of phase II (SDC, 2014).

[1] For more information on UN-REDD+ visit https://www.un-redd.org/

6 Methodology

Empirical data for this thesis was gathered by conducting interviews with charcoal producers, members of village and district governments and with academic experts on the core research topics. Subsequently, the interviews were transcribed and a Qualitative Content Analysis (QCA) was undertaken.

Fieldwork was conducted between mid-June and end of July 2020. Due to the traveling constraints imposed by the Covid-19 pandemic, interviews with charcoal producers and members of village and district government, as well as their transcription and translation were outsourced to Tanzanian researchers.

The following sections explain in detail which methods were used for data collection (6.1), processing (6.2) and analysis (6.3). Challenges and limitations are reflected upon in subsection 6.4.

6.1 Data Collection

The empirical data used for this thesis was gathered through interviews with charcoal producers and members of village and district government. In order to acquire a systemic and comprehensive understanding of contextually complex "fuelscapes" (Bergmann, Roden and Nüsser, 2017), community knowledge and participation of local as well as more regional stakeholders is pertinent (Graef *et al.*, 2015). Interviews with charcoal producers were conducted employing a survey questionnaire with open and closed questions in collaboration with the overall project. In addition to these surveys, structured interviews were conducted with members of governmental agencies at the village and district level. Background information was collected through expert interviews on core topics such as agroforestry, charcoal producers' livelihoods and the role of institutions. Table 2 includes an overview of all the interviews conducted and the ones analyzed in this thesis. The overall sampling strategy and the selection of the sub-sample are further specified in section 6.1.1.1.

Table 2: Overview of collected data (* indicates that the village is part of the TFCG-project). (Source: own representation)

Interview Type	**Total Number of Interviews Conducted**	**Sub-sample Analyzed in this Thesis**
Survey Interviews with Charcoal Producers	*Total: 161* 16 in village A 26 in village B 37 in village C* 27 in village D* 29 in village E* 26 in village F	*Total: 20* 5 in village A 5 in village B 5 in village C* 5 in village D*
Structured Interviews with Members of Village and District Government	*Total: 16* 2 in village A 2 in village B 2 in village C* 3 in village D* 2 in village E* 2 in village F 3 from the district government	*Total: 11* 2 in village A 2 in village B 2 in village C* 2 in village D* 3 from the district government
Expert Interviews	5	5

Methodologically, interviews are one of the most widely used methods to gain comprehensive and wide-ranging insight into a phenomenon and all of its facets (Azevedo *et al.*, 2017). They also have a longstanding tradition within human geographical research as a valuable method of collecting qualitative data, especially when asking people about certain practices (Dowling, Lloyd and Suchet-Pearson, 2016).

In accessing the case study villages, collaboration with Sokoine University of Agriculture and TFCG was instrumental. Previous to data collection, permission was also sought from the district government and subsequently from the village council during a specified village council meeting. Thereby, the project objectives and a description of the intended data collection process and the processing of the data, thereafter, were presented. Interviews with charcoal producers and members of village and district government were conducted in the context of the larger research project. The survey for interviewing charcoal producers and the questionnaires for the members of village and district government were employed for a larger sample, of which a subsample was chosen after data collection, fitting the scope of this thesis. The following sections describe in detail the specific methods used for the in-depth survey interviews and the (sub)sampling approach, expert interviews and structured interviews with members of village and district government.

6.1.1 Survey Interviews with Charcoal Producers

In order to put the questions for the interview together, at first an interview guide with guideline questions was developed. Due to the constraints posed on the fieldwork, the guideline questions were then incorporated into a larger survey questionnaire for the overall project. This methodological adaption offered a very practical solution to these major changes while remaining conform with the research goal and overall approach. All charcoal producers were interviewed using the same mixed methods survey questionnaire, in order to obtain data for both the overall project and this master project, thus yield both quantitatively and qualitatively analyzable data, respectively, in one go. Mixed method questionnaires have proven to be an effective approach to research complex issues such as environmental ones, opinions and awareness or social interactions and networks (McLafferty, 2010). Particularly, their strength in regard to the gathering of qualitative data lies in exploring social aspects and processes as well as participants' values and attitudes (McGuirk and O'Neill, 2016). Hence, this method of data collection suits the objective of the research at hand. Another strength of this method is that it can be used complementarily with other forms of in-depth qualitative research, such as focus-group discussions, key informant interviews or, in this case, expert interviews (McGuirk and O'Neill, 2016).

To develop purposeful questions, which each relate to at least one aspect of the research, the process of question development suggested by Sarantakos (2012, p. 264) was followed. In this process, research topics, based on the research questions, are first translated into variables. The variables are thereafter translated into indicators and finally, these indicators are formulated into questions to be asked in the survey interviews. Variables include aspects such as tenure rights, access to off-farm resources, trade-offs of specific tree (species) utilization and knowledge about sustainability. Indicators mainly include different aspects of human and social capital, such as knowledge, skills, health, interaction with others etc., derived from the theoretical framework (see section 4.). An overview showing the variables, indicators and questions is provided in Annex A. The questions were then merged into topically coherent sections of the larger survey. The final survey included both closed questions, for example on household size, education level, tax and revenue per bag of charcoal, and open-ended questions, for instance why they became a charcoal producer. Combinations of open-ended questions with closed ones helped to further explain answers given to the latter. Closed questions allow subsequent quantitative analysis (Fink, 2003, p. 37), as was the intent for the larger project. For the qualitative analysis employed in this thesis, however, open-ended questions potentially yield more in-depth

answers, especially if the goal is to investigate participants knowledge and understanding of, experiences with and attitudes towards practices, social processes and structures (McGuirk and O'Neill, 2016). Since the research questions focus on just these aspects, i.e. charcoal producers' practices in regard to on-farm tree use, their knowledge about agroforestry farming and charcoal production as well as the social structures, these questions were indispensable for further analysis. Together with the quantitative answers, the survey interviews provide a more holistic understanding of local charcoal production, the role of on-farm trees and human and social capital in enabling transition towards sustainable charcoal systems.

As McGuirk and O'Neill (2016, p. 247) state, a well-designed questionnaire requires "a great deal of thought and preparation" as well as critical reviewing and reflection. In addition to the process of carefully developing questions as described above, this was complied with by several cycles of feedback from different, experienced scholars, including a Tanzanian member of the research team. Apart from reviewing the wording and order of questions, careful attention was given to ethical aspects conforming to the cultural context. In this part of the process, the questionnaire was also translated into Swahili. Before commencing with the actual data collection, the questionnaire was pre-tested to ensure that the participant group would be able to understand the questions (Fink, 2003, p. 14). Consequently, the phrasing and order of a few questions was adapted to achieve a more understandable and fluid survey, without compromising the content at which the questions were aimed. The full survey questionnaire is included in Annex B (English version).

The interviews were administered face-to-face by three Tanzanian researchers, and generally took 1.5-2 hours. Dr. Vincent G. Vyamana, Independent Senior Researcher/Consultant- Forestry/Resource Management, lead the data collection with his expertise in the collection methods and livelihood research in general. He was joined by Moshi Salehe Mpembela and Jamal Hatib Jengo, who both hold a bachelor's degree in forestry from Sokoine University of Agriculture and who knew villagers and village council members from a pilot study in 2019 for the overall project. To ensure congruity between individual interview situations with interviewees but also for the three different interviewers, an interview protocol was put together. This protocol includes a checklist of things to prepare and introduce before starting (e.g. consent form), during and after the interview. The interviews took place at the respective home of the interviewee to ensure comfort and confidentiality. Prior to the interview, participants were informed about the research objective, its goals and about the interview process. They were further informed that all information about them and the information they provided in the interviews would be and remain anonymized by assigning and – if at all – only referring to a pseudonym. Interviewees were also allowed to deny answers to questions they did not feel comfortable with. Before starting the interview, consent was sought from the interviewee to the recording of the interview and/or written notes made during the interview by signing a consent form. The consent form is based on Kruegel (2019) and complies with the ethics requirements of the University of Zurich and the Nagoya protocol between Switzerland and Tanzania. Furthermore, a safety protocol was put in place to reduce the risk of infection in the face of the Covid-19 pandemic, including masks and hand sanitizer for workshop participants, interviewers and interviewees as well as physical distancing of 1.5m.

6.1.1.1 Sampling and Sub-sampling Strategy

A stratified random sampling approach was taken in order to obtain information that is representative for the population of charcoal producers. The sampling strategy was applied to attain a stratification for three different wealth categories: poorest, poor and non-poor; as defined by indicators chosen by (sub-)village representatives. The indicators for each village of the subsample are listed in Annex C. This stratification is suitable, because a household's wealth (category) is highly influenced by and, at the same time, influences a household's access to natural resources such as arable land. The wealth

category can explain to a large extent which diversification opportunities a household can (or has to) participate in (Ellis and Allison, 2004; Vyamana, 2009). The number of interviewees was set so that statistical analysis could be performed on the sample for the overall project and aimed at 30 participants per village.

For this sampling strategy, a participatory workshop was held in each of the six villages. For each workshop, four representatives of every sub-village were invited. In a first round, all sub-village representatives came together in order to define the indicators for the three wealth categories and thresholds (Annex C). Thereafter, the four representatives of each sub-village came together and wrote down the names of each charcoal producing household in their respective sub-village on manila cards. The cards (households) were then grouped according to the previously defined wealth categories. The number of producers in each wealth category of the villages in the subsample is shown in Annex 0.

A total of 161 charcoal producers were interviewed across six villages. For this thesis, however, only a subsample was analyzed by performing a qualitative content analysis, as described below (section 6.3).

6.1.1.1.1 Subsample

Since the total sample of interviews exceeded the scope of this thesis, a subsample needed to be determined. Based on the survey sheets, which include detailed notes about the interviewees' responses, a purposeful sampling approach according to Patton (2015, p. 281) was applied. In a first step criterion-based case selection was performed to exclude interviews lacking relevant information. The following criteria, as shown in Table 3, were defined based on the research questions (RQ). A major inclusion or exclusion factor was, whether sections or questions relevant for answering these research questions were mostly answered or unanswered, respectively. For example, the information from section 9 and 10 were essential for answering research question 3 (social capital). In some cases, the answer itself was also decisive. For example, all interviewees who had no trees on their farm were excluded, since that would naturally inhibit them from utilizing on-farm trees, which is a major aspect for research questions 1 and 2. This was also the reason for excluding village F, since most participants did not have any on-farm trees. Subsequently, village E was also excluded to balance out the number of project and non-project villages. These two steps reduced the number from 51 to 35 interviews. From the remaining 35 interviews, 20 were selected following a maximum variation sampling (Patton, 2015, p. 283) to include interviewees from all three wealth categories (poorest, poor, non-poor), male and female, different education levels (no formal education, primary education, secondary education) and varying answers to question 2.17 and 2.18 (yes and no, different arguments) (see Table 4). The latter two questions are especially relevant for answering the second research question. Since not all notes on the survey sheets were in English, but also in Swahili and they only contained a summary of the answers, interviewers and their personal recollection about additional contents of the interviews were further relied upon for the subsampling.

Table 3: Criteria for subsampling strategy, as derived from survey questions and research questions (RQ). (Source: own representation)

Research Focus	**Survey Question**	**Criterium**
Number of on-farm trees (RQ 1)	1.12 How many trees do you have on your farm (planted and naturally growing)?	Total number of trees >1
Use of on-farm trees (RQ 1 & 2)	3.1 – 3.8 What do the trees provide? Are they used for charcoal production? Do you sell or trade products derived from those trees? What do you use the money for? What part of the tree do you harvest? Do you plant new trees?	Questions have to be mostly answered, ≠ n/a

Table 3: continued.

Research Focus	Survey Question	Criterium
Attitude towards tree planting (RQ 2)	2.17 Would you consider planting trees specifically for charcoal production on your farmland? 2.18 Under what circumstances would you consider planting trees for charcoal production on your farmland?	2.17 must be answered with yes or no. 2.18 must include one or more reasons
Human Capital (RQ 3)	2.6 How did you acquire your farming skills? 5.9 What do you use your income money for? Section 6: health Section 7: skills and knowledge about charcoal production	Questions/ Sections must be mostly answered
Social Capital (RQ 3)	Section 9: Interaction with other charcoal producers Section 10: Interaction with other farmers	Sections must be mostly answered

With these criteria 20 interviews, 5 each from villages A, B, C and D respectively, were selected for the in-depth analysis as shown in Table 4. In the results, the interviewees are referred to by the combination of the letter A, B, C or D representing the respective village and the number of the interview (e.g. interviewee number 19 from village B is referred to as B-19). When a statement concerns a number of interviewed producers they are also referred to as interviewees (not including experts or government members).

Table 4: Subsample analyzed in this thesis. Criteria "section must be mostly answered" is not included as these criteria apply to all selected interviews in the subsample. (Source: own representation)

	Village	Interview Nr.	Wealth Category	Gender	Education	Farm Size	Number of On-Farm Trees (planted, retained)	Survey Questions 2.17/ 2.18 (planting new trees for charcoal production)	
non-project villages	Village A								
	A	4	poor	m	primary	6.5ha	many, yes	no	not for charcoal, timber and fruit
	A	6	poor	m	primary	2ha	20, 15	no	no regeneration of charcoal trees
	A	10	poor	m	secondary	15ha	0, 5	yes	good market
	A	13	poorest	m	5/7 years primary	2ha	20, 12	yes	planting materials
	A	15	poor	m	primary	1.2ha	0, 20	yes	planting materials
	Village B								
	B	8	poor	m	no formal education	3a, 1a	few planted trees in village A	yes/no	seedlings available
	B	11	poor	m	primary	14ha	15, >50	no	heavy work for cc production
	B	19	poor	m	primary	1.6ha	2, 20	no	land size
	B	21	poor	m	primary	4ha	9, 100	yes	planting materials
	B	23	non-poor	m	primary	10ha	5 acres forest	yes/no	already planted cashew trees
project villages	Village C								
	C	21	poor	m	primary	>10ha	1, 100	no	village forest available
	C	22	poorest	f	primary	6ha	2, 0 (there seems to be a line of trees for shade for the chickens)	yes	scarcity
	C	30	poorest	m	primary	6 ha	6, 6	yes	not for charcoal but cashew/ fruit
	C	31	poor	m	primary	1ha	35 unclear, how many planted/natural	yes	when forest is depleted
	C	39	poor	f	primary	3ha (rented	3, 4	yes	own land
	Village D								
	D	5	poor	m	primary	0.8ha	both	yes	declining forest, distance to forest
	D	14	poor	m	primary	10ha	70, 50	yes	if trees serve as timber and charcoal
	D	18	poor	f	primary	7.25ha	4, 6	yes	in case the good trees are finished
	D	24	poorest	m	no formal education	0.1ha owned, 1.2ha rented	6, 6	yes	distance to forest high, stronger restrictions
	D	25	poorest	m	no formal education	0.05ha, rents 1.2ha	4, 7	yes	more land

6.1.2 Academic Stakeholder Interviews ("Expert Interviews")

As part of the data collection, five semi-structured, exploratory expert interviews were conducted in order to gain an initial overview of the field of research through the contextual, socially institutionalized knowledge of experts (Meuser and Nagel, 2009). Expert interviews consist of a specific interview form,

which is an often-applied method in social science research, as it deals with a specific mode of knowledge (ibid). Nonetheless, it can be argued that any interviewee could be seen as an expert and is, in a way, given that expert status through the researcher's identification of a person as especially knowledgeable in regard to the objective of answering the research questions. Charcoal producers are experts of their own practices and livelihoods. However, in order to distinguish expert interviews as an interview method from others such as narrative interviews, experts are in this case defined by their expert knowledge, which exceeds everyday knowledge of a specific context and thus is not held by everyone within it. This exceeding knowledge is considered expertise when it is contextually specialized and socially institutionalized. Expertise is acquired by the expert through her*his professional or honorary position and function in a specific context, allowing her*him privileged access to this context-specific knowledge (Meuser and Nagel, 2004, 2009). And it is exactly this in-depth and context-specific, but more importantly exceeding and institutionalized knowledge of experts, which they hold within their field of action (as opposed to them as a private individual) that the expert interview targets.

All experts interviewed have an extensive background in researching their field of expertise and/or hold a major position in an organization or institution specializing in the respective field. Expert 1 (in the results referred to as E_01) conducts research on on-farm fuelwood production in a neighboring region in Tanzania. Expert 2 (E_02) holds a leading position at a research institution on agroforestry in Tanzania. Expert 3 (E_03) has recently conducted research on institutional aspects of charcoal production in Tanzania, including fieldwork in the research area. Expert 4 (E_04) has an extensive background in researching the livelihoods of rural smallholder charcoal producers in SSA. Expert 5 (E_05) is a Tanzanian scholar with extensive experience in rural livelihoods research and has worked closely with the TFCG project.

Expert interviews can be subdivided into different categories. These include the exploratory and the systematizing expert interview. In this thesis three of the former and two of the latter were conducted. The purpose of exploratory expert interviews is to provide initial orientation and structuring of the research field in order to help developing a clearer understanding of the research questions to be investigated. The expert is asked about her*his contextual knowledge on the subject of research as a complementary source of information, in this case rural charcoal producers, members of governmental agencies and secondary literature. This can be particularly helpful if the field of research is substantively new to the researcher (Bogner and Menz, 2009), as was the case for the author. These interviews became especially important with the fieldwork constraints obstructing the conduction of the author's own data collection and highly limiting her knowledge and insight of the local context, as the author has never been to the field herself. Three exploratory expert interviews were carried out with experts E_03, E_04 and E_05 on the following topics: rural and charcoal producers' livelihoods and the role of institutions and policies in Tanzania and similar contexts.

The systematizing expert interview differs in that it is less about the general context and sounding out of its dimensions, but it investigates very specialized knowledge of experience and action in a specific field, which the expert holds through their practice in a particular field of action (Bogner and Menz, 2009). For this thesis, two systematizing expert interviews were conducted with experts E_01 and E_02 on agroforestry practices and on-farm tree utilization in Tanzania. Regardless of this distinction, most of the expert interviews yielded background information of both exploratory and systematizing nature, especially the one with E_05.

Conducting qualitative expert interviews is usually realized by using a rather open topic guide, which allows the researcher to remain flexible in the interview situation and pose follow-up questions to generate more in-depth or event-specific elaborations (Meuser and Nagel, 2009). Meanwhile, the topic guide assures that all relevant topics are discussed and that the empirical data is comparable across interviews since the same topic guide is used (Bogner and Menz, 2009), apart from a few field-,

institution- or expertise-specific questions. The topic guide for the expert interviews is shown in Annex E.

6.1.3 Structured Interviews with Members of Government Agencies

Livelihoods research has often been deemed incomplete as it generally neglects institutions and their influence, especially on people's access to resources (de Haan and Zoomers, 2005; Geiser *et al.*, 2011, p. 263). To address this criticism, members of influential, formal local governing institutions at the village and district level were interviewed in a structured interview. In structured interviewing, a questionnaire with carefully ordered and worded, open-ended questions is used, which dictates the interview process and makes it highly question focused (Dunn, 2005, p. 87). The questionnaires for village and district government members is included in Annex F. Throughout the six villages, interviews were conducted with two village council members (thee in the case of Village D). Additionally, three members of the district government were interviewed. The questionnaires for the different government levels aimed at topics such as management, governance structures and access to the forest. For all the village government members, the same questionnaire was used, with a few additional questions about their engagement with TFCG for project-villages.

In this thesis, village government member interviews were only analyzed if interviews with charcoal producers from that same village were part of the subsample, i.e. village A, B, C and D. Hence, the analysis was done for the following village government (VG) and district government (DG) members: VG_A1 and VG_A2 for village A, VG_B1 and VG_B2 for village B, VG_C1 and VG_C2 for village C, VG_D1 and VG_D2 for village D[2], as well as DG_1, DG_2 and DG_3 from the district government. The same character combinations are used when referring to these members of government in the results.

6.2 Data Processing

All interviews were transcribed and interviews with charcoal producers and with members of government agencies were also translated from Swahili to English for their subsequent analysis. Transcription of interviews serves the purpose of limiting the loss of information through its mere recollection by the interviewer and individual biases. It furthermore enables the researcher to repeatedly screen and process contents of the interview, so they can be reexamined for further purposes or shared with others (Azevedo *et al.*, 2017). The level of detail and content included in the transcripts is determined by the research question and method of analysis (McLellan, MaCqueen and Neidig, 2003).

Since the author did not conduct the interviews personally with the help of a translator they were conducted in Swahili. Consequently, the author could not transcribe the recorded interviews herself, hence, transcription and translation into English were indispensable as the content only then became accessible and understandable to the author for analysis. The interviews with charcoal producers were transcribed and translated by Moshi Salehe Mpembela and Jamal Hatib Jengo, who also conducted many interviews themselves. Interviews with village and district government were transcribed and translated by Chenny Saira Magafu. Since the translation and transcription was not done by professionals, things that were not clear from the transcript or seemed to be lost in translation were discussed with the person who wrote the transcript in order to gain more background information and a clearer understanding. The supervision of the translation and transcription process was under the supervisors of this thesis, Prof. Dr. Maria J. Santos ad Hanneke van't Veen. All expert interviews were held in English by the author, who also transcribed the recordings in the original language.

[2] The interview with VG_D3 was analyzed but excluded from the results as it did not yield any additional information to that from VG_D1 and VG_D2.

In order to minimize the loss of information and keep transcripts as close as possible to the original statements, transcription rules were predefined (Azevedo *et al.*, 2017). These rules also minimize the difference in style between different transcribers and possibly the following coding and interpretation, as there were two transcribers for the interviews with the charcoal producers and a third person for the interviews with members of government. In addition, such rules make the transcription process and the degree of inevitable reduction from the original audio transparent to others (McLellan, MaCqueen and Neidig, 2003). In this thesis, a combination of pure verbatim transcript with a protocol with special characters is used; a word for word transcription which also includes nonverbal aspects such as accentuations, laughter or hesitation to answer, yet with a degree of detail that still produces intelligible transcripts (Mayring, 2014, pp. 46–47). The special characters also apply to excerpts from transcripts in the results section. In order to prevent more information from getting distorted or lost in translation, direct quotes in the results section are presented unaltered from the original transcripts, with the exception of a few necessary (but clearly marked) additional comments for context by the author. Table 5 shows the list of transcription rules and special characters applied.

Table 5: Transcription rules and special characters. (Source: adapted from Azevedo et al. (2017, p. 164))

Special Character	**Meaning**
(inaudible/ unintelligible segment)	Segment is inaudible or unintelligible, without assumption of transcriber.
?(…)?	Segment unintelligible, content in parentheses suggest researcher's assumption (*italics*)
(*xxxx*) (*hesitation to answer*)	Transcriber's comments, notes, explanations (*italics*)
(*laughs*)/ (*caughs*)	Non-verbal sounds, emotions
ACCENTUATIONS	Words pronounced with strong emphasis
(.)/(…)	Short/long pause
[…]	Comments or omissions of sensitive data added by the author after transcription for better understanding, only applied in quoted segments in section 7.

Transcription of the expert interviews was done in a more denaturalized and summarizing fashion, since the focus lay mostly on the content in general and its use as background information. A mixture of smooth verbatim transcript and comprehensive protocol was produced from the interview recordings (Mayring, 2014, p. 45). Off-topic segments at the beginning or end of the interview were either summarized in bullet points or not transcribed if irrelevant. Since these interviews were held in English, translation was not necessary.

6.3 Data Analysis

For the analysis of the interview transcripts, Qualitative Content Analysis was chosen, applying a combination of inductive and deductive coding. As described in further detail below, this mixed approach allows for categorizing after core theoretical concepts of this thesis and at the same time enables for additional important aspects to emerge from the data itself.

6.3.1 Qualitative Content Analysis

Qualitative Content Analysis (QCA) is a qualitative method to analyze written, verbally or visually recorded communication data. Contrary to quantitative methods, the categorizing process inherent to QCA enables the researcher to include interpretative and latent aspects of the phenomenon under investigation (Schreier, 2014). Originally, it was used to analyze media such as newspaper and magazine articles, political speeches and advertisements. Apart from social-scientific research, QCA is nowadays

often used in communication and journalism as well as psychological and medical research to explain and better understand quantitative data (Elo and Kyngäs, 2008; Neuendorf, 2017).

QCA facilitates organizing and condensing the bulk of raw data into manageable content-related categories, whereby data fragments assumed to concern the same content are classified into the same category (Elo and Kyngäs, 2008). Categorizing can either be performed inductively, where theory is developed out of the data; or deductively, whereby categories are predetermined by previous knowledge and literature to test theories, models or concepts. In the latter case, data is coded according to these predefined categories (Elo and Kyngäs, 2008; Schreier, 2014), which in this case largely relate to the variables and indicators used to formulate the survey questions (see section 6.1.1., Table 6 and Annex A). A third option is the combination of inductive and deductive coding and categorizing (Kuckartz, 2016), which is applied in this thesis. This complementary approach minimizes distortion through the researcher's preconceptions as it allows for topics to emerge inductively beyond the deductively coded ones (Mayring, 2015, p. 86). Characteristically, the systematic process follows pre-set rules, which fulfill the elementary scientific conditions of reliability and validity (Mayring, 2014, p. 14; Schreier, 2014). Reliability is attained by transparently disclosing and strictly following the rule-based procedure (Mayring, 2015, p. 123). This way, an interpersonally comprehensible process could be achieved for larger projects, where more than one person is involved in coding (Schreier, 2014) which is, however, beyond the scope of this thesis. Validity is generally owed to the setting in the broader research process: through the focus on subjects and everyday life (Schreier, 2014; Mayring, 2015, pp. 124–125). Construct validity is mostly given through the theory driven research process (Elo and Kyngäs, 2008). While QCA allows to investigate the richness and the nuances of the data, quantitative generalizations such as giving percentage-values could be statistically misleading and also overly simplify the diversity and detail of context given in the answers. Additionally, reflection on how the positionality and frame of reference of the researcher shape the analysis (McGuirk and O'Neill, 2016) (see section 6.4.1).

The process of QCA can be divided into three main steps. The first step is to prepare the analysis by selecting the unit of analysis, i.e. words, sentence fragments, whole sentences or whole paragraphs. The content-analytical units are determined by the research question(s) and depend on the quantity of data to be analyzed (Mayring, 2015, p. 61). When choosing single words, one risks fragmentation; whereas when looking at paragraphs, important details might be overlooked leading to overgeneralized and undifferentiated results (Schreier, 2014). The coding unit determines the smallest component of material, while the context unit defines the largest component of material to which a code can be assigned (Mayring, 2015, p. 61). The recording unit, on the other hand, defines which portions of the material are confronted with the category system (ibid). In this thesis, the coding unit is defined as a word, the context unit used is a few sentences, depending on how much context is necessary. Since coding encompasses inductive coding, the emerging category system hence illustrating the sum of aspects included in the transcripts, the recording unit includes all transcripts of a kind (expert, charcoal producer, government members) (ibid).

The second step incorporates organization of the data. Several different forms of QCA can be distinguished, each with specific techniques and protocols for this process. The most adequate variation is chosen according to the research question and empirical data (Mayring, 2015, p. 67). For the analysis of this thesis, a content-focused structuring qualitative content analysis according to Kuckartz (2016, p. 97 ff) is applied, it being especially suitable for analyzing guideline and other forms of interviews. In this form of QCA, main categories are deducted from the research question directly, which are closely tied to both the theoretical background and the method for data collection (Kuckartz, 2016, p. 101). In deductive analysis, the categories function as variables whose expression and/or attributes are identified for each section of a text or other form of recorded communication data – in this case, a transcript (Schreier, 2014). Subsequently, all coded text passages belonging to the same category are

gathered (Kuckartz, 2016, p. 106). Contrastingly, inductive category building involves open coding, whereafter codes are summarized into sub-categories which can be further grouped into new, higher order or main categories (Schreier, 2014) or, in this case, also into deductively defined main categories (Kuckartz, 2016, p. 106). Designation of a name to the codes and categories is done by choosing content-characteristic words or terms that best summarize the main content of the coded segments. For example, if the interviewee explains that s*he became a charcoal producer when clearing land for agriculture, in order to cope with hardship, or s*he claims it is not her*his official job, then these statements are coded with "for land clearing", "hardship/difficulty in life" and "'not my official job'", respectively, the latter one being coded in-vivo. These codes were then gathered under the category "reasons for becoming a charcoal producer", which was deducted from the questionnaire. The goal is to achieve as much intra-categorial congruity and inter-categorial difference as possible. Eventually, the categories are abstracted and conceptualized. This is an iterative process and abstraction continues as long as possible yet still reasonable (Elo and Kyngäs, 2008). The same holds for deductively set categories, after the first round of coding, the emerging category system is revised and if changes are made, the material is reviewed with these revisions (Kuckartz, 2016, p. 110).

In a first round four transcripts were mainly inductively coded, while deductive codes and categories were also set wherever suitable. Subsequently, the arising codes and the category system were reviewed and reorganized. Overlapping codes were merged into one code or turned into a sub-category and a more overarching category. In a next round, additional transcripts were coded applying the revised category system from the first round wherever possible and/or adapting, specifying and reorganizing it where adequate. Whenever new codes emerged, already coded transcripts were reviewed again with the new category system. This iterative process was performed until all the transcripts were coded and revised. Once the majority of transcripts had been coded, sub-/categories with a large number of coded segments were further specified by adding inductive sub-categories and codes. For instance, at first, all sections mentioning tree planting or interviewees' interest in doing so – whether for charcoal or other purposes – were coded with "interest in tree planting for charcoal production". By the 17th interview, this category included over 50 coded segments covering various opinions and aspects. Hence, the segments were re-coded with either "Yes" if the statement was in fact about trees for charcoal production, or "Not for charcoal" if it was about tree planting for other purposes. Another sub-category "tree species" emerged for all the tree species farmers would like to plant. Additionally, segments from the sub-category "yes" specifying (un-)favorable circumstances for tree planting, were further redefined into "conditions". Thereby the codes "training", "favorable markets", "land tenure", "financing", "seeds/seedling available" emerged inductively. For the segments coded with "Not for charcoal", two other purposes emerged: "fruit" and "timber".

Table 6 shows a few examples of deductively defined categories and sub-categories, which are based on the indicators that were used to formulate the survey questions and which were derived from the research questions and the theoretical framework as explained in section 6.1.1 . The complete category system, including the inductive sub-categories and codes, is shown in Annex G.

Table 6: Examples for deductive category building based on the research questions. (Source: own representation)

Research Question	**Main Categories**	**Sub-Categories**	**Inductive codes**
1. How are agroforestry on-farm trees utilized for charcoal production in the research area?	Source for harvesting	On-farm charcoal production	e.g. charcoal production during land clearing; charcoal production on other people's farms
	On-farm trees	Benefits	e.g. fruit; timber

Table 6: continued.

Research Question	Main Categories	Sub-Categories	Inductive codes
2. What are the barriers and opportunities of using agroforestry and on-farm trees for charcoal production?	Interest in planting trees for charcoal production	Yes Not for charcoal	e.g. conditions e.g. timber, fruitsß
3. How does human capital and social capital influence these barriers and opportunities?	Human Capital	Health in charcoal production Knowledge about regulations	e.g. injuries e.g. permit for charcoal production
	Social Capital	Social capital for charcoal production	e.g. charcoal producers' association

The third step of QCA is to report the results of the analysis by summarizing the content of the coded segments within a relevant category (Elo and Kyngäs, 2008). For the presentation of the results, all categories relevant to the respective research question are screened for their sub-categories and codes as well as their properties and expressions, in order to obtain all relevant aspects. These are then outlined and to illustrate them further, selected coded sections from the transcripts are included in the results as quotes.

The main challenge with QCA is that compared to quantitative analysis, it is much less standardized and considerably more complex. Criticism on this method includes framing it as overly simplistic or not qualitative enough, especially if the data is presented too condensed and overly summarized, if the category system is under- or over-developed or through excessive interpretation by the researcher during analysis (Elo and Kyngäs, 2008). In order to increase reliability of the research, connection and reasoning between data and results must be shown (e.g. with direct quotes and references), as presented in the results (see section **Fehler! Verweisquelle konnte nicht gefunden werden.**).

6.4 Reflection on Positionality, Challenges and Limitations

In academic journals, research generally appears as a linear and straightforward process. In practice, however, it is often a lot more messy, as the challenges arising during fieldwork can never be fully anticipated (Billo and Hiemstra, 2013). The same was experienced throughout this thesis. Due to the worldwide outbreak of Covid-19 by the end of February 2020, conducting the fieldwork in person and on-site became impossible. Consequently, data collection had to be significantly adjusted to these new circumstances – as mentioned in section 6.1.1 – thus setting off a whole string of new challenges.

The original plan was to conduct a separate and complementary data collection to the overall project, with in-depth guideline interviews for this thesis and survey interviews for the larger project. I would have conducted approximately twenty in-depth guideline interviews myself, with the help of a translator. The survey interviews would have been conducted by a team of researchers hired to conduct fieldwork and covered roughly 30 survey interviews in each of the six villages. However, due to travelling constraints, data collection had to be adjusted so that the survey and the guideline questionnaire were merged into a survey with both quantitative, close-ended questions and qualitative, open-ended questions. These changes to the fieldwork plan and data collection subsequently affected the sampling strategy and the data processing. Contrary to the expert interviews, where the expertise of a person is targeted (Meuser and Nagel, 2009), the qualitative, semi-structured guideline interview

aims at the individual, subjective realities of the interviewee. The interview guide is topic focused (Dunn, 2005, p. 88) and it is kept as open as possible but as structured as necessary, depending on the focus of the research (Helfferich, 2019, p. 671). In a semi-structured interview, the interviewee is invited to freely and openly talk about their experiences and practices along the ordered yet flexible guideline questions. The open structure still allows the researcher to probe for further comments and explanations whenever relevant or guide the conversation back on relevant topics if the interviewee should go too far off track (Dunn, 2005, p. 88; Babbie, 2013, p. 347; Helfferich, 2019, pp. 670, 672 ff). I further intended to conduct these during and after narrative walks, in order to enrich the interview with visual impressions (Oudwater and Martin, 2003; Jerneck and Olsson, 2013; Silverman, 2013). Photographs and detailed field notes would have further supported the analysis (Dowling, Lloyd and Suchet-Pearson, 2016). Since the whole sample for the overall project and thus the actual data includes 161 survey interviews, a subsampling strategy, based on the research focus and questions, was applied after data collection had been concluded. As the interviews were held in Swahili, transcription and translation had to be outsourced as well.

6.4.1 Positionality

When conducting research in a different context from one's own cultural normativity, the former is influenced by the latter leading to unavoidable power relations between the researcher and the research subjects (Rose, 1997). Hence it is crucial to reflect on and disclose ones positionality and its influence on the research and its outcome (Billo and Hiemstra, 2013).

I am a white woman in her late twenties, raised in a middle-class and rather well-educated family. Apart from one year as an exchange student in a rural town in northern California, and travels mainly to Western-European countries, I have been spending my life in peri-urban and urban areas in Switzerland. To this day, I have never been to the African continent. I can only imagine the cultural discrepancies – socio-economically, environmentally and overall – between my own background and the backgrounds of the rural population of Kilosa District. One could argue that within the six or seven weeks of fieldwork my understanding of the local context, the culture and the environment, would still be very little. Without having been to the field at all, however, especially the interpretation of the data sometimes felt a bit like tapping around in the dark. Fortunately, one of the expert interviews with a member of the fieldwork team helped to clarify and verify the results and discussion. Not having been to the field, however, might have also offered me a more neutral point of view for the analysis. As Bourke (2014) notes, through their position(-ality) the researcher can, in comparison to the research subjects, be an outsider, partially, for example, as a white researcher interacting with people of color. Even though the local resarch team consisted of three researchers, which all hold degrees of higher education, if not the power relations, at least the cultural differences could be reduced since they are all Tanzanian citizens.

6.4.2 Outsourcing the Fieldwork

In addition to the cultural gap, outsourcing the fieldwork further meant three people conducting the interviews, instead of only myself with a translator. This in turn implied that for one thing, the data is slightly influenced through the different interviewers and their individual styles, as there is always some degree of interviewer bias in face-to-face administered surveys (McLafferty, 2010). The variation in data collection was reduced by employing an interview protocol. Secondly, not being there in person obviously also meant that asking spontaneous follow-up questions myself and probing for more in-depth answers on topics particularly interesting for my research and beyond the questionnaire; which should be one of the major advantages of face-to-face interviews (McLafferty, 2010), was not possible. Thirdly, according to the research team, not being there ourselves, but having them, three Tanzanian natives, conduct the research, had slightly raised villagers' skepticism, especially in one of the non-

project villages. Fortunately, the pre-established contact during a previous field visit by Hanneke van't Veen and a voice-recording explaining our absence as well as reporting preliminary results from that visit helped to (re-)install trustworthiness. Being there ourselves might have made it easier for the villagers to trust us. On the other hand, being there could also have had other effects on the data and practical implications regarding gender aspects, social, emotional and physical limits (Billo and Hiemstra, 2013). Furthermore, as there were no interceptions for direct translation, the flow of the interview was more natural.

In recent north-south collaborative research, especially regarding fieldwork, concerns and criticism have been raised about the inequalities and disadvantages faced by local collaborators. These include lacking acknowledgement of their contribution, rare and meagre inclusion throughout the research process apart from data collection, the physical and emotional pressures they are exposed to, and fieldwork ethics, especially in regard to the flow of information about the results back to the community (SSRC, n.d; GICNetwork, 2019). We have tried to address these concerns through a number of measures. Especially during the final stages of assembling the survey questionnaire and translating it to Swahili, the whole team was involved. The local researchers have provided invaluable feedback covering concerns about wording or sensitive questions being asked and on how to improve questions they were unsure about, all of which was thoroughly discussed and adapted to incorporate their feedback. Regular updates about data collection and the well-being of the research team were held and support was provided whenever needed, requested and feasible. In order to ensure their physical safety, especially in the face of the Covid-19 pandemic, funds were allocated to protective and preventative measures such as masks and hand sanitizer for both the fieldwork team as well as the workshop and interview participants. To address ethical concerns, interview participants were asked for their permission to gather and record the data and an agreement was signed assuring the anonymity of each person who contributed to data collection. Questions which participants were not comfortable answering, were skipped. At each village meeting, prior to the workshops and interviews, preliminary results from the pilot study for the larger project were shared with the communities. Results of this fieldwork session will be presented during the next fieldwork session, which is planned for summer 2021. We are incredibly grateful to our Tanzanian research team and their invaluable work, without whom my thesis would have become impossible, hence we highly acknowledge and appreciate their contribution (see also Acknowledgements).

7 Results

This section comprises all the relevant results from the Qualitative Content Analysis of all interviews with charcoal producers, village and district government members and academic experts. The results are roughly structured in accordance with the research questions. Experts' views on mentioned aspects are discussed in a separate sub-section (7.6) at the end of this section.

7.1 General Characteristics of Charcoal Production in the Case Study Villages

Charcoal production is widely conducted in the study region. Most producers only produce part-time and seasonally to compensate for food and income shortages during the agricultural off-season (A-15, B-11, B-19, B-21, B-23, C-22, C-30, C-31, D-05, D-14, D-24, D-25) or whenever necessary (A-13); like in case of emergencies *"with problems such as hunger or diseases"* (C-21) or when food runs out (A-04). The producers' main livelihood activity, however, is agriculture. Even B-21, C-39, D-14, D-18 and D-24, who claim to be full-time charcoal producers, say they do not produce full-time throughout the year. For them, production mainly occurs from April at the earliest to November or December at the latest, when agricultural activities are low. Albeit, some produce specifically at the end of farming season to pay for agricultural inputs such as renting a tractor (B-08, B-19), or when demand increases (B-11) and *"when the price of charcoal is high from February, March before it started to rain heavily*" (A-15). Time management between farming and charcoal activities can be split flexibly depending on the situation and need as illustrated in the following quotes:

> *"It is not a full time it is just a part-time job simply because we also engaged in agriculture. When the harvesting period is over, we assess if the income we earned is enough or not enough. If the income is not enough to satisfy our needs, then we engage in charcoal production in order to increase that income" (C-30)*

> *"There was certain period when there was a famine, I do not remember when was that, either on previous year before last year or what year exactly, I made almost ten kiln of three to four bags, in that period I even stopped farming and my family took responsibility of farming at that time. And if I got a chance, I turned into farming but most of the time I based on charcoal production" (A-04)*

The reason for production is a determinant of the quantity of charcoal they aim to produce. For some, the amount of money needed for a specific purpose decides over the amount of charcoal they produce (A-13, B-08, B-23, C-30, C-39, D-24). As mentioned above, A-15 and B-11, as well as D-05 and D-18 also tailor their production quantity to the level of demand. Another factor influencing the production amount is tree availability, which, in project villages, is determined by block allocation (C-21, C-30, C-31, D-14, D-24). Manpower available can be a limiting factor on the quantity produced (A-04, A-13, B-19, D-25). As A-04 elaborates, physical condition, time, food and financial supplies, as to afford putting everything else on hold, are likewise important factors:

> *"Depending on time I have and if I am on good health condition, if I have an ample time I can produce ten to twenty bags of charcoal, but also I depend if I have food and savings since charcoal production seems to be the wealthy business" (A-04)*

A similar statement about the financial ability to produce charcoal was made by C-21. Production quantities vary from 10 to over 200 bags per year according to interviewees' estimates. Some only

produce between 10 and 30 bags per year, approximately[3], especially in village A (A-04, A-06, A-13, A-15, B-08, B-23, C-39). Among the interviewees in the subsample, mainly producers from project villages seem to produce more, starting at 80 to 100 bags per year (C-31, D-05, D-25), 120 130 bags per year (C-21, C-22, D-24), 175-200 bags per year (B-19, B-21, C-30), and 500 to 600 bags per year (D-14, D-18). For the latter two producers, the production quantity seems rather high and it is unclear from the interview statements whether they produce that much as a group or as an individual.

Producers earn varying amounts for a bag of charcoal. In project villages one bag sells between TZS 5'000[4] (C-22, C-30, D-14, D-18, D-25), TZS 6'000 (C-31, D-24), TZS 8'000 (D-05) and TZS 10'000 (C-21) per bag. In non-project villages a bag yields between TZS 10'000 (A-04, A-06, A-10, B-08, B-11, B-19, B-21) and TZS 15'000 (A-13). During the rainy season, prices can also rise to TZS 15'000-20'000 per bag (A-15, B-08, B-19). Prices further vary between selling locations from TZS 25'000 at a neighboring village F to TZS 35'000-40'000 at Dumila (B-23). A few producers across all four villages complain that the profits they obtain from charcoal production are unstable and too low (A-15, B-11, C-22, D-18). C-22, D-24 and D-25 also mention that the customer base has changed as they are not willing to pay the previous prices anymore.
Income from charcoal production is mainly spent on basic household needs and agricultural activities. Investments in household needs include supplementary food such as salt, vegetables, "ugali" (maize flour for porridge) (A-10, A-13, A-15, B-08, B-19, B-21, C-21, C-39, D-05, D-24), school fees, uniforms and supplies (A-04, B-19, B-21, C-30, D-14, C-30, C-31, D-14), health like medicine, soap, body oil or hospital visits (A-10, B-19, B-21, B-23, C-21, C-39, D-24) and clothing (A-10, C-21). Investments in agricultural inputs comprise pesticides, buying/renting land, livestock, renting a tractor or paying for grinding grains (A-13, B-08, B-11, B-19, B-23, C-30, D-14, D-24, D-25). D-24 says: *"I can save [TZS / year] 40,000/= but I will save it in form of livestock or poultry and not as money"*. In case of emergencies or need of cash he can then sell the chickens or other livestock. Some further invest in building materials (A-10, C-30), or other businesses (C-39, D-18).

> *"There is no charcoal producer that is not a farmer" (D-14)*

This quote holds true for all interviewees. C-39 also indicates that farming is not really an option: *"with the life here and you do not farm, it becomes difficult"*. A very similar statement was made by D-05. Crops cultivated include primarily maize, rice and sesame, but also potatoes, tomatoes, sugar cane, sorghum, sunflower, millet, groundnuts, peas and cassava. Many also combine crop farming with livestock keeping (A-06, A-10, B-11, B-19, B-23, C-22, C-31, D-14, D-25), mainly chickens, goats and cattle. Income from farming is highly variable as *"it depends with the season for example farming depends mostly on rain"* (B-11).

Eight interviewees further diversify their livelihoods beyond farming and charcoal production by pursuing additional income generating activities. A-13 works as a laborer, C-21 builds mud houses, C-22 sells *minara* (bundles of dried palm leaves), C-39 sells beer, rents out houses and sometimes runs a small retail business, D-18 owns a sardine retail business. A-04 also mentions he does not want to remain a charcoal producer forever but has aspirations to move up the value chain and become a charcoal trader. A-15 wants to expand his rice farming in order to enter wholesales instead of just participating in retail. A-13 hopes to improve his situation by investing in goats:

[3] Production quantity per year was approximated by calculating statements on how many bags per kiln and how many kilns per year they produce. Statements were sometimes inconsistent or conflicting, and averages were taken between high and low estimates. These numbers should only be taken as a rough estimate.

[4] TZS 5'000 convert to approximately CHF 1.95 (Exchange Rates UK, 2020)

> *"yes, what I am struggling to change now is to try to raise goats so as I can be like my colleagues, if I face any problem I can sell one goat so that I can solve the problem which is quite different from this tough work" (A-13)*

Investment of income from farming, selling tree products and other businesses is made similarly to money from charcoal production, mainly basic household needs. Savings are kept in the form of bags of crops or as livestock (i.e. chickens or goats) (A-13, B-08, D-05, D-14, D-24). However, this saving strategy is rather insecure. D-24 says the Maasai stole his goats, and B-08 states:

> *"it is very importance to save because there is a lot of challenge in life, I don't save my money in a bank but I usually leave some bags of maize unused as my saving, but this kind of saving is not good because sometimes people tend to steal them" (B-08)*

Then again, some do not have any savings: *"I do not save any money, there are too many emergencies"* (B-19), or never calculated them since those are very little (A-10, A-13, B-21, D-25) or because if they have any money, they spend it (C-39).

Most interviewees plan to continue producing charcoal in the future. Only five interviewees say they do not want to further pursue charcoal production in the future. Their reasons are either that they are looking for other business opportunities (A-04, A-10), or they are getting old and will not be able to participate due to their physical condition (A-15, B-11, B-23). All others plan to or rather have to continue, mainly because of the income generation opportunity and a lack of alternative options. In the words of A-13: *"that is why I am telling you this work is hard, and because I have no alternative, if I get a permit and because life is hard then I will sustain [charcoal production] because there is no food in this year ?(low yield)?"*. Similar statements about having no other opportunity of generating (cash) income were made by D-24 and D-25. For many producers, hardship or "difficulty in life" and its mitigation with income from charcoal production was the main reason for becoming a charcoal producer in the first place and/or remaining to be a charcoal producer in the future (A-04, A-06, A-10, A-13, B-08, B-19, B-21, C-21, C-22, C-30, C-31, D-05, D-14, D-25). Several statements along the lines of the following quote were made:

> *"It is when I face toughness and difficultness time in life, so I just decide produce charcoal before farming season arrives so that I can sell charcoal while farming and that how I can sustain daily needs" (D-05)*

Even those who did not specifically mention "difficulty in life" as a motive, they all mention cash income generation as one of the main reasons for producing charcoal (A-15, B-23, C-39, D-18). Adding to the previous quote by D-05, C-39 says: *"Because it acts as an alternative source of income while I am also clearing my land"*. The exception is B-11, who only mentions farm clearing as his motivation for charcoal production.

Causes for hardship mentioned by the interviewees include a number of risks and hazards impeding agricultural production, which is foremost for subsistence needs (A-04, A-13, A-15, B-08, B-11, B-19, B-21, B-23, D-24). Among these risks and hazards are increasing diseases and pests (A-04, A-10, B-08, B-11, C-22, C-30, C-31, D-05), such as termites (D-25); monkeys eating crops also seem to be a problem in village A (A-04, A-06, B-08 (part of his farmland is in village A)). Over the past five years, another challenge for maize production have been plagues of insects affecting maize varieties, locally called *Kantangaze* (VG_A2) and *Fall Armyworm* (VG_A1). VG_A1 therefore emphasizes the importance of improving agricultural production, as high production amounts (i.e. surplus) will likewise also increase farmers' abilities to contribute to development projects. Environmental challenges causing hardship include climate change (C-30), unpredictable rains (D-05, D-25), droughts (D-25), floods (A-13, B-19, C-30), and fires (A-04). According to A-13, this year's (2020) rainfall conditions led to crop failure and so

he depends on the income from charcoal production to *"avoid hunger calamity"*. A-04 faced a similar situation with regard to food insecurity in another year, where he resorted to charcoal production to make ends meet.

Village government members are aware of the environmental challenges their inhabitants face, including unpredictable rainfall and flooding (VG_A1, VG_A2, VG_B1, VG_B2), which killed most of the maize plants this year (2020) (VG_A1, VG_A2). Other, developmental challenges include that some of the villages do not have electricity yet (VG_A2, VG_B1, VG_D2). A clean and safe water supply system, which has not been extended out to the villages yet, is also a major issue (VG_B1, VG_C1, VG_C2, VG_D2). Some villages do not have a dispensary (VG_B1, VG_C2, VG_D2). Also, school infrastructure is lacking (VG_B1, VG_C2, VG_D2) but most village governments are already or now planning on investing in the expansion of that infrastructure by building classrooms, offices and houses for teachers and toilettes (VG_A1, VG_A2, VG_B1, VG_B2, VG_C2, VG_D1, VG_D2). Part of the tax revenue in village C is further planned to be invested in constructing a water well and a dispensary (VG_C1).

7.2 Utilization of On-Farm Trees for Charcoal Production

All interviewees except for D-05, D-14, D-24 and D-25 utilize on-farm trees for charcoal production. Most producers who utilize(d) their on-farm trees for charcoal production do or did so during land clearing (A-04, A-06, A-13, A-15, B-11, B-19, B-21, B-23, C-21, C-39). Only few individuals say they have used on-farm trees for charcoal production besides land clearing activities (A-04, A-10, C-31, D-18). C-31 for example stated: *"yes, there was a mango tree that was so big that I harvested it and produce charcoal"*. Similarly, D-18 indicates that she has cut down a large coconut tree and produced charcoal with it. A-06 utilizes trees after having cut them for the purpose of planting other trees, mainly fruit trees and bushes in order to prevent fires. He also uses on-farm trees for charcoal production if they are *"defect or is rot"* (A-06). In another case the trees utilized stem from very different purposes:

> *"I cut down some tree that are used by monkeys to hide themselves so as to prevent them from eating crops I cut down those trees" (A-04)*

Regarding production during land clearing, some producers mention that just burning the trees (A-15) or not exploiting them for charcoal would be a waste or a loss (A-04, B-11) whereas utilizing them provides cash income (A-04, B-21, C-39). Moreover, burning them (as in slash-and-burn) can be hazardous (A-15). Farmers, and in village A also a company, sometimes invite other charcoal producers to help them (C-39), hence some charcoal producers also produce on other people's farms (A-15, B-19):

> *"they come and request permission to produce, I allocate them an area to cut and they produce charcoal. This helps me in preparing my land for farming" (C-39)*

> *"in people's farm, we reach an agreement with the farm owner and then I cut down trees" (B-19)*

> *"we clear the [company's] land for three years after that we pay twenty thousand per acre" (A-15)*

Tree harvesting for charcoal is mostly done by cutting down the whole tree from the trunk to the leaves, whereby the branches are mostly utilized to ignite the kiln. Some even use the stump at times (A-04, A-13). C-22 says she cuts the tree one foot above the ground. Others leave only the very small branches (B-19, B-23, D-24). If the tree is cut to be used as timber, then sometimes the remaining branches are utilized in charcoal production or as firewood (A-04, A-13). Large trees are preferred since they generate more charcoal, but smaller trees are utilized if there are no bigger ones available or to fill up the kiln (A-10, A-13).

Availability of trees at different sources is important for whether producers decide to harvest the trees from their own farm. If there are trees available on-farm, then those are harvested (A-04, B-21, B-19, B-11, C-21): *"we usually produce charcoal on our farms and when our farms run out of trees and that when we move up there (into the forest)"* (B-21). As B-19 states, using the on-farm trees also has another advantage: *"during farming season I often produce charcoal on the farm because It is close to home"*, which means *"it also becomes easier to monitor the kiln if its crumbled because its close"* (B-19). This is also closely connected to farm-clearing in preparation for cultivation, as this is a priority for the farmers. The following statement by A-04 illuminates this connection: "*Yes, I cut down trees where I will to cultivate later on and this help me from not going too far searching for tree, while there is a possibility of getting trees here*".

In project villages, if access to the village forest is restricted, because of limited allocation in the designated block, then on-farm trees and other trees outside the forest are also considered, as illustrated by the following quotes:

> *"for now, it is in my farm because they have said that the permits are over by June and they have said that they would distribute these again next time" (C-39)*

> *"if I am allocated in the block, I produce from the village forest but if not I produce from my farm. Because sometimes, you might not be allocated and so I clear my land for farming and produce charcoal from the trees" (C-21)*

D-05 just mentions using on-farm trees as an option when the blocks are closed but does not do it himself since his trees are not favorable for charcoal production. C-21 further elaborates that charcoal production mostly happens on-farm in July, when old permits have expired, and the new ones have not yet been issued until August. Similar statements were made by other producers from the project villages C and D (C-31, C-39, D-05, D-18). C-39, D-14, D-24 and D-25, on the other hand, say that they are not allowed to use any sources other than the block:

> *"I do not prefer to produce from other areas because by producing from the forest block, you feel secure because if you produce from other areas you can be caught by guards from natural resources [VNRC]" (D-25)*

Meanwhile, it seems to be the opposite in non-project villages. B-08 says that in his village most people produce from their farms since producing in places outside your farm: *"it is illegal, if they found you, you are arrested"* (B-08).

Low availability of off-farm trees due to small village forests was another reason mentioned for using on-farm trees instead (A-10). Interviewees from village B state that there is no or very little village forest (B-11, B-19, B-21), what is left is mostly depleted, especially on the mountains (B-19, B-21, B-23), and that most forested areas are owned by individuals (B-08). A-13 even resorts to using tree stumps for charcoal production because he has neither trees left on his farm nor access to other sources to get wood from:

> *"I harvest them from my farm and the tree are already gone I can't depend neither on neighborhood land nor the government's and that's why I said in my area I utilize even the stumps" (A-13)*

For those who do not have trees suitable for charcoal production anymore or generally only few trees on their own farmland, they (are forced to) resort to off-farm sources (B-19) or, in project villages, depend on the reopening of the blocks (D-05, D-18).

> *"Nowadays I'm stealing trees in the forest because I don't have trees here at home" (B-19)*

> *"the trees in my farm are still young so I either produce charcoal from the forest block or from neighboring bushes" (D-18)*

B-21 decides based on demand, where to harvest trees. If the customers are many, he goes to the forest; if customers are few, he utilizes on-farm trees. A-10 decides depending on the slope and soil moisture, because it is easier and better to construct a kiln in flat, moist areas. An common reason why some interviewees are not yet utilizing their on-farm trees for charcoal production or deriving other benefits from them is, that many trees are still too young (A-04, A-06, A-13, B-08, B-19, C-30, C-31, D-14, D-18, D-24). The long establishment period of trees hence prolongs the reaping of benefits.

The opinions and perceptions between members of village government about on-farm charcoal production are likewise discrepant. To set the scene: village governments can take back land from individuals if it is not utilized for agriculture within three years (VG_A1, VG_D2). A statement to that effect was made by B-08 who bought a piece of land with trees on it:

> *"they [village government] told me that I should clear my farm so that next time when they come to inspect they want to find me farming" (B-08)*

Like many others, he decided to produce charcoal from those trees as was recommended by other villagers. DG_1 states, that in non-project villages, most of the charcoal production happens on private land and during land clearing since these villages do not have a sustainable land use plan. However, land should not just be clear cut completely; when farmland is given to villagers to clear, the village government instructs them to retain big trees because they help them get rain (VG_A1).

7.3 Challenges and Opportunities for On-Farm Tree Utilization

A number of challenges emerged in addition to the reasons mentioned as to why some are not using their trees for charcoal production currently:

> *"I do not plant trees because I don't have the seeds to those trees (strong wind howls) and even a place to get them I do not know. and even the education on how to plant these trees I do not have" (A-10)*

This quote points out two challenges: availability of seeds or seedlings and training on how to plant and nurse trees. The former was also mentioned by other interviewees (A-13, A-15, B-08, B-21, B-23). Additional restrictions mentioned by the interviewees include: small land size (A-15, B-19, D-24, D-25), land tenure (A-15, C-39, D-25), financial support (A-06) and favorable and respectable market conditions (A-10). Negative tree-crop interactions or fear thereof are further reasons for hesitation to plant trees. D-18 mentions that too many trees might create shade and reduce the area for crop cultivation. A-04, A-06 and B-19 mention that they have cut down on-farm trees in order to reduce competition between trees and other crops, while A-06 and B-19 also have relatively small landholdings.

Land tenure is critical as it is prohibited to plant trees on rented land. Regardless, C-39 did plant trees on rented land: *"I am planting trees because I have plans of purchasing it [the rented farmland]"*. She did not indicate whether this was explicitly allowed by the landowner or not. However, for now, she has stopped planting new trees because *"the owner can change his decision to sell it anytime"* (C-39), indicating that tenure security is also an issue. A-10 rents land from an in-law, and when asked about a certification or limitation of tenure he acknowledges:

> *"There is no limit. At any time, he would decide to take it back, he would take it back. So, until then I will continue to farm" (A-10)*

Generally, it is worth mentioning, that none of the interviewees, who say they own land, have an official certificate to confirm their land ownership, apart from A-04 and B-11, and C-22 only for part of her land. Some of them mention something along the lines that such certificates had been promised by the village government but have not been issued yet (A-06, C-21, C-22, D-18, D-25).

Conflicts over land ownership as mentioned in the following quote are also a major issue, not just at the individual level, but also at village (villages A, B, D) and district levels.

> *"But most of areas especially in our village there is a lot of land conflicts. The other side of village there is Maasai community, the pastoralist and the other side there is [religious organization, name omitted] that are in conflict so we only left with mountain." (A-15)*

Village A and B both share areas of unclear land ownership with village F (not in the subsample) and with large-scale landowners. For one thing, the village border between villages A and F is not respected, which is the result of an increasing number of people in need of land and consequently, of land scarcity (VG_A2). Other conflicts over land ownership and scarcity arise in villages where there are investors with big land holdings as is the case in villages A and B. Often, DG_1 says, the consequence, is encroachment and forest degradation. VG_A1 notes that a religious organization, who owned a large area, had bribed officials and thereafter villagers were violently evicted from that land. They have been waiting for over seven years now for this land conflict to be resolved. Meanwhile, a court apparently decided that the organization has to return the land, but so far, ownership has not officially been signed back to the village government (VG_A1). Village B faces a similar issue with two large estates of unclear ownership. One area was bought by a research institution that is currently not using it, resulting in encroachment by farmers who had previously lived on that land for farming and livestock keeping. VG_B1 further states that since their village only recently became independent from village F, they have never dealt with land allocation and there is no-one responsible. In connection with this, there is no clear information about if and how the second estate has been reallocated between village B and F. At the same time, there are many complaints from villagers that they have no farmland (VG_B1).

Village D shares part of its borders with non-project villages. The boundary cuts through the forest and its exact course is disputed:

> *"their case [village D] is on border marker that is indicated by huge stone but nowadays they have removed the stone and they cannot identify to what extent border ends" (DG_1)*

The unclear border in combination with the neighboring non-project villages not having a sustainable land use plan leads to encroachment and unsustainable harvesting in what the project villages have demarcated as blocks for specific sustainable uses (DG_1, DG_3). Additionally, there are some villagers who still live in the areas demarcated as forest according to the land use plan, because when the plan was made they refused to leave the forest and reject the compensation offered. Also, since those plans were made the village government has changed and those who continue living in the forest claim that they had an agreement with the former government, of which the new one is unaware (VG_D1, VG_D2).

Another governance issue is that of who has the authority to allocate land:

> *"There are challenges that Sub village chairperson are the one who allocate the land, but this is against the law , the law says village allocations start from the Council, then to the General assembly" (DG_1)*

A similar statement was made by DG_2 about land allocation issues, implying that support to the villages is difficult because the district lacks sufficient human resources:

> *"it [verification of land ownership] could be difficult. if officers or leader in low ranks have done [land allocation] in wrong way, it is true. because. as District we have 40 wards, and forest officers are three to four, so to be satisfied with the document they brought here, is difficult unless there are complaints" (DG_2)*

As indicated in this quote, a further major challenge for the governance of charcoal production in general, possibly also complicating efforts to promote sustainable on-farm production, is the lack of capacity of the district government to support village governments and villagers directly, as further discussed in section 7.5.

Another issue impairing efficient and effective governance of village land and forest in non-project villages is that they do not have a (sustainable) land use plan (DG_1). In regard to the village forest, invaders entering the forest without a permit are the biggest challenge. As also stated by a number of charcoal producers, these invaders come mainly from other villages (VG_A2). In village A the number of invaders have declined through forest patrols and therewith, pressure on the forest has been reduced as well (VG_A2).

An additional challenge, which was not mentioned by producers directly as a challenge for tree planting, but nonetheless bearing general conflict potential is cattle from pastoralists. In village D their cattle sometimes invade the forest block (VG_D1). In village A, pastoralists have even claimed certain areas and restrict others from farming there (VG_A2). Other conflicts between farmers and pastoralists arise when cattle invade the farms to graze and destroy crops (and seedlings) in the process (C-30, D-14). There are systems in place where the Agricultural Officer estimates the damage and the farmer is compensated for the loss. If the owner of the cow cannot pay right away, part of her*his cattle is handed over to the farmer as a security deposit. Retrieving a cow costs TZS 70'000 to TZS 80'000 (VG_A1).

> *"they [pastoralists] pay but sometimes they migrate to other locations and don't pay, so that causes loss to farmers" (VG_A1)*

7.3.1 Benefits of On-Farm Trees beyond Charcoal

While charcoal is one of the most frequently motioned benefits of on-farm trees, interviewees also pointed out nine other direct and indirect benefits they provide. Overall, the most often mentioned benefits are shade, charcoal, fruit and income with 11, 10, 10 and 9 interviewees mentioning them, respectively. The full list of benefits and individual benefits for each interviewee are displayed in Table 7. Direct products and benefits obtained include firewood, timber, fruit and medicine. For timber, farmers mostly plant teak trees. Most of these are still immature, and interviewees expect their benefits only in the future (A-04, A-13, B-08, C-22, C-31, D-14, D-18). Others already benefit or did not specify (A-15, B-11, B-23). Fruit trees cover a variety of species, including mango, coconut, orange, lemon, jackfruit and guava. The bulk of their harvest goes towards household consumption. In terms of ecosystem benefits, one indicated by three farmers is improved soil fertility (B-11, B-21, C-21), specifically through "*manure*" from the leaves when they fall (B-11), or as C-21 states: *"the trees provide me with fertilizer when they rot"*. Three farmers also state that the trees attract rain (A-06, A-15, D-18) and D-25 also considers fresh air. Another benefit named is shade (A-04, A-06, A-10, A-15, B-11, B-19, B-23, C-30, D-14, D-18): *"I left some [trees] so that when I want take a rest on my farm I don't have to worry about the shade"* (A-15), a very similar statement was also made by D-18. Income from selling tree products (charcoal, timber, firewood, fruit and medicine) is another benefit (A-04, A-06, A-10, B-11, B-21, B-23, C-31, D-05, D-18). Trees are furthermore seen as an insurance for the future when the forest is depleted (A-04, A-15, B-21, C-30, C-31, D-18). As A-15 puts it: "*trees are like a guard"* and as stated by C-30, due to their perennial nature, trees allow for continuous harvesting. Some farmers derive six or more different benefits (A-06, A-15, B-11, D-18).

Table 7 : Benefits from on-farm trees. Numbers in parenthesis (e.g. (x), (4)) signify future benefits that have not been reaped yet. (Source: own representation).

	Total	Charcoal	Timber	Firewood	Fruit	Medicine	Shade	Soil fertility	Rain[a], Fresh air[b]	Income	Insurance for future
A-04	5, (1)	x	(x)	x	x					x	x
A-06	7	x		x	x	x	x		x[a]	x	
A-10	5	x		x		x	x			x	
A-13	1, (2)		(x)	x	(x)						
A-15	6	x	x	x			x		x[a]		x
B-08	1, (1)		(x)		x						
B-11	8	x	x	x	x	x	x	x		x	
B-19	1						x				
B-21	4	x						x		x	x
B-23	5	x	x	x			x			x	
C-21	2	x						x			
C-22	2, (2)	(x)	(x)		x		x				
C-30	3, (1)	(x)				x	x				x
C-31	4, (2)	x	(x)		x	x				x	x
C-39	1	x									
D-05	2				x					x	
D-14	2, (1)		(x)		x		x				
D-18	6, (2)	(x)	(x)	x	x		x	x	x[a]	x	x
D-24	0, (3)	(x)			(x)					(x)	
D-25	3				x		x		x[b]		
Total		10, (4)	3, (7)	8	10, (2)	5	11	4	3, 1	9, (1)	6

7.3.2 Interest in Planting Trees

Some of the interviewees are not willing to plant trees specifically for charcoal production, albeit showing general interest in planting trees for other purposes, namely teak trees for timber production (A-04, A-06, C-21, C-30) and fruit trees (A-04, A-06, B-11) and/or they hve already planted such trees (A-04, A-06, B-11, C-21). A-04 further specifies that he does not need to plant trees for charcoal production because he can use the ones he has on his farm (6.5ha) which contains a small forested area. The farmland of B-11 is the largest (14ha) within the subsample and (still) contains relatively many trees (over 60). A-06 says he would not plant trees for charcoal production because timber trees regenerate while charcoal trees do not. He also sees an advantage in having fruit trees because fruit can be sold to generate income. C-21 says he would not plant trees for charcoal for he has been allocated a plot in the village forest block. Another aspect that emerged is the establishment period for trees from planting them until benefits can be reaped. However, this did not come up directly with their motivation to plant trees or not, but from their experience with planted trees where they expect benefits in the future but for now these trees are still immature (A-04, A-06, A-13, B-08, B-19, C-30, D-05, D-14, D-18).

Generally, all interviewees except for A-10 and A-15 have planted trees on their farms for various purposes – mainly teak and fruit trees – whereas B-23 says he has already planted trees specifically for charcoal production. Tree types and species interviewees are interested in planting include: mtiki/teak *(Tectona grandis)* (A-04, A-06, C-21, C-30, C-31, D-05), mlama mweusi and mweupe *(Combretum mole and collinum)* (A-13, B-08, B-23, D-18), misolo *(Pseudolachnostylis maprouneifolia)* (A-10, A-13), mpingo *(Dalbergia melanoxylon* (hardwood for timber)) (A-15, D-18), mninga *(Pterocarpus angolensis)* (D-18), and

a variety of other "miombo" and hardwood species. Similarly, D-24 would like to plant mango, or just any marketable trees so that he can get fruit first and then later harvest the tree for charcoal production. Hence one tree would serve more than one purpose.

The majority of interviewees indicates that they would be interested in planting trees for charcoal (A-10, A-13, A-15, B-08, B-19, B-21, B-23, C-31, C-39, D-05, D-24, D-18, D-25). B-08 says "*yes, I really need trees*". He has relatively small landholdings (1.2ha owned and 0.4ha rented) that only contain a few trees. Distinct motives for tree planting for charcoal and other purposes are pointed out by A-15 and D-18:

> *"my motivation comes from first to get needs ?(benefits of trees)? and I know charcoal is very important, firewood, wood for constructions and even for medicine so trees have many benefits" (A-15)*

> *"when you decide to plant trees, those trees have two reasons; there are trees that can be used for timber and from the trees left you can produce charcoal. So, you earn income from two sources" (D-18)*

Similar statements like this last one from D-18 are reported by and A-04, C-30, C-31 and D-05, where the stems of the tree are used for timber and the residual branches are utilized for charcoal production. In this case yet again, one tree would serve two purposes at once.

Several interviewees additionally mention that reasons motivating them to plant trees are if/that tree availability in the forest is declining (C-22, C-31, D-05, D-24) and/or the distance to the forest is increasing (D-05, D-18).

7.4 Effects of Human Capital and Social Capital on Charcoal Production from On-Farm Trees

7.4.1 Human Capital

Generally, the education level of 15 interviewees is "standard seven", which corresponds to primary education. A-13 only completed five out of seven years of primary education. Three interviewees (B-08, D-24, D-25) have no formal education and only one interviewee received secondary education (A-10).

7.4.1.1 "Knowledge" of Regulations

The diverse statements above, about producers stating where they are or are not allowed to produce, suggest quite variable, even conflicting knowledge about and compliance with charcoal regulations. The analysis revealed that this does not just concern which sources are utilized and permitted but also holds true in regard to permits for production, the maximum amount allowed to be produced and sanctions for not complying with the regulations. Misinformation about regulations is, though, not just apparent among producers but also among members of village and district governments.

In general, producers are aware that a permit is needed for charcoal production. Then again, apart from B-21, C-21, C-30, C-39 and D-14, none of the producers have one. C-21, C-30 and C-31 say they register for the permit as a group, for which they pay together (TZS 261'000); hence they do not have individual permits. C-39 adds that permits are given out by the Village Executive Officer after block allocation. D-14 says the village government pays for the permit, which costs them TZS 264'000 per year. B-08 says that a permit is needed for farm clearing. B-11 first states he does not have a permit, but then later acknowledges he received his permit, a hand-written note, for free since he is using an axe and only if using a chainsaw you are obliged to have a permit (B-23) which costs TZS 10'000 for a certain number of days (B-11).

B-21 discloses that his reason for having a permit is because otherwise he could be harassed by the village government. According to A-06 and A-15, however, a permit does not necessarily protect you:

> *"yes, because it's a farm they don't give us permits the ones that are given permit are those that produce charcoal on the mountains and since it's not my official job I don't look for a permit, sometimes you might have a permit but still you can be bothered by [district] natural resource officers and they impose very strict conditions on the permit" (A-15)*

Reasons why most others do not possess a permit is because according to them, they do not need one since they do not produce in the village forest (A-15), it is not required for land clearing (A-13, B-11), it is not their *"official"* or *"permanent"* job (A-04, A-13, A-15), *"there is no need for me because I rarely produce charcoal"* (A-06) and it is the wholesaler or transporter who needs a permit from the village council (C-30, D-14). Furthermore, due to these bad market conditions, producers are not willing to pay for the permits (D-14, D-18). C-22 and C-31 do not have one for now because they stopped producing as prices have dropped (C-31). B-19 on the one hand claims there is no use in getting a permit because there are no trees available, but on the other he would like one because you can be blocked if you do not have it.

According to A-15, permit issuance depends on whether you want to produce or transport charcoal:

> *"those who went say if you apply for a permit you are asked if the permit is for charcoal production or charcoal transportation? If you are producers when [they] will come and inspect your area if it fit for production or not, if they found your area in a mountain and valleys places they ban your permit and if you are transporter they want to know where they charcoal was produced and if they are satisfied then they will hand you a permit" (A-15)*

Another aspect raised in this last quote are restrictions on where charcoal production is allowed. As briefly discussed above (7.2), there seems to be little clarity or unity on this matter. All interviewees from project villages do produce from the block, whereas some additionally produce on-farm (C-21, C-39, D-05), in spite of it being forbidden according to C-39, D-14, D-18, D-24 and D-25. Meanwhile, in non-project villages A and B, some producers knowingly produce illegally in the village forest (A-10, B-19, B-21). Especially the area along the mountains is said to be restricted by several interviewees (A-15, B-08, B-11); other restricted areas are those reserved for beekeeping (B-08, B-19). A-06 and B-21 even state that charcoal production is technically forbidden in general. A-15 attributes the illegal production to the fact that the government does not provide a favorable environment for charcoal production.

Statements about when and where a permit is needed and from which government agency it has to be acquired vary even between government members. VG_A1 declares:

> *"if he/she need to produce, he or she should report to village executive. if he will be allowed he/she can start producing charcoal. you should not produce a charcoal without a permit from village office" (VG_A1)*

These permits are only valid for charcoal production for domestic consumption, but not for business (VG_A1). In village B, charcoal production during land clearing is allowed under the following conditions:

> *"Yes, after clearing the farm land, he can use a fallen tree for making charcoal within his farm, when he has produced the charcoal, he pay fee for the production" (VG_B1)*

And in village D: *"no (...) [I] am not sure yet may be natural resource committee know about this. I have never experienced this [charcoal production during land clearing]"* (VG_D1). Meanwhile, two interviewees from village D concede they or others are doing so. According to district government, no matter the source of production, producers should register through the village government:

> *"there are difference in management each areas has its own procedures if its village forest or farmland when he wants to cut the village government should be informed and if there are fees or contribution for development project he or she should pay" (DG_2)*

As reported by VG_D2, no permit is needed for on-farm production. Contrarily, DG_3 asserts that on-farm charcoal production during land clearing does require a permit from TFS, but that some of the new landowners are not being informed about this regulation by the village government when they sell them the land. The person wanting to produce charcoal during land clearing is supposed to do as follows:

> *"[S*he] pays money for the charcoal bags that he/she expect to get after producing, because if you let them pay after harvest you will never ever see him/her. so that's why we ask them to pay before harvesting" (DG_3)*

In order to obtain the right to harvest forest products in village B, an application letter has to be written to the village council. As VG_B1 states: *"for example if I want to harvest for timber, I will pass here (village government) for application, then village council will discuss my application, then they all take it to General assembly"*. The village council meets once a month and the General Assembly, which includes the village council, all the committees and the general public, get together once every three months. However, according to VG_B1, this system is not really applied and there is no official payment process in place. Moreover, not a single charcoal producer has applied for a permit in either village A or B (VG_A1, VG_B1). VG_B2 notes that permits for harvesting forest products are free of charge, but if you are caught without a permit you will be fined. VG_A2 agrees that permits are needed for any kind of harvesting activity in the forest. VG_A1 specifies that a permit for charcoal production is needed if the quantity is for business and exceeds five bags for home consumption. However, the village government itself is not allowed to issue permits for charcoal production. VG_A1 says they are issued by the Office of Natural Resources in Dumila, VG_A2 disagrees by stating that it is only the district council in Kilosa. According to DG_3 all permits regarding charcoal harvesting and transportation are handled by TFS. Finally, in project villages, applications for permits must go through VNRC (VG_C1), who then allocate plots in the block (VG_D1).

Costs stated for permits are TZS 30'000 per month according to A-06, TZS 20'000 per month according to D-18 and TZS 5'000 per group member and year according to C-31. A-13 remarks that the permit is too expensive, since he produces only rarely compared to others who would pay the same but produced much more:

> *"back then we were paying [TZS] 5,000/= and stay for 2 to 3 months and you are asked again to pay while you didn't harvest anything in your kiln although some were harvesting" (A-13)*

VG_D2 says the village government pays the cost of TZS 280'000 for the group permit as a motivation for charcoal producers to abide the sustainable production guidelines.

Another issue seems to be corruption:

> *"They were asking us to pay for it but I saw it as the liar, because they took money and nothing happened and I almost got into a fight because of that money, For example, once when we contributed the money, some money were lost for personal interests and they only send small money" (A-13)*

B-08 also mentions that the issuance of permits takes a lot of time. In project villages, permits and block allocation are stopped in June (C-39) and new permits are only issued in August (C-32) or according to C-31, they are valid for the months of October until May.

There are also restrictions in place concerning which tree species are allowed to be harvested for charcoal production (A-06, C-30, C-31, C-39, D-14, D-24, D-25). D-14 explains that timber trees in the block are marked with paint and that those are not supposed to be harvested for charcoal production.

Knowledge about the amount of taxes and who is responsible for paying them is also rather diffuse. A-06 and B-08 say taxes of TZS 1'000 per bag have to be payed to the village government. B-11, B-21 and B-23 suggest taxes per bag are TZS 500 if you pay freely, but if you are arrested it is TZS 1'000 per bag (B-23). A-10 and C-21 pay TZS 2'000 per bag. Others say the customer pays for the taxes (C-30, C-31, D-14, D-18, D-25), which amount to TZS 12'000 (D-24) or TZS 12'500 per bag (D-18). A-13, D-05 and D-25 say they do not pay taxes because they (A-13, D-05) only produce in small amounts. A-04 says he does not have to pay at the farm, only at the gate at Dumila, where taxes are TZS 2'000 per bag.

Several interviewees from project villages mentioned a raise in taxes which led to a reduction of the price that the customers pay to the producers, as the customers are the ones who have to compensate for these taxes (C-30, D-18). Before the tax increase a bag sold at TZS 7'000 (C-30, D-18), now most producers in project villages only get TZS 5'000. In 2018, the tax was raised by the central government from TZS 6'700 to TZS 12'500, in order to unify prices throughout the country (VG_C2, VG_D1, VG_D2). Even though this price is not paid by the producers themselves; they are severely affected by these changes:

> *"for charcoal producers, customer has become, I mean their profit has been lowered much. And the market price has remained the same. So charcoal producers are forced to lower price. From [TZS] 7000 to [TZS] 5000 and this act, our charcoal producers many times hesitate and volume of charcoal has to be increased. Thats why customer start running, they run to where there is no such restrictions" (VG_D1)*

This is corroborated by very similar statements from DG_1. He further mentions that theoretically, the village revenue should have increased since more revenue could have been earned from these taxes. He also stated, however, that this did not take the expected effect since buyers have ended up purchasing less charcoal. VG_D1 does disclose that even though general village revenue has decreased, revenue from charcoal has increased because of the raised taxes. According to VG_D1 and VG_D2, producers still earn TZS 7'000 per bag of charcoal. VG_D2 thinks producers should accept lower prices of TZS 6'000 to attract more buyers and village government could compensate them by providing food.

Limitations on the maximum amount of charcoal producers are allowed to produce are not known (A-13, B-08, B-23, C-31, D-24, D-25) or are thought to be inexistent (A-10, B-11). C-21, C-22 and D-25 acknowledge they exist but do not know the exact amount. Others state that it is basically as much as you can produce from the allocated plot (D-14, D-18) and D-05 specifies that the plot size allocated in the block depends on how much charcoal a someone would like to produce. D-18 also asserts that you can be fined if you produce more than 40 bags per plot but later on mentions that you might be able to yield 50 bags with a good technique. The only interviewee mentioning a specific amount is C-30 who

says the limit is 200 bags per person and year. Moreover, most producers do not know who decides over these limits, some think it is the village government or VNRC (C-31, C-39, D-18), others suppose the decision is made by the district government (D-05, D-14). VG_D1 says that for all producers of the village together, they are allowed 2'900 bags per year.

Sanctions for producing without a permit include fines (A-06, A-08, C-22, C-31, D-24) of TZS 50'000 (A-10, B-18, C-30, D-25) or a doubling of the regular taxes if you are arrested, which amount to TZS 1'000 (B-23), arrest (B-08), confiscation of charcoal bags (B-11, C-22, D-18) and production equipment (D-05), destruction of the kiln (C-21) or banning from future production (C-31). Instead of fined you can be jailed (C-31) for three months (D-05) or 6 months (D-18). For exceeding the limited amount, you can get a warning (C-30) or a fine of TZS 10'000 per bag (D-18). D-05, however, states that *"if you meet someone you know (a leader) you can just talk and everything may turn to be okay"*, implying that enforcement is not always done according to the laws and regulations.

VG_B1 states that most producers run away when village council representatives go on patrol to gather production fees, which are TZS 500 per bag. VG_B2 adds that both the producer and the buyer pay TZS 500 each. Sanction for "illegal" production is a fine of TZS 50'000 (VG_B1, DG_1). In non-project village A, fees of TZS 2'000 are collected per bag when the production amount reaches five bags or more. If someone wants to produce more than five bags, s*he has to apply for a permit from the Office of Natural Resources, which no producer has ever applied for so far (VG_A1). DG_3 states that when district forest patrols find producers in the forest without a permit, they bring them to the District Office of Natural Resources and confiscate their bags. They are also invited to come back to get training on which procedures and guidelines to follow. About 60% of those who are caught attend these trainings, and 8% thereof agree to get a license (DG_3).

VG_A1 remarks that the village government has no authority to arrest or punish illegal harvesters in the forest. Once they catch someone, they must call the District Natural Resource Officer. In contrast, VG_B2 says that the village government is in charge of forest protection, even though the village does not have a village forest reserve, hence it would be general forest under the authority of the District Office of Natural Resources and TFS (DG_1).

Another aspect where actual practices diverge from official regulations is transportation of charcoal. Several interviewees mentioned transporting charcoal by bicycle by themselves and or by transporters/customers (A-04, A-06, A-13, A-15, B-19, B-23, D-05, D-14). According to DG_1 this is not "*official for transporting*" as it is difficult to control.

7.4.1.2 Knowledge and Awareness of Environmental Sustainability

> *"I just leave some trees in my farm to conserve them because if we take charcoal production as permanent work all the trees will be gone, the trees were growing from the bottom of the mountain but now you can only find trees on the top of the mountain. It will be really difficult to reach at the top when we get old, since trees will be far from where we used to cut them. When I arrived here there was a dense forest and if you want to produce charcoal you just take trees right in front of you but now as you can see" (A-04)*

All interviewees are aware that currently, certain charcoal production practices can be, or are negatively affecting the environment. Many are conscious of the fact that the manner in which trees are harvested impacts the forest (A-15) and influences its ability to regenerate (A-04, B-23, D-14). Not cutting down trees at all or at least not in large amounts or all at once, but rather here and there and leaving some in between, is better for the forest (A-04, A-06, A-15, B-11, B-21, C-21, C-30, D-05, D-24) since cutting too

many trees could also cause desertification (A-04, C-30). The method of leaving some trees instead of clear cutting is called *"draft"* in project villages, as explained by D-05:

> *"Okay, there's boundaries to limit and guide you, so the trees are cut down in a draft style. This style helps to conserve trees since we cut we don't harvest the whole forest. Therefore, trees grow in this area while cut in another area" (D-05)*

Not cutting down trees "*haphazardly*" and randomly can reduce pressure on the forest (A-06, B-21, C-39). The equipment used may also have an influence: using an axe allows the tree to regenerate (B-08) whereas using a chainsaw kills the tree (B-23). B-23 adds that trees cannot regenerate in a former production area and therefore shifting the kiln around out of convenience to be closer to the harvesting site destroys the environment, so he would always build the kiln in the same location. Finally, making sure not to accidentally start a fire – especially during unloading of the kiln – was mentioned several times (A-04, A-06, B-19, C-30, C-31, C-39, D-05, D-14, D-18, D-25).

Kiln efficiency estimates vary greatly between 100% (D-18), 75% (A-06, C-30), 70% (C-31), 60 to 70% (B-11) and 50% (A-10). Some say the wood-to-charcoal efficiency depends on the kiln construction and the producer's skills (A-04, A-10, B-08). A higher yield can be obtained from a *msonge* (conical) kiln compared to a box kiln (B-11, C-21). Others have never thought about kiln efficiency, do not know, or say that this cannot be predicted (A-15, B-19, B-21, C-22, D-05, D-24, D-25).

Many interviewees state that the amount of trees as well as the state of the village forest has declined over the last few years (A-04, A-06, A-10, A-13, A-15, B-08, B-19, B-21, B-23, C-22, C-30, D-05, D-25):

> *"because those trees that we use for charcoal production it takes 20 to 30 years to reach a stage that can be harvestable again and those places that we harvested tree until now there is no any sign of trees and it almost the same years as I told you (20 to 30 years)" (B-19)*

> *"they have decreased because we cut them and we don't plant new trees and they take a very long time to regenerate and grow in a size enough to be harvested again" (B-21)*

Some interviewees from project villages, though, observe no change since the areas where they had harvested in previous years are now regenerating (C-39, D-14, D-18, D-24) and others even state they observe an increase in tree cover and availability (C-21, C-31). C-31 argues that trees increased in number because unlike before the project they are now conducting forest activities more systematically, allowing the forest to regenerate. DG_1 declares that regeneration is not occurring (yet), hence it must be encouraged and well monitored, largely agreeing with the statements from interviewees from village A at the end of the next paragraph.

Some say that planting new trees would be important to help the forest regenerate and ensure charcoal production in the future (A-04, B-21, B-23, D-18):

> *"charcoal production has big impacts ?(on the forest)? when we cut down trees we are supposed to plant a new one but we don't do that" (B-23)*

Ideas on how to minimize the impact of production on the environment are divergent. A few interviewees admit that they do not know about it (A-13, D-08, B-21, C-22). A-13 implies that more guidance is needed. Several interviewees mention it being illegal charcoal production that is damaging the environment and that this must be stopped in order to conserve the forest (A-15, D-18). Some argue that it is especially people coming from outside the village who are producing illegally (A-04, A-10, A-13, A-15). In addition to destroying the forest, C-31 adds that if illegal production and logging will not

stop, everyone might be prohibited access to the forest as a consequence. More protection of the forest is necessary in order to allow charcoal production in the future (A-04, A-10, A-13, A-15).

The majority of interviewees would or already do report illegal production (A-04, A-06, A-10, A-13, A-15, B-08, B-23, C-21, C-22, C-30, C-31, C-39, D-14, D-24), mainly because it destroys the environment (A-06, A-10, C-30, C-31). A-15 feels it is his duty as a villager to protect village property. A-13 is cautious, however, as reporting someone can be dangerous:

> *"When a person entered with force and once you tell him but still continue to use force, you have to be kind and cool for the sake of your family, so I just keep silent to save my life" (A-13)*

Five interviewees would not report illegal production (A-15, B-19, B-21, D-05, D-25) because they would be ratting out a colleague (A-15), they have compassion if this person is in the same difficult situation as they are (B-21, D-05): *"if a person will produce charcoal in small quantity I will not report him because I know he just do it to earn money for daily basic"* (D-05), or because there is a patrol for that (D-25).

7.4.1.3 Mode of Acquisition of Knowledge and Skills

The main mode to acquire knowledge and skills is through learning from others. All of the interviewees learned how to produce charcoal from friends, neighbors and other villagers (A-13, A-15, B-08, B-19, B-23, C-21, D-05) by helping them, through learning by doing and some only by observing what others did (A-04, A-06, A-10). D-24 just states that he started on his own but does not give any indication as to who he learned from, neither do B-11 or C-30, and only D-14 says he taught himself. A-10 says that he does not know how to improve his technique because he never received official training since there is none. All interviewees from project villages C and D used to produce charcoal already before the project arrived in their village, except for C-22 and C-31, who gained their charcoal production skills solely through the training by TFCG. The others all mention they have changed their techniques according to the training by TFCG and through that, they have been able to improve both quality and quantity of the charcoal they produce. C-39 indicates she received some training, but it remains unclear whether that was through TFCG or not.

In regard to learning from others, the same as for charcoal also applies to farming. Most interviewees had learned from their parents, some received additional training or expanded their knowledge by learning from others.

> *"I did not go through any [official training], but I used to live with elderly people from SUA (Sokoine University of Agriculture) in their plantation, as the worker I gained some knowledge for instance banana farming and mango. But I did not get any formal education, but only through observing others" (A-04)*

Some interviewees received more official training, for example from a development project (D-14), through participating in seminars held by the Agricultural Officer (B-11, B-23, C-31) or in primary school (A-06, A-15, B-08, C-21, D-05).

7.4.1.4 Labor and Health

Charcoal production is physically strenuous and hard, difficult work (A-04, A-06, A-10, A-13, A-15, B-11, B-19, C-21, C-39, D-05, D-14, D-18, D-25). As D-05 points out: *"It takes a bit time in this, as to cut down the tree with only axe is very cumbersome, so it may take up to 2 weeks"*. Production in this case study is carried out only by hand tools "*You need to have axe, sword, hoe and shovel, when you have them, you have already accomplished the mission"* (A-04). B-11 elaborates *"the equipment that I use, are usually an axe, bush*

knife and these are at the stage of cutting down the tree. When it is at a stage of covering the kiln, it is required a spade and a hoe". Some also use a rake or a tree branch that is shaped like a rake for unloading the kiln, to which B-21 adds: *"if you have it you can use it [rake] but the problem is you have to buy them"*.
With only rudimentary equipment and practically no safety gear used or precautions applied by the interviewees, charcoal production is also quite dangerous and many of them have suffered injuries: *"when using these working equipment, accidents are unavoidable"* (A-06). Many of them have sustained cuts from axes and bush knives while cutting trees (A-06, A-14, B-11, B-19, B-21, C-21, D-18, D-24), got crushed by logs during harvesting or kiln construction (A-10, A-13, B-08, B-19, B-21, C-21) or suffered burns during checking or unloading the kiln (A-13, B-21, C-39, D-18, D-25). Some of these injuries reduced producers' ability to work for a week or two (A-13, B-08, C-21), in other cases up to a month (A-06, A-15, B-19, B-21, D-18). D-24 notes that his injury with an axe impaired his ability to work for six months. Only B-23, C-30, C-31, D-05 and D-14 said, they have never endured any injuries except for maybe splinters and scratches.

The dust, smoke and heat producers are exposed to during production also dehydrate the body and affect the respiratory system (A-04, A-06, A-10, A-13, B-08, B-11, B-19, B-21, B-23, C-22, C-31, C-39, D-14, D-18, D-24, D-25).

> *"because, when the dust settles on your chest, you feel pain (he continues to elaborate pointing locations where he feels pain). I went to complain to the hospital on the pain and they told me that it is because of charcoal production and that we do not drink milk while producing charcoal. So we were told that the smoke and dust affect areas of the kidney" (B-11)*

Some further indicate they got Tuberculosis from charcoal production (C-39) and suffered from loss of appetite (D-24).

Safety precautions taken include wearing a piece of cloth as a mask during unloading of the kiln (B-23, C-31) and wearing shoes (A-13) or gumboots (D-18). As a preventative measure, most producers suggest it is important to drink milk against the effects of the dust, e.g. the resulting coughing (A-04, A-06, A-10, A-15, B-08, B-11, B-19, B-21, C-22, C-39, D-14, D-18).

> *"if you don't wear protective equipment, extreme heat may cause liver disease and affect lung too and we are also advised to wear a mask during charcoal unloading to protect ourselves from smoke since once I got coughing but due to difficult living condition we cannot afford to buy such equipment's. if you wear those equipment you will not get those problems" (C-31)*

> *"No, we do not take [precautions], how do we take safety measures while we have nothing to wear to protect our body" (D-05)*

D-18 takes pain-relieving medicine before starting with the production process. Additionally, periods of rest between production cycles were mentioned as a measure to reduce physical impacts (C-30, D-05, D-25) and to keep a "full mindset" during production, which reduce the likelihood of accidents (A-04).

> *"That's why I just do it for certain times only not throughout the year. I just produce for two to three months then I stop as you know charcoal production has no profit rather than diseases" (D-05)*

7.4.2 Social Capital

7.4.2.1 Social Ties

Especially producers in project villages mentioned, that they produce with three or four others, mainly relatives, who are old enough, or neighbors (A-10, B-19, C-22, C-30, C-31, C-39, D-14, D-25). They mostly cooperate with the same people because they know them well and they like their work ethics (C-22, C-30, C-31, D-18). C-21 works with eight people who are all family members, because other people are too unreliable and might not show up. D-14 and D-18 mainly work with people they know through the charcoal producers' association. Cooperation gives producers access to more labor and tools they might not own themselves, as illustrated by the following quotes:

> *"we help each other in cases where there is a tool you are lacking; the workload is heavy you need assistance or if you are stuck and need advice you go seek help from others" (D-14)*

> *"we usually cooperate in making the kilns. For example, today we can start with the kiln of this one then tomorrow we shift to another person" (D-18)*

> *"we used to rotate cooperating in each other's plots allocated in the forest block till we completed all plots" (C-22)*

C-31 and C-39, on the other hand, hire people to help:

> *"yes, we used to work together and we had a collaborative group but we decided to quit because you can help someone but turn up he is lazy to help you back so it's better to pay someone to help you rather than working as a team" (C-31)*

Those producers who mainly produce on their farms, and in non-project villages, tend to rather produce alone or only with one or two other persons (A-06, A-13, A-15, B-08, B-11, B-23, B-21, D-05). A-04 works mostly alone, but occasionally seeks help from various people. Since D-24 comparatively builds very few kilns per year, he also collaborates with only one other person. B-19 produces alone on-farm, and with three to five others when he does so in the village forest.

Apart from cooperation in regard to labor, most producers also share their knowledge and skills about charcoal production through their social connections. In his capacity as secretary of the charcoal producers' association, C-30 teaches others on which trees to cut and which not to. Only A-13 and A-15 say they do not exchange knowledge and skills with others; A-15 says it is because charcoal production is not his official job while A-13 mostly produces alone.

All interviewees from project villages C and D are in the charcoal producers' association, except for D-05. Being a member of the charcoal producers' association is a requirement for allocation in the block (C-31, D-18). Membership costs TZS 1'000 (D-18) or TZS 5'000 (C-31) per year. Some interviewees have special responsibilities within the association: C-30 is the secretary of the charcoal producers' association and C-22 is tasked with the supervision of packing and loading charcoal bags in village C. In non-project villages A and B, none of the interviewees are in a charcoal producers' association. B-08, B-11 and B-23 note that such an organization does not exist in their village, whereas A-04 just states that he remains mostly on his farm and produces very little charcoal and only rarely, hence he is not a member in any association, alike A-10, A-13, A-15, B-19, B-21 and B-23.

Farming cooperation works similarly to cooperation in charcoal production. Many interviewees help out or are helped out by two to four people, again mainly family members and neighbors. They help each other with physical labor (A-04, A-06, B-08, B-11, B-23, C-22, C-33, D-05, D-14, D-18) (e.g. weeding,

cultivation), seeds (A-04, A-06) and financial capital (A-06). Almost all interviewees exchange knowledge, skills, ideas and advice about farming with others, except for C-22. The exchange is mainly about what, how and when to plant, and on how to improve farming activities. D-25 is involved in a group for sharing farming skills: *"we have a tradition of visiting each other's farms to check the techniques people use and such people are about 6 of them that I can welcome them to my farm"*.

Apart from the charcoal producers' association, some interviewees are also part of other community or farming associations like a micro-credit association called VICOBA (B-11, C-22, D-18); A-06 is a member of a political party, B-11 is a member of MVIWATA and C-31 of Shamba, which are both farming associations, whereas C-39, D-14 and D-25 are involved in a more informal farmers network and exchange. C-22 is also a member of the participatory forest management network MJUMITA. D-18 is also a member of JUHUDI, which supports women in the community. B-08 is a member of the village soccer team. Overall, only 3 interviewees from non-project villages are involved in any associations and only one of them is in more than one (i.e. two) (B-11). In project villages, all interviewees except for D-05 are in at least one association and many of them are in two or more (C-22, C-30, C-31, C-39, D-14, D-18, D-25).

7.4.2.2 Shared Norms and Values

Interviewees' answers to whether they feel they have similar goals in life compared to other villagers are about half and half between yes (A-10, A-15, B-19, B-21, B-23, C-22, C-30, C-31, D-05) and no (A-04, A-06, A-13, B-08, B-11, C-21, D-14, D-18, D-24). Some say that since they live in the same place sharing the same environment and activities and thus facing the same problems, their goals are very similar (A-10, C-30, C-31, D-05). Others feel that the difference in income levels also leads to divergent goals and ambitions (A-13, B-08, B-11, D-14). In spite of having different goals in life, most interviewees feel supported by other villagers because they help each other with advice on farming (A-06, B-19, C-31, D-05, D-18) and with farming activities in general (A-04, B-23), they cooperate in development activities (B-08, B-21, D-14) and support each other in times of need or in case of emergency (A-10, B-11). Associations that one is a member of can also be an important source for support (C-22, C-31). Only a couple of interviewees do not feel supported by their fellow villagers (A-13, D-24).

7.5 Interaction with and between Government Agencies

Interaction between interviewees and the village government ranges from almost daily (B-19) to never (D-24). Almost all producers know at least one member of the village government (A-06, A-10, A-13, B-19, B-21, C-21, D-18, D-24), many are acquainted to two or three (A-04, A-15, B-08, B-11, C-22, C-30, D-05, D-25). A-06, B-11 and C-30 have family members on the village council. C-31 is a member of the VNRC himself and B-23, together with seven of his family members, is on the village council, which counts 25 people in total.

VG_A2 and VG_B2 say there have never been any village meetings specifically on charcoal. In village A, the number of producers has decreased due to restrictions from the government (VG_A1) and/or most villagers are apparently not interested in charcoal production, it is, in the view of VG_A2, mainly outsiders who come and destroy the forest in the process. This is also reflected in the topics of discussion with village council members mentioned by the interviewees. While charcoal is not explicitly referred to at all, environmental conservation is a topic (A-06, D-05). In regard to how the village government should support interviewees in the future, the main aspects mentioned are regarding development, agricultural production and forest protection. Only one person specifically noted that the village government should provide more support for charcoal producers through enabling a more conducive environment, i.e. better market conditions (A-15).

Interaction between producers and district officials or TFS is very rare. Many interviewees do not interact with the district government and have never heard of TFS (A-04, A-06, A-13, B-11, B-19, B-23, C-22, D-05, D-14, D-18, D-25) and thus they also do not feel supported by either of them. The only interviewee who declares having directly interacted with them is C-30, secretary of the charcoal producers' association:

> *"yes, they are from the central government and this project [TFCG] (wind blowing) (inaudible segment) and we interact with them because at first the central government didn't believe that charcoal production can improve the forest ?(not totally destroy the forest)?, charcoal production seem like it destroying the forest but it's called a sustainable charcoal production because it has got some properties like training people and they came here and inspect the area" (C-30)*

In regard to information dissemination, DG_1 and DG_2 claim that they communicate directly with charcoal producers:

> *"aah this is direct because one of my role is to make sure all citizens get the real explanation of the policies so when we receive those guides we stand for it to make sure citizens are aware of it" (DG_2)*

It is TFS together with the district's Office of Natural Resources who are responsible for informing charcoal producers about changes in regulations (e.g. tax increases) (DG_3). At least among the interviewed charcoal producers of the subsample, this sort of interaction between them and the district government is hardly reflected. Some producers feel that the district government and TFS could increase their assistance. As the following as well as the previous two quotes imply, TFS and the district government seem to have a misperception about charcoal production and how it is practiced, at least in project villages:

> *"first they should know that the one who are producing charcoal are from poor condition and they do that because of hardship so they should set a good price for the charcoal in order the producer could have the time to rest after selling his charcoal in a good price" (C-31)*

Others would generally like more support from the district government in regard to development, different livelihood activities, solving problems in the village (A-13, C-22) and land allocation (B-19, B-23). A couple of interviewees mention that they would contact the district, if the village council fails to take action against illegal charcoal production (C-31, D-05).

Village government members do not feel very much supported by the district government either, especially when it comes to dealing with land conflicts. VG_A2, VG-B1, VG_B2, VG_C1, VG_C2 and VG-D1 have sent various complaints to the district but neither received any assistance nor have they ever heard back. Mirroring what producers say about interaction with TFS, cooperation between village governments and TFS seems to be rather low.

Contrarily, DG_3 claims they visit the villages regularly and that all village governments have their phone number so that they can call in case an issue should arise. DG_1 states that they work together with the villages regarding forest management and planning. Their support to the villages also involves training on how to fill in forms for permit applications and follow-up on its implementation. They also instruct the village council and include them in the decision-making process, for example concerning the raise of taxes on charcoal previously mentioned by producers and members of village government. DG_2 also points out that they cooperate very closely with the villages through Executive Officers at the village and ward levels. In regard to charcoal specifically he states:

> *"forest officers are there, they monitor production also we have gates which track charcoal transport and lumber they check if the procedures has been followed [following procedures] (receipt), there are good monitoring" (DG_2)*

Then again, DG_1 admits that they have been working together much closer and more regularly with project villages than with non-project villages. A major reason for this is, that the project initiators themselves provided means of transportation and funding or enabled the respective villages to fund visits through increased revenue, whereas non-project villages are hard to get to and lack funding to compensate the visiting government officials. The factors impairing the district's ability to work efficiently and provide the support needed are the lack of funding and staff members for the Office of Natural Resources. These limitations are the result of both debts of the district council and forest issues not being a priority (DG_1, DG_3). According to VG_B1, this tendency also operates at the village level:

> *"due to different activities we have in the village I can say sometime we forget that we need to take care. We have responsibilities to take while the forest tree continue disappearing" (VG_B1)*

For this reason, he thinks a committee should be formed specifically for dealing with charcoal production (VG_B1).

According to VG_C2 and VG_D1, communication with the district had been easier and better when TFCG was still around to provide assistance. Now that the project phased out and the village forest was handed over to the village government, support from the district has become much more difficult:

> *"I recommend them to come back to give us back up because you find central government or District council they slightly restrict us. when we send our complain[t]s, because when you are in village, you have no power, when you send complain[t]s you need to have money to stand for it and the village money are in the bank, you can't get it is simple way. When you say wait, wait, this get worse." (VG_D1)*

Decreased support from TFCG has also been noticed by producers (C-30, D-05, D-18, D-24, D-25). Or as D-18 states: "*this whole year [2020] they have not come*". VG_C1 and VG_D2 indicate that the introduction of MJUMITA, TFCG's forest conservation network, will be supporting them with forest management and training. For this service, the village pays 7% of charcoal revenue in two installments per year (VG_C1, VG_C2). The percentages of revenue they have to pass on to MJUMITA (7%) and the district (10%), however, are seen as a hindrance to village development efforts such as improving the school infrastructure (VG_C2). Moreover, considering the statements above, support from the district government, at least to village C, has not (yet) improved despite these revenue payments.

Apparently, there was some friction between the district government and TFS about the TFCG-project and its expansion to include more villages. Since project villages have the mandate to govern their village forest themselves through CBFM, they are also the ones collecting the revenue from its products. The district government supports the project because they see CBFM as the best way to protect forests, since the local villagers know their village forest very well and no additional infrastructure or manpower (i.e. police) are needed (DG_1). TFS, however, depends on the same revenues from forest products. So when the district wanted to include more villages in the project, TFS was not pleased (DG_1). This situation poses a major challenge for the promotion of CBFM also under different projects.

In village A, some producers and villagers living close to the forest are secret informants about the state of the forest, and they report illegal production to the village government (VG_A1). VG_A2 says the cooperation with villagers reporting illegal activities in the forest is working well nowadays. He

attributes this collective effort of protecting the forest to education about its value, for instance regarding its role in bringing rainfall to the village. A similar system is in place for informing the district government about illegal activities (DG_1).

7.6 Academic Experts' Views

This subsection includes results from the five interviews with academic experts, whose research focuses on charcoal production and/or agroforestry in SSA. As illustrated by the statements from charcoal producers, experts have witnessed charcoal production as a supplementary activity for sourcing cash income whereas the main livelihood activity of smallholder producers is agriculture for subsistence food production. E_05 therefore argues that promoting agricultural productivity, which is generally low, is even more pertinent than improving charcoal production for the livelihood sustainability of charcoal producers.

7.6.1 On-Farm Tree Utilization

Charcoal production from on-farm trees has been observed by all experts, especially during land clearing. E_04 has witnessed some sustainable practices in Rwanda, where farmers use eucalyptus trees from their farms, which regenerate easily. In most cases, however, the permit structure for on-farm production is unclear or complicated. Moreover, charcoal produced on-farm competes with that produced off-farm, in spite of the latter possibly being less sustainable (E-04). E_03 and E_05 say that on-farm production is the only permitted source for non-project villages under current regulations and by-laws, whereas in project villages production is only allowed in the village blocks allocated according to the sustainable land use plan. Hence, the arrangements are opposite and under the current conditions, on-farm production is not a (legal) option in project villages.

7.6.2 Challenges and Opportunities for Utilizing On-Farm Trees for Charcoal Production

E_01, E_02, E_03 and E_04 agree that one challenge to planting trees specifically for charcoal in the study region is, that currently, scarcity is not (yet) perceived severely enough. The establishment period until trees have produced enough biomass to be utilized for charcoal production might also be too long (E_01). E_02 says that, while awareness about the benefits of agroforestry and its synergies with development and environmental goals is expanding, a generally increased presence of agroforestry in high level documents (i.e. policies) is needed to promote and upscale its implementation and derive benefits. As mentioned above, E_03 and E_05 point out the current by-laws in project villages, which do not allow charcoal production on-farm. Small landholdings were also mentioned as a potential inhibitor (E_01). Another major factor influencing the motivation to plant trees is the economic value and market of tree products (E_02). Generally, the academic experts suggest not to plant trees solely for charcoal production but integrate them in the generation of other products and services which increase agricultural productivity (E_02, E_04, E_05). They all agree that enhancing agricultural productivity is crucial to sustain the livelihoods of the rural population, including charcoal producers and that promoting agroforestry is one option to do so.

However, failings of past agroforestry projects should be carefully considered in order to avoid repeating them, e.g. exotic species that became invasive (E_04, E_05). E_04 has worked with a project promoting *Acacia* tree planting for charcoal production in the DRC, where seedlings are raised in a community nursery, of which participants take care in turns. Once the seedlings are established, each farmer gets a certain number to plant on her*his farm. Communal efforts lead to individual benefit, which is important to highlight in order to motivate farmers to plant trees. The project is tailored to local practices of shifting cultivation, whereby seedlings are integrated into the rotation and intercropped with local staple foods (E_04). E_02 suggests an agroforestry system of intercropping

Faidherbia albida, which can improve soil fertility, does not compete with crops due to deep roots and shedding its leaves during the cropping season, thereby providing enough light for the crops grown underneath. The pods can further be used as fodder for livestock. E_05 also sees a large potential of integrating chicken production for the rising regional market into an agroforestry project, which would again promote alternative income strategies. Indigenous nitrogen-fixing trees can help to improve soil fertility and provide feed for the chickens (E_05). The combination of different tree and shrub species is a core aspect for farmers, especially for those with small landholdings where high tree-density would lead to lower crop performance, whereas with wide spacing in-between, trees cannot produce sufficient leaf biomass to improve soil-fertility. Nitrogen-fixing shrubs could be a solution to this problem (E_02, E_05). Boundary tree planting was further mentioned as a feasible option in the case study region (E_02).

Utilizing residue from timber production, especially from planted woodlots, would be an alternative option. Thereby, planted trees, albeit not necessarily on-farm, could be an opportunity for more sustainable charcoal production as well. Cooperation with and close proximity to timber processing plants would also reduce the cost of accessing a large concentration of biomass (i.e. residue) which would otherwise be burnt without providing any further value (E_04).

7.6.3 Aspects of Human and Social Capital

Several aspects in regard to dimensions of human capital, mainly knowledge and skills, were mentioned by the academic experts. E_05 confirms that there are very few other income generating opportunities in the study area, mainly because people in these rural villages lack access to information about alternatives and how to pursue them efficiently. Information dissemination about the regulations on sustainable charcoal production, at least in village D, was found to work rather smoothly and producers seem to be well-informed (E_03). This is possibly connected to stricter implementation and enforcement in village D as compared to village C (E_05). In non-project villages, forest and charcoal governance is, as mentioned above (section 7.5), inhibited by the village government not having the mandate to enforce regulations but also by the limited knowledge of the village government of what the regulations actually are (E_05). At the district level, E_05 corroborates that forestry is not an issue of priority and therefore allocation of funding for and capacity to fulfill their mandate is very delimited.

Participatory training on improved kiln construction is necessary to improve their efficiency and relatively reduce the resource intensity of charcoal (E_04). In project villages, these efforts payed off: according to them charcoal producers are exclusively using the improved technique and appreciate the increased quantity generated. Training and capacity building would be an important aspect for any tree-planting project as well (e.g. like the *Acacia* tree project or the agroforestry-chicken system mentioned above). Education and training about management not only of the nursery but also about seed management including the collection and storing of seeds from indigenous wild and/or already domesticated trees is needed. This is particularly crucial for the self-sustainability and -sufficiency of such a project beyond the presence of the initiators (E_04, E_05).

In regard to social capital, the state and importance of local social capital was discussed. E_04 emphasizes the relevance of strong local institutions, like associations, for (a more) efficient governance of the charcoal sector, but also for the establishment and success of a tree planting project, like the *Acacia* project in the DRC. Building on existing institutions (social and others) and tailoring concepts, that might look good on paper, to local realities and practices is vital for such programs (E_04). According to E_05, the charcoal producers' association remains active in project villages; however, none of the associations have applied for a permit this year. E_03 also says that the introduction of the TFCG-project increased the entry-costs for participating in charcoal production in project villages by making it mandatory to be a member of the association and also get training on sustainable harvesting and production practices.

7.6.4 Government Agencies and Governance of Charcoal Production

The conflict of interest between the TFCG-project and TFS was also mentioned by E_03. This is a major limitation to the project, as upscaling would be needed to exploit the full potential of charcoal in improving sustainable forest management and development through increased village revenues (E_03). A related challenge, which upscaling could counteract, arises from sustainably produced charcoal competing with all the charcoal produced apart from sustainable production projects (E_03, E_04). This is also reflected in the higher prices producers from non-project villages obtain per bag of charcoal, compared to producers from project villages (section 7.1). The lack of government capacities to enforce charcoal regulations was likewise observed by several experts (E_03, E_04, E_05). In the experience of E_04, formal institutions and regulations look good on paper but have not proven successful in efficiently governing charcoal production. Strong informal institutions might be more successful in doing so. Optimally, the formalization of charcoal production governance should take existing informal institutions into careful consideration and build on those, to account for the realities on the ground. However, much effort and political will – starting at the national level – is needed (E_04). An additional challenge in governing charcoal production is that under the current division of authority between village governments and TFS over forest areas in non-project villages, the former have no authority to enforce regulations (e.g. arresting or charging illegal harvesters) but must contact TFS to do so (E_05).

In regard to charcoal trade, E_03 states that there is some level of governance, including the requirement of having a permit for transportation and the prohibition of transportation with two-wheel vehicles. Yet, for the production end of the value chain, there is no policy and generally no formalization of the charcoal sector (E_03), which is mimicked by the divergent knowledge about, awareness of and compliance with existing regulations among producers. In regard to permit regulations and prices, E_05 states that prices for permits have become unaffordable for producers in project villages so that nowadays, charcoal transporters or traders, sometimes from the same village, are the ones purchasing the permit. Thereafter, they hire producers as casual laborers, who end up earning even less, while the traders make large profits. More support from different levels of government, specifically for producers, is needed (E_05).

8 Discussion

8.1 Utilization of On-Farm Trees for Charcoal Production

The results show that current utilization of on-farm trees for charcoal production is not very deliberate, but rather that on-farm production happens mostly as a result of land clearing or because of other reasons why producers want to get rid of a tree. Environmentally speaking, this is a dangerous trend due to the permanent nature of this kind of deforestation, threatening the miombo woodlands and their benefits. Other producers decide to rather use off-farm resources while they are available or once land-clearing is accomplished, and on-farm tree availability has therefore seized. Only one interviewee states he has planted trees particularly for charcoal production. Some interviewees also say that even though they are currently still too small, they plan to utilize on-farm trees for charcoal production in the future.

While producers from non-project villages state that they are only allowed to produce from their farms, some producers from project villages say that on-farm production is prohibited, which is confirmed by village government representatives. Hence, under current laws and by-laws, producers from project villages are (technically) not allowed to utilize on-farm trees – even if they are clearing their land anyway. Nonetheless, producers from non-project villages illegally harvest in the village forest and those from project villages illegally produce on their farms. Changing current practices and therewith reducing pressure from deforestation – whether from land clearing for agricultural extension or charcoal production – on the miombo woodlands, is crucial to protect and ensure their environmental, economic and social benefits for all the livelihoods depending on them (Syampungani *et al.*, 2009).

The results show that charcoal production from on-farm trees is mainly practiced during land clearing, whereby trees are utilized for charcoal production as a by-product and to generate desired and otherwise foregone cash income. This connection between land clearing to extend farmland and charcoal production was also found by Doggart et al. (2020) in their study across Tanzania, suggesting that a substantial part of charcoal is sourced from on-farm trees during land clearing. In terms of environmental sustainability, both these trends of land clearing and off-farm charcoal production are threatening the environment. Land clearing for agricultural expansion of smallholder farms is the main driver for deforestation, followed by charcoal production (Doggart et al. 2020). In their study, Gmünder et al. (2014) compare different typical charcoal value chain scenarios for Tanzania, among them traditional production in the forest, improved production and production during land clearing for agriculture. Especially in terms of climate change and its mitigation, permanent conversion of land use from forest to agriculture through clear cutting is the worst case scenario as compared to charcoal production from the forest, which usually only leads to temporary deforestation (Gmünder *et al.*, 2014). This renders the current utilization of on-farm trees for charcoal production from land clearing a highly unsustainable practice, as trees are not left to regenerate in the four case study villages. Moreover, and as also suggested by Doggart et al. (2020), these findings underline the need to jointly address charcoal production and agriculture instead of proceeding with isolated approaches.

Charcoal production in the forest, in turn – even with selective tree cutting as in project villages – leads to forest degradation (Chidumayo and Gumbo, 2013). Forest degradation is already being witnessed by several interviewees from both project and non-project villages. For those who argue that forests are regenerating, evidence from other studies suggests that certain Tanzanian woodland species, such as the miombo in the research area, indeed have the capacity to regenerate through coppicing (Doggart et al. 2020). Others indicate that coppicing is only possible if stumps of about 1.5m height are left. In cases where forests were severely depleted and producers even resorted to digging up and utilizing these stumps, the potential for regeneration is considerably reduced (Chidumayo and Gumbo, 2013). In this study, this practice is applied by one individual on his farmland following land clearing. In project

villages, TFCG training includes harvesting techniques which allow for coppicing as mentioned by one interviewee in accordance with project guidelines (TTCS, 2017).

For those who are planning to use their on-farm trees in the future, training and regulations about coppicing and regeneration are needed. This knowledge and skill would be even more crucial for those charcoal producers who also harvest in the village forest of non-project villages, where according to interviewees, the forests are declining. For obvious reasons, tackling illegal production should be integrated into a more general formalization and institutionalization of forest management, whereby training and educating producers are pertinent aspects as further discussed in section 8.3.1. In general, regeneration – as in, the proportion of land which is allowed to regenerate – was found to be the most influential factor in preventing forest loss (Mwampamba, 2007).

8.2 Challenges and Opportunities for On-Farm Tree Planting

As shown in the results, all but two interviewees have planted trees on their farm before while 15 out of 20 are also interested in planting trees specifically for charcoal production. Hence, interest in planting trees among interviewees is generally high; if not for charcoal specifically, then for other trees and their products. A project focusing on on-farm tree planting may be well received, especially if it provides seedlings and training. In order to promote more sustainable sourcing of wood for charcoal production through on-farm trees, trees would need to be planted explicitly for charcoal production. However, a number of challenges and opportunities linked to planting and utilizing of on-farm trees for charcoal emerged.

Major challenges are land size and ownership, perceptions about negative tree-crop interaction, conflicts with pastoralists, trade-offs with other benefits and the current state of by-laws in project villages. Additionally, interviewees' challenges of utilizing and planting new trees, and the reasons mentioned as to why producers are not utilizing their on-farm trees (regulations, establishment period, other options available), are likely to influence farmers' interest in planting trees. These challenges would need to be addressed in a tree planting project. The same motives for already using on-farm trees and a focus on general challenges producers are facing in the pursuit of their livelihoods may be an incentive (e.g. proximity of trees, seasonal gap, lack of alternatives). Especially trees serving multiple purposes could potentially not only reduce pressure on forests but also diversify households' income strategies and reduce their dependency on charcoal production in the long run.

8.2.1 Challenges

One challenge for on-farm tree planting that emerged from the interviews is small land size, particularly when it comes to planting new trees. This issue was brought up by four out of 20 interviewees. The connection between land-poverty and ability to invest in tree-planting was also found by Jumbe and Angelsen (2011) in their study about the choice of fuelwood source. Land ownership is another critical aspect, as was also found by Faße and Grote (2013). Two interviewees are renting land, on which they are prohibited from planting trees. All others claim to be the owners to their land, however, only one interviewee said he has a certificate to document his ownership. Clarity over landownership is not only an individual, but also a village and district level issue, especially in villages A and B where unclear landownership is rooted in splitting from another village and the presence of large plantations. These circumstances can be a hindrance for farmers to invest in tree planting or for those who want to or need to acquire more land for this or other purposes, as village land resources are scarce and their ownership would be insecure.

As indicated by district government officials, unlawful land allocation through unauthorized members of (sub-)village government exacerbate this problem. Such practices may even be customary and

socially accepted, yet they profoundly impact patterns of access and benefit distribution (Ribot and Peluso, 2009). While formalization of land ownership as part of the process of land use planning, e.g. in project villages for CBFM, is a crucial component for tenure security, it also bears the risk of neglecting previously agreed land ownership under customary rule and may lead to uneven and unjust distribution of the project implementation costs (Mabele, 2019). This seems to be the case in village D where some farmers living in the forest, which became the forest reserve, were evicted or refuse to leave based on their agreement of land ownership with the previous village government. Assessment and protection of customary land rights, including consultation of and consent from stakeholders affected by land allocation to individuals, companies or for CBFM alike, are crucial in order to avoid (re)producing inequality: displacement should only be the very last resort solution (Dalupan *et al.*, 2015).

Conflicts between farmers and pastoralists, mainly over the latter's cattle invading the former's farmland and the resulting harvest loss, was only mentioned by a couple of producers in the subsample. However, it seems to be a general problem at the village and district level and was also found in other studies (Benjaminsen, Maganga and Abdallah, 2009; Saruni, Urassa and Kajembe, 2018). This could be a potential issue during the establishment of newly planted tree seedlings. Proper land use planning is one important way to help mitigate farmer-pastoralist conflicts (Saruni, Urassa and Kajembe, 2018). Involving pastoralists in planting ventures and the planting of tree species, which can provide them with fodder especially in the dry season, could possibly be a complementary way to counter these conflicts.

Some farmers' perception is that trees on-farm have a negative impact on crop production owing to competition. If widespread within the communities this belief could be a major challenge for tree planting or even be the cause for continued land clearing where it has not been completed already. Likewise, a large-scale agroforestry project in the lake region of Tanzania at first struggled for acceptance and adoption. It took a few years of increased collaboration and improved training to overcome this challenge as well as evidence of positive results from early adopters to convince late adopters (Johansson *et al.*, 2013). The time it takes for trees and their benefits to be fully established could further hinder farmers' motivation to plant trees. However, interviewees did not mention this as a reason for not planting trees and seem to be largely aware of the benefits the trees will bring them in the future.

Sustainable harvesting practices on-farm are another crucial aspect in order to preserve the benefits of on-farm trees. Aside from charcoal production and the income generated therewith, on-farm trees have a variety of other benefits to the interviewees ranging from direct to environmental, and other benefits. Interviewees seem to value trees and their benefits, as is demonstrated by how many are interested in planting or have already planted trees for specific uses. A few interviewees mention environmental benefits, such as improved soil fertility, attracting rain and providing fresh air. The aspect of trees and forests attracting precipitation was also mentioned by members of village governments from villages A and B. Scientifically, Xue and Shukla (1993) observed that changes in the surface cover, e.g. through deforestation, lead to lower surface roughness and higher reflection of solar radiation, which in turn leads to higher atmospheric stability and decreasing formation of convective storms that generate rain. The connection between watershed conditions and forest degradation has also been found in a study on the effects between unsustainable land-use practices, including charcoal production and agricultural practices, on water sources in Kilosa District by Mugasha and Katani (2016). Their study shows that unsustainable land use practices reduce both water quality and quantity. In addition, these practices lead to soil and forest degradation, loss of biodiversity and increased climate variability (Mugasha and Katani, 2016). Consequently, these environmental effects negatively impact people's livelihoods by decreasing income and thus increasing poverty, conflicts between different user and interest groups, disease and hunger (ibid). If protected and promoted, however, such environmental services of trees could contribute to livelihood resilience in the face of a changing climate (Charles, Munishi and Nzunda,

2013). Balancing on-farm charcoal production with the provision of other services derived from on-farm trees may not be an impossible but a challenging task. While the non-charcoal benefits may be a trade-off to utilizing the trees for charcoal production, as perceived by farmers, the use of these other benefits may not be a worse option, especially from an environmental perspective.

As shown in the results, the current state of the TFCG project in villages C and D poses several hindrances and challenges to the utilization of on-farm trees for charcoal production. In project villages C and D, producers must harvest only from the designated block within the village forest while producing charcoal on-farm is not allowed. In this case, current regulations and by-laws pose a restriction to on-farm tree utilization. New by-laws would be needed to enable tree planting efforts for on-farm charcoal production. Regulations and restriction on where harvesting is allowed or prohibited, however, do not seem clear to producers in any of the four villages. In each village, producers also harvest in prohibited areas, sometimes knowingly. Meanwhile, even some village government members do not know the regulations and by-laws correctly. For an agroforestry or tree planting project for charcoal production to succeed, these regulations would need to be unified, clarified and well communicated to producers.

Overall, the governance of village forests and the sustainability of harvesting practices in project villages seems to be working better than in non-project villages. Continuation of these governance and sustainable harvesting practices both in the forest and in general are key also in case of shifting sustainable production to the farm. However, the capacity to continue this "good governance" is threatening to decrease. Since the TFCG-project has ended, producers and village governments of project villages alike perceive much less – yet much needed – support in their efforts to keep up with the guidelines. Complicating the situation further, taxes on charcoal have been raised in an attempt to unify prices across the country. The consequence is, that these "additional" taxes are deducted from what buyers pay to the producer. As shown by the tax increase and its repercussions on market conditions in village D, especially for producers, regulations can also have adverse effects at the individual, but also at a village level. Comparable observations were made by Mutune et al. (2017), Schure et al. (2013) and Zulu (2010). Interestingly, these tax increases were not mentioned by producers or village government representatives from non-project villages, suggesting they are not enforced, which possibly explains the higher prices producers from non-project villages receive per bag of charcoal. The latter further suggests that the sustainably produced charcoal from project villages has to compete with possibly less sustainable and more informally produced charcoal, which has also been found by other studies (Robinson and Lokina, 2011; Cavanagh, Vedeld and Trædal, 2015; FAO, 2017, p. 83).

Under these worsened market conditions, it is questionable how motivated producers from project villages remain to follow a project's (or other) sustainable production guidelines. It also potentially weakens the self-sustainability of the project. A worst-case scenario would be what Hardin (1968) termed the "tragedy of the commons"; overexploitation of common pool resources, in this case the village forest, through individuals maximizing their self-interest whereas the costs of this exploitation are carried by the whole community. The most practical solution he sees is privatization. In other cases, however, privatization has led to severe degradation, whereas local social institutions have proven to be more successful (Pretty and Ward, 2001). The (re-)institutionalization of forests through CBFM in the TFCG-project may play a crucial role in avoiding such a tragedy. In comparison, project villages seem to have forest management under much better control than non-project villages, supporting the argument that institutions can indeed have a positive effect on the protection of forests, even without privatization (Yami, Vogl and Hauser, 2009).

To some extent, however, the efforts of sustainable forest management are defied by the boundary conflict between village D and a neighboring non-project village, from where producers encroach the

disputed forest area. This encroachment across the contested border in the forest impairs the governing power of local authorities. That unsustainable harvesting activities by external actors , in addition to the proximity of the forest to large urban centers, have the ability to impair the effectiveness of protecting a forest under CBFM has also been found by Treue et al. (2014).

Ineffective governance of charcoal production both in the forest and on-farm poses a general issue also in non-project villages. Statements of producers from non-project villages about the state of the forest indicate that overexploitation of the village forest is clearly happening, especially in village B. As in the case in village D, intrusion and environmentally damaging harvesting practices by outsiders contributing to the declining state of the forest was mentioned several times by interviewees from non-project villages. With the forest not being under CBFM and hence the village government having no authority to control the forest or protect it from outsiders, they are made dependent on the support from the district government and TFS. Meanwhile, TFS does have the authority but neither the financial nor the human resources to effectively support them, as admitted by the district government.

It was mentioned by both the district government and one expert, that TFS does not want more villages to become part of the project, since that would result in the creation of a village land forest reserve under the control of the VNRC and revenue collection for the forest products by village governments. Scholars alike have been questioning the willingness of governments, or in this case a government extension agency, to actually decentralize and transfer authority and governing power to the local communities (Ribot, Agrawal and Larson, 2006). In the establishment of other CBFM initiatives, disputes on revenue collection between district authorities and village governments as well as a high level of techno-bureaucratic measures required for the establishment of the village land forest reserve, management plans and by-laws were a major issue (Scheba and Mustalahti, 2015). The complexity surrounding the establishment of such plans and regulations requires not only time and financial resources but also know-how about the process, for which villages depend on the support from external experts. This is often provided through projects, NGOs, other donors (ibid) and governments at a higher level, inhibiting the villages' own capacity to take full control over their resources (Scheba and Mustalahti, 2015; Huggins, 2018). In this case, support to project villages came mainly from TFCG and has (naturally) substantially decreased since the phase-out of the project.

As indicated by the frequent mentioning of "*difficulty in life*" and the lack of alternative income generating activities being the main reasons for engaging in charcoal production, it is mainly a coping strategy and diversification by necessity or for survival, according to the classification of Shackleton et al. (2008, pp. 519–520). As stated in this definition, diversification out of necessity is the consequence of a lack of alternative income sources and can turn into a long-term income generating strategy (Shackleton *et al.*, 2008; Schure, 2012), which is the case for the 15 producers who plan to continue producing charcoal in the future. Diversification for survival, in turn, is fallen back on as a last resort and serves as a safety net with income from the diversification activity, in this case charcoal production, being very low (Shackleton *et al.*, 2008; Schure, 2012). The latter form of diversification is seen especially among producers who only produce charcoal when emergencies occur and immediate need of cash arises, and they therefore only produce very few bags, just as many as needed to cover the expenses (e.g. A-13, B-08). Resorting to charcoal production in response to lacking alternatives to charcoal production and, thus, the significance of promoting alternative income opportunities was also observed by Zorrilla-Miras et al. (2018) and Kiruki et al. (2019), especially for those with a high and/or increasing dependency on income from charcoal production. Hence, unless alternative income generating options are established and/or different production practices are introduced, charcoal production will continue with current practices. While this is a major challenge, insights on why producers decide to harvest from certain sources and for specific reasons also inhabits opportunities for considering and addressing these aspects form a different angle. One viable option to provide more and alternative diversification and income generating opportunities could be the promotion of agroforestry.

8.2.2 Opportunities

On-farm diversification through agroforestry has been found to increase livelihood resilience, particularly in the face of changing climatic conditions (Charles, Munishi and Nzunda, 2013; Quandt, Neufeldt and McCabe, 2019). Lusambo et al. (2007) also argue that, in order to reduce deforestation and degradation of the miombo woodlands in Kilosa district, people's economic opportunities and environmental conservation efforts should be addressed at the same time. These two issues could be jointly mitigated through agroforestry or on-farm tree planting, as was also among the suggestions by Beukering et al. (2007), to provide alternative income strategies. Promoting on-farm tree planting and thereby providing farmers with additional tree crops could reduce their dependency on charcoal production. This dependence could be further reduced by promoting trees with diversified benefits, like trees of which the stem can be used for timber and the branches for charcoal, as they hold the potential to improve on-farm production and at the same time diversify income opportunities. The combination of agroforestry and livestock in the form of chickens would potentially be an additional income and saving strategy as suggested by E_05. Some more concrete options are discussed in section 8.2.3.

Village government members and experts alike agree that an increase in agricultural productivity should be highly prioritized in order to improve the livelihoods of producers and rural households in general. Promoting agroforestry, and therewith increasing agricultural productivity in rural areas, would also be in line with the National Agroforestry Strategy (NASCO, 2010) and the agenda of the National Agricultural Policy (URT, 2013), aiming at poverty reduction through improved and intensified farming practices. The dependence on rainfall for their smallholder agriculture and the difficulties of increasingly unreliable rainfall patterns as well as pests were mentioned by many charcoal producers as a major challenge for food and crop production and are ultimately often the reason for producing charcoal. Low agricultural productivity, which is barely enough to sustain subsistence use, is inherent to smallholder production across East Africa. Especially in the face of a changing climate, more climate resilient agricultural practices alongside higher productivity are a key issue (Nyagumbo *et al.*, 2020).

In regard to insect pests affecting productivity, two moth species, namely Tomato Leaf Miner (*Tuta Absoluta*, locally called "*Kantangaze*") and Fall Armyworm (*Spodoptera fugiperda*) were mentioned. *"Kantangaze"* were mainly referred to concerning the reduction of maize yields in this study. Generally, they are more known to infest tomato plants, thereby reducing tomato yields in Tanzania by as much as 50% (Materu *et al.*, 2016). Farmers knowledge on how to control this pest has shown to be very low, often resulting in inadequate measures such as the application of inappropriate pesticides with adverse effects including killing non-targeted organisms, polluting water sources and increasing production costs. Therefore, education and training of farmers in regard to pest control is crucial (ibid). Fall Armyworms are a threat throughout Africa especially for maize production, the most important staple crop, but also for sorghum and a variety of other cultivated crops, with infestation rates of up to 100% (Sisay *et al.*, 2019). A field trial study in Tanzania found that intercropping maize with cowpeas for instance can improve parasitism of fall armyworms through biological pest control (Ngangambe and Mwatawala, 2020). Another study on farmers' knowledge and management of pest control for fall armyworms paints a similar picture of ineffective application of pesticides and an urgent need for sustainable and integrated management strategies (Makirita *et al.*, 2019). Information dissemination, education and training on sustainable practices are ultimately key also in regard to pest control.

Njenga et al. (2017) agree with E_01 who argues that planting trees is only attractive to farmers if there is severe scarcity of wood resources, but not as long as trees in the forest are still available and accessible. Although charcoal producers generally do notice a decline of the forest's state and its availability of

trees, severe scarcity does not seem to be perceived as a problem just yet. The fact that none of the interviewees have woodlots or otherwise established trees on their farm particularly for charcoal, possibly supports that hypothesis. The factor of no perceived scarcity has been found as relevant for the choice of woodfuel source by Jumbe and Angelsen (2011). In this study, however, most interviewees generally seem to be highly interested in tree planting, suggesting that scarcity alone does not explain the general motivation and interest of participants in tree planting. Jumbe and Agelsen (2011) further found that the proximity to the wood source further influences the choice of woodfuel source. While the distance to the forest was not mentioned explicitly, proximity of trees on their farm seems to be appreciated by producers in this study and could be a favorable attribute to motivate farmers for on-farm tree planting and utilization. Beyene and Koch (2013), on the other hand, found no evidence that increasing distance to the forest leads to intensified sourcing of woodfuel from private land in Ethiopia. Age of the household might have an influence, assuming that with longer ownership of land, older people have had more time to invest in tree planting on their land (Beyene and Koch, 2013).

8.2.3 Recommendations

While fuel switching to more modern energy sources should be promoted, it will take time. In the meantime, good governance and sustainable practices of woodfuels, including legal frameworks, policies and institutional arrangements are urgently needed (Schure *et al.*, 2019; Sola *et al.*, 2019). Gmünder et al. (2014) conclude that the establishment of land use plans, sustainable forest management and training in conservation agriculture are pertinent to reduce pressure on forests. In addition, Vyamana (2009) advocates for more coordinated and combined efforts of natural resource management in general and for taking a landscape approach instead of just looking at an isolated forest. One such option could be to combine CBFM with the promotion of conservation agriculture, like agroforestry. When compared to charcoal production during land clearing and uncontrolled production in the village forest, land use planning and CBFM indeed have the potential to improve forest conditions in the miombo (Blomley *et al.*, 2010). Moreover, CBFM could be combined with payments for ecosystem services (PES), whereby households' reduced forest use is compensated with individual material benefits (Ngoma *et al.*, 2020). Under UN-REDD+ this could include the promotion of conservation agriculture (e.g. agroforestry) as an agricultural intensification practice, which allows for mitigation of deforestation as opposed to agricultural extension, which has been identified as a major cause thereof (Mutabazi, 2014; Doggart, Morgan-Brown, *et al.*, 2020). Alternatively, Krishna et al. (2013) suggest payments for agrobiodiversity conservation services (PACS) and Ghazoul et al. (2009) advocate "landscape labelling". The latter could account for community efforts at the landscape level. Scaling up conservation efforts from individual farms to landscape levels is imperative to successfully address issues of complex, landscape-level systems such as biodiversity conservation (Tscharntke *et al.*, 2015).

Several options for alternative income generation activities and integrating charcoal production in agroforestry systems exist in the region, if sensitively introduced. Promoting the integration of on-farm trees and chickens could be a way to help charcoal producers on their rise out of poverty. Especially for the poor and very poor, chickens have been acknowledged to be a valuable asset in a study on climate smart agriculture in Mvomero district, a neighboring district to our study area (Vyamana *et al.*, 2015). According to Mlozi et al. (2003) and E_05, there is a large and unsaturated market for locally produced chickens in Kilosa and Morogoro Region. As Ellis and Mdoe (2003) found, the process of poverty reduction follows a sequence of accumulating and trading-up assets, for instance from chickens to goats, from goats to cattle and from cattle to land. Some producers already pursue this strategy and plan to or already did invest in chickens or goats as a saving strategy.

In regard to tree species, several would be ecologically and socially acceptable. Two species, which interviewees are interested in, that can and already serve for the production of both timber and charcoal are mtiki (*Tectona grandis*) and mlama mweupe (*Combretum mole*). The former has big branches that are

residual in timer production but are used for charcoal in the study area. Mlama can be used for timber and charcoal but also other purposes (Ruffo, Birnie and Tenganäs, 2002, p. 636). However, these species are what producers call "modern" trees and are not indigenous to the region. E_05 proposes indigenous multipurpose trees, such as *Albizia versicolor*, that can be used as fertilizer trees and also supply feed for livestock, such as chicken and ruminants, prior to reaching their maturity for timber production. For those practicing shifting cultivation, rotational woodlots with *Acacia* species could be another possible solution, as suggested by Kimaro, Isaac and Chamshama (2011). *Acacia* species include a number of fast-growing varieties, which produce very dense wood that would generate high quality charcoal. Additional benefits include their carbon sequestration potential comparable to native vegetation in the region (Kimaro, Isaac and Chamshama, 2011). *Acacia polyacantha* could either be included in rotational woodlots or serve as fertilizer trees in mixed intercropping. A field trial in Morogoro showed that as a fertilizer tree, *Acacia polyacantha* has the potential to increase maize yields threefold (NASCO, 2010). There are different projects and studies in other SSA countries on establishing *Acacia* woodlots specifically for charcoal production (Oduor, Ngugi and wa Gathui, 2012; Njenga *et al*., 2013).

Among the fastest-growing *Acacia* species is *Faidherbia albida*, a nitrogen fixing variety, which can be well integrated with maize production in agroforestry systems, as suggested by E_02 and a large body of literature (e.g. Sanchez, 1995; Barnes and Fagg, 2003; Garrity *et al*., 2010; Kegode *et al.*, 2017; Kuyah *et al.*, 2019). Its unique phenology reduces competition with crops, as it sheds its leaves at the beginning and regrows towards the end of the rainy season, thereby providing highly nutritious fodder during the dry season (Barnes and Fagg, 2003). *Faidherbia albida* also provides households with firewood and could be utilized for charcoal production of average quality. Additionally, *Faidherbia albida* is beneficial to beekeeping and serves for various uses in traditional medicine, among others for chest and respiratory ailments (ibid), from which many producers suffer. Moreover, it is a non-invasive and indigenous species throughout most SSA countries, including Tanzania (Barnes and Fagg, 2003; Kegode *et al*., 2017).

Agroforestry systems with *Faidherbia albida* could potentially and partially address the seasonal gap in agricultural production and income, which farmers currently cope with by producing charcoal. The connection between production seasonality and it being supplementary to agricultural activities was also found by Baumert et al. (2016) in Mozambique. Charcoal production is mainly practiced during the dry season and the quantity of charcoal made depends on how well agricultural production covers subsistence needs (Baumert *et al*., 2016). Hence, alternative income sources are foremost needed during the dry season. The fodder produced from *Faidherbia albida* during the dry season could be used by pastoralists on their own farms or sold to them by other farmers, reducing either group's dependence on charcoal money.

Generally, more research on the domestication of tree species and germplasm with specific traits and their suitability for the local environment might be needed (Leakey *et al*., 2005). In the case of tree species for charcoal production in the case study villages, important traits could include a high annual growth rate, high resistance to environmental factors and pests, low competitiveness with other cultivated crops, quality after pyrolysis, soil fertility amendments and other desirable by-products such as fruit or fodder.

For positive outcomes of a project to be sustained even after its phase out, ensuring strong local ownership of the project and well established local capacities are key (Khang and Moe, 2008). One concrete idea which could serve this purpose was brought up by expert E_03. He proposes that, as part of the project program, villages put together an exit strategy which includes budgeting a part of the revenue to finance continuous support from the initiators beyond the scope of the project itself. Another integral part – which is currently still lacking for the trial-based TFCG-project – would then be to create and instate coherent policies to support the continuity of the positive outcomes (Khang and Moe, 2008).

8.3 Influences of Human Capital and Social Capital

Overall, a number of challenges and opportunities connected to human and social capital have emerged concerning on-farm tree utilization. For human capital, especially knowledge or lack thereof can enable or inhibit more sustainable practices. Social capital among producers in the form of the charcoal producers' association has enabled the introduction and distribution of new technologies in project villages. However, the low capacity of the district government to support villages and producers and hence missing links across these different scales currently inhibit the wider success of the project.

8.3.1 Human Capital

In terms of human capital, various levels of knowledge about production in general, regulations and sustainability emerged. While knowledge about the environmental effects of charcoal production and ways to reduce them can be a good start to promote further sustainable agricultural and charcoal production practices, the limited or sometimes faulty knowledge regarding current laws and regulations are a hindrance to such ambitions.

8.3.1.1 Challenges

Both knowledge and misinformation about regulations on charcoal production among producers but also members of the village government seem to reflect the incoherent governance. While district government officials state that the information flow between them and producers in the villages is well established, diffuse statements by producers and some village government members suggest a different reality. One example is, that most producers produce from their farm but do not have a permit or even state they do not need one for on-farm production or since "it is not their official job". The actual regulation on this issue is, that charcoal production of any source and amount, even during land clearing, always requires a permit (URT, 2019).

Moreover, the majority of producers does not know how much they are allowed to produce or who has to pay taxes and to whom. This lack of knowledge about regulations could be a hindrance to sustainable practices of on-farm tree planting and utilization for charcoal production. When producers do not know the regulations, they can hardly be expected to follow them. Scheba and Mustalahti (2015) report similar findings on diffuse "knowledges" and misinformation among villagers in their study on CBFM in the Angai Villages Forest Reserves in Tanzania's Lindi region. Villagers and village government members including VNRC are unevenly informed about ownership of the forest reserve, responsibility for its protection and practices that are permitted or prohibited in the reserve. The diverse information levels also lead to misinterpretation and inadvertent practices (Scheba and Mustalahti, 2015). The authors attribute the insufficient information dissemination to workshops being held only with VNRC and village council members and mostly nothing being written down, hence sharing the information (if at all) happens by word of mouth. Additionally, the custom of compensating workshop participants for their time but not for passing on the information to fellow villagers, claiming that financial resources to do so are unavailable, created an uneven distribution of knowledge and information, rendering it exclusive to few well-positioned individuals (ibid). In the case of this study, the dissemination of information and knowledge about forest use and management seems to be hindered mainly by the villages' lack of financial resources to compensate district officials for their visits.

The insufficient clarity over policies and regulations governing the charcoal sector have likewise been identified as a major reason for the unregulated and informal nature of charcoal production (Neufeldt *et al.*, 2015). For producers to actually adhere to rules and regulations for more sustainable practices, the legal framework, including the permit structure, must be simplified and more easily applicable to the

daily realities of producers (E_04). Furthermore, current regulations and changes thereof must be clearly and comprehensively communicated to producers, village governments and any other stakeholder. As E_05 states, capacity building in that regard is necessary at all levels, from the individual to the district level. Mugo and Ong (2006) suggest that, after recognizing the significance of charcoal production as a fundamental first step, one specific, existing or newly established institution should be in charge of governing charcoal production as a formal and profitable sector. Similar suggestions were made by Schure et al. (2013) who found that charcoal production is mainly governed by informal institutions and customary laws in place of the largely unimplemented formal governance across the charcoal value chains of Central- and West-Africa. Building on the functioning local level institutions and customary systems, empowering and formalizing them (e.g. through CBFM) holds potential to improve governance that supports sustainable practices and livelihood outcomes (Schure *et al.*, 2013).

8.3.1.2 Opportunities

One option to reach individual producers and/or farmers with information directly and at no or low costs could be through mobile phones. Access to mobile phones has been found rather high in rural areas of Tanzania. A study in Kilosa district in 2012 assessed that 67% of participants had access to a mobile phone (Mtega, 2012), whereas more recent research in the Dodoma region found that 85% of participants had access to basic mobile phones and another 12% to smart phones (Weld *et al.*, 2018). Mobile phones can grant easy access to agricultural and other market information, e.g. regarding charcoal (Dewees *et al.*, 2010; Mtega, 2012; Weld *et al.*, 2018), the lack of which has been identified as keeping farmers' bargaining power and benefits lower than those of other stakeholders within the value chain (Magesa, Michael and Ko, 2014). Additionally, mobile phones have the potential to provide access to basic financial services and improve currently used savings strategies. Lotto (2018) found, that 83% of adults owning a mobile phone also possess a mobile money account. The study by Lotto, however, does not differentiate the utilization of such services between rural and urban areas, whereas Lawuo et al. (2013) found that application of mobile banking services and – again – knowledge thereof, was very low in rural Tanzania at the time of the study. Apart from knowledge about the existence and how to access such services, access to electricity for charging a mobile phone would have to be established, at least in villages A, B and D since they do not have electricity.

Most charcoal producers are aware that their own and/or others' production practices are damaging the environment. Many have noticed that trees in the forest are declining because of harvesting for charcoal production. These results resonate with findings from an earlier study on charcoal production in Tanzania (Beukering *et al.*, 2007). The negative effects of intruders and their unsustainable harvesting practices emerged as a problem for sustainable forest governance also in other projects (e.g. UN-REDD+) in Tanzania (Kessy *et al.*, 2016). Apart from tree harvesting in a draft manner, producers see a need for more protection. Some already think tree planting would be an important effort to minimize the impact of charcoal production on the forest. Producers' knowledge and awareness about the sustainability of current forest activities could provide fertile ground for promoting on-farm tree planting and utilization for charcoal production. Faße and Grote (2013) came to comparable conclusions in regard to agroforestry practices and woodfuel production in Tanzania. Environmental awareness is key to more sustainable agricultural and woodfuel extraction practices and their proper implementation (Faße and Grote, 2013). Hence, further education and training on these matters should be promoted.

Adding to the need of education and training but specifically in regard to on-farm tree planting, interviewees themselves mention that they would like or need training on how to do so. A study on the efficiency of farmer-to-farmer extension in Kilosa district found, that this form of disseminating knowledge, information and skills was a resource efficient means (Nakano *et al.*, 2018). Since the general mode of acquiring skills – whether for charcoal production or farming – seems to be through learning from others, this mode is suggested to be suitable for tree planting projects. Additionally, producers

from project villages widely adopting and sharing the techniques introduced by the project already show promising results to that intent. Moreover, regarding to introduction of tree planting initiatives for example, the learning curve increases the benefits, as adaption to and learning from new technologies improves their utility and benefits (Hafner *et al.*, 2020). The fact that most interviewees have received at least primary education, implying that the majority of them are literate, has been found to be sufficient and promising ground for promoting new agricultural technologies (Vyamana *et al.*, 2015).

Kiln efficiency is highly overestimated (50-100%), as several studies have determined that kiln efficiency of earth mound kilns vary between 8-11.1% at the lower end and 20-23% for high estimates (Mwampamba, 2007; Chidumayo and Gumbo, 2013; Hoffmann *et al.*, 2018) with considerable variation between regions (Schure *et al.*, 2019). Training and education on enhancing kiln efficiency, especially in non-project villages where unimproved kilns are still widely used, are major factors and hold at least some potential for reducing pressure on tree resources (Mwampamba, 2007). Besides linking improved production techniques to training and education, they must also be appropriate and acceptable within the local context in order for them to be adopted by producers (Beukering *et al.*, 2007; Schure *et al.*, 2019). Ultimately, together with agroforestry interventions for on-farm charcoal production, improved kiln efficiency has a great potential to significantly reduce pressure on forests and wood requirement for charcoal production in general (Iiyama *et al.*, 2014).

In regard to labor capability and physical health of producers, similar findings of high injury rates and no protective measures are reported for Liberia, where three quarter of the participants have suffered injuries from charcoal production (Alfaro and Jones, 2018). Training and education on how to implement protective and preventative measures should be adequately addressed in workshops and projects. Better yet, alternative, less physically demanding and damaging income opportunities would further improve producers' human capital. At the household level, money earned from charcoal is largely spent on food among other basic necessities. Hence, charcoal does not only improve the food security of consumers by providing an energy source for cooking (Hoffmann *et al.*, 2017), but also the one of producers' households, by allowing them to supplement subsistence food production. The same holds true for the consumption of fruit from on-farm trees as well as income from selling these and other tree products, when the money is reinvested in buying supplementary food, which was mentioned by several interviewees. Buying supplementary food different from one's own production can further lead to a more diversified diet, supporting the immune system as a health benefit (Franzo *et al.*, 2013). Additionally, charcoal money is spent on other health related aspects including medicine, hygiene products and hospital visits, as well as on the education of the children by enabling them to pay for school uniforms, supplies and fees. Hence, income from charcoal production provides an important source of investment in the human capital and capabilities of household members, thereby possibly enabling livelihoods less dependent on charcoal production for the next generation.

8.3.2 Social Capital

The current state of social capital among producers provides promising ground for the promotion of new agricultural and charcoal production techniques. Social capital formation in the form of a charcoal producers' association shows promising results in the sense that many of the producers in the project villages state that they share their knowledge and still cooperate with other members from the association. Together with reciprocal labor sharing, the sharing of information and knowledge indicates high value for this form of social capital to the involved charcoal producers (Coleman, 1988). Meanwhile, it also holds great potential for necessary expansion regarding linking social capital to higher levels of government, which currently remains largely absent.

8.3.2.1 Challenges

The maturity of these forms of social capital influences their self-sustainability and longevity (Pretty and Ward, 2001). The association was initiated by an external agency (TFCG), likewise are norms and rules mostly externally imposed through the creation of a project. The fact that neither association in villages C or D nor individuals have applied for permits this year already indicates reduced participation. Members as well as village government officials have mentioned the diminished support from TFCG and are hoping for the organization to return for further support. Based on these aspects, the statements about the charcoal producers' association and the maturity classification by Pretty and Ward (2001, p. 218), this particular association is still mostly in the reactive-dependence stage, endangered of breaking down easily. Yet, the fact that the association still exists and that members acknowledge the benefit of mutual support and the project in general – at least for the state of the forest – also harbors hope that the association has the potential to evolve to the second stage: realization-independence (Pretty and Ward, 2001).

Scarce or uneven connections between villagers, village governments and the district poses another challenge for villages and villagers to access these resources for support, especially information and technical support, to successfully govern their forests and charcoal production. District Natural Resource Officers visit non-project villages much less frequently than project villages. Project villages, which already receive benefits through the project itself, also seem to have obtained more support from the district government. This affects forest management, land use and land conflicts as well as village governments' and individuals' capabilities to deal with these issues. While the district technically offers an open ear at the "special table" once a month at the district commissioner's office, many villagers might not have the time, means of transportation or financial resources to attend, especially the further away they live from Kilosa. Notwithstanding, the district government officials themselves state that they have trouble reaching the non-project villages due to lack of funding and means of transportation. As portrayed in the statements from district government officials, their ability to directly, efficiently and effectively support the villages is constrained by a lack of funding and human resources. As blatantly put by one of the district government members, forest issues are not a priority. The lack of capacity of government and enforcement agencies has also been noted by several other studies and reports on charcoal production and its effects on the forest (Chidumayo and Gumbo, 2013; Neufeldt *et al.*, 2015; FAO, 2017, pp. 108–110; Zorrilla-Miras *et al.*, 2018; Sola *et al.*, 2019).

Another issue in the context of the case study villages is the risk of elite-capture of benefits and the reinforcement of existing inequalities and exclusionary power-structures through the establishment of CBFM. This is the case at least in village D, where some villagers residing in the area that is now demarcated as the village forest reserve refuse to follow the eviction notice, indicating that their stance was not taken into consideration during the establishment of the village land use plan. Similar circumstances have been reported also from other areas in Tanzania, where the focus of the government, NGOs and other donors was not primarily to create a participatory land use planning process but it being just a steppingstone in the wider project. Hence, the focus of sustainable forest management led to the involvement of only a few well positioned villagers, neglecting the participation and needs of less powerful stakeholders (Huggins, 2018). Elite capture of benefits and failure to include the poor and poorest in CBFM has also been found to be a risk by Vyamana (2009). Therefore, participatory involvement of all stakeholder groups throughout the establishment of CBFM is crucial. Nepotism is another prevalent challenge identified in the governance of forest products in Tanzania (Milledge, Gelvas and Ahrends, 2007). To what extent this issue prevails in the case study villages, especially in village B, would require further investigation.

8.3.2.2 Opportunities

Nonetheless, associations and other forms of social capital, including formal and informal institutions as well as collaborative action potentially render natural resource management more efficient and, as a result, increase benefits from these resources for members (Leach, Mearns and Scoones, 1999; Fulkerson and Thompson, 2008). The charcoal producers' association as one formal institution involved in the governance of the village's natural resources, namely access to and sustainable harvesting activities in the forest, has proven to be quite successful and efficient, notwithstanding invaders from other villages. Thus, the association and the TFCG project in general influence not just individual harvesting behavior but also enable and reshape communal action towards more sustainable forest management (Putnam, 1993).

The wide adoption and continued practice of new production technologies introduced by TFCG within the producers' association indicates that other technologies (e.g. tree planting) could also be established in similar ways. Spillover effects and learning from others could facilitate widespread adoption with in the community (Foster and Rosenzweig, 1995; Fitzsimons, 1999). Generally, members from project villages seem to be better connected to associations and their resources, whether for charcoal production, financing or other community groups, indicating established bonding of social capital (Hunt, Durham and Menke, 2015).

Most producers from project villages are in the charcoal producers' association, whereas such an organization does not exist in non-project villages. Furthermore, charcoal producers in project villages cooperate with more people in production and also tend to produce higher quantities than producers from non-project villages. Similar findings are reported by Zorrilla-Miras et al. (2018) for Mozambique, where a higher production quantity was observed for those participating in forest associations. Opposingly, those who mainly produce on-farm rather work alone or with fewer people and produce smaller quantities. When promoting on-farm production by the establishment of associations, careful attention has to be given to limiting the amount that is permitted to be produced, even on-farm. As suggested by E_05, this maximum amount should be calculated based on present tree volume. Handberg and Angelsen (2015) found that compared to PES, CBFM is more efficient in influencing forest use, especially concerning pro-social use motivated by moral and non-monetary values. Hence, if associations were tied to CBFM, this could positively affect (i.e. reduce) harvesting rates, calling for the establishment of CBFM as well as a charcoal producers' association also in non-project villages.

In regard to improving agricultural production, social capital plays an important role as well. Pretty highlights that experience from agricultural development efforts can contribute to long-term success "if people at the grassroots are well organized or are encouraged to form groups, and when their knowledge is sought and utilized in planning and implementation. Thus the human and social organizational dimensions of development have crucial implications for long term benefits" (Pretty, 2002, p. 51). The formation of new institutions and building on existing strong ones would likewise be necessary for the success of an agroforestry tree-planting project with a community nursery (E_04) as in the "Governing Multifunctional Landscapes"-Project by CIFOR (2020) in the DRC. In this project, the nursery is a collective effort out of which each participant receives her*his own seedlings to include in the crop rotation. The incorporation of seedlings in the rotation accommodates traditional farming practices and reduces competition between trees and crops (E_04) – an often-mentioned challenge for tree planting (Wiskerke *et al.*, 2010), which could therewith be avoided. Moreover, producers are organized in associations to facilitate the dissemination of information and techniques (CIFOR, 2020).

While bonding social capital is apparent, especially in project-villages, bridging and linking social capital seems to be largely absent. The lack of linking social capital is mirrored in the scarce connections and interactions across different scales of governance (Bebbington, 1999; Hunt, Durham and Menke,

2015), i.e. between both charcoal producers and village governments with the district government. This lack of linking social capital seems to be an important factor for the village government and the villagers' knowledge about current regulations and their implementation. Bridging social capital through connecting charcoal producers' associations from different villages could further increase producers' bargaining power and knowledge sharing. Moreover, this form of bridging could reduce the asymmetry of power and resource distribution between producers (or farmers) and government officials (Agrawal and Gibson, 1999).

For the successful implementation of an agroforestry project, cooperation across multiple levels of governance and various stakeholders has been found to be a crucial factor in such a project in northern Tanzania, as such links and bonds enabled the consideration of opportunities and challenges and proactive avoidance of conflicts and/or their socially robust resolution (Johansen et al 2013). Establishing such new "social infrastructure" would enable better information flow and encourage trust among stakeholders (Pretty, Toulmin and Williams, 2011). As Agrawal and Gibson (1999, p. 639) put it: "For community actors to possess some leverage in their dealings with state officials, it would be imperative that they organize themselves into larger collectives or federations that can span the gap between the local and the national". In conclusion, bridging and linking social capital would be all the more important for more efficient information and knowledge sharing and generally improving the support from the district government.

9 Conclusion

As in many SSA countries and other regions of Tanzania, in the case study villages examined in this thesis, charcoal production is a vital source of income to supplement subsistence farming and generate cash to pay for basic necessities and cope with hardship. Especially in non-project villages, the effects of charcoal production on the forests are becoming evident and changes are required to counterbalance these effects without threatening the livelihoods of producers and their households. The main objective is not to promote charcoal production in general, but to steer current practices onto a sustainable path as charcoal will remain an important energy source for decades and its environmental impact must be diminished. Additionally, creating alternative income generating opportunities could reduce pressure on forests and provide sustainable livelihood diversification strategies independent of charcoal production in the long term. In the case study villages, current practices of on-farm charcoal production are highly unsustainable as they are a by-product of permanent land clearing for agriculture. For sustainable on-farm charcoal production practices, on-farm trees would need to be (re)planted and in sufficient numbers. In the long run, however, with the assumption that eventually, the fuel switch to modern fuels will occur, farmers' dependence on charcoal has to be reduced and alternative income generating opportunities and economic activities must be available for them to sustain both their livelihoods and the environment.

Agroforestry, with its manyfold benefits in the form of products for own consumption and/or sale, and its ecosystem services including erosion control, increased soil fertility, among others, holds the opportunity to address current and future issues beyond charcoal production. Opposing these benefits, the implementation and promotion of agroforestry systems poses its challenges, mainly concerning issues of land size, land ownership and tenure security, which are amplified by land conflicts in general. In terms of human capital, charcoal producers' knowledge and awareness of the environmental impact of charcoal production could provide fertile ground for the introduction and promotion of more sustainable harvesting and production practices. Training and education in such topics has shown promising results for improved practices in project villages. The lack of knowledge about regulations on the other hand is currently limiting compliance and hence, effective governance of charcoal production. Interaction between producers, mostly by helping each other in terms of labor or by sharing skills and knowledge, is widespread, especially in project villages through the establishment of the charcoal producers' association. The same can be observed for farming activities in both project and non-project villages. Hence, strong bonding of social capital is evident. Contrastingly, the bridging of social capital among charcoal producers and in general beyond the village is not prevalent, yet should be encouraged in order to enhance the information flow and hence the bargaining power of producers. Moreover, linking between the district government and individuals is mostly inexistent, while with village governments these links have proven highly insufficient, mainly due to capacity shortfalls. In order to promote and scale up efforts for more sustainable practices, enhancement of bridging and especially linking social capital up to the district level would be crucial.

Additionally, aspects of longevity and self-sustainability of such projects need to be well thought through, in order to avoid the seizing of sustainable development programs and projects after their phase-out. Transferring power explicitly to the local communities through CBNRM as well as building on, utilizing and expanding existing human and social capital are key aspects for long-term success. Capacity building through training and revenue mechanisms alongside the promotion of existing or new local social structures and institutions in order to eventually run things independently from outside support, is crucial for the lasting sustainability of an initiative to plant on-farm trees for charcoal production and other purposes. Enhancing human capital through training on tree planting, nursing and managing would cater to the same goal. In conclusion, more sustainable practices including planting on-farm trees for charcoal production and/or establishing CBFM are possible, yet they require

careful consideration of and substantial investments in existing human and social capital of both the producers and the community as a whole.

Given the circumstances, the methods applied in this thesis provided information-rich data for an in-depth analysis to answer the research questions. The survey interviews allowed insight into producers' daily realities of charcoal production, their struggles and perceptions, their knowledge of charcoal production and their interactions with others in a wider context. The interviews with members of village and district governments enabled a comparison of the different realities between the formal governing agencies and those most affected by their governance. Together with the existing literature on the topics discussed, the expert interviews helped to frame the results within the wider context. Additional research and methods may provide further insights. Focus group discussions and more in-depth interviews may be useful to specify the needs, wishes, expectations, attitudes, etc. towards a tree-planting project in order to tailor such an initiative to this specific local context. Sampling and general research targeting gender issues specifically could further reveal important aspects in order to address and reduce existing inequalities. Since this was not a major focus of this thesis and hence the sampling strategy, such issues did not emerge from the data and would require further investigation. Network analysis could moreover help to identify the state of existing networks on which a tree planting initiative could build and provide for efficient sharing of knowledge and information. Finally, ground surveys and analysis of remote sensing data could help to determine the actual state of the forest and the degree of improvement or deterioration over the project lifetime and in the future.

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11 Annex

A. Variables, Indicators and Questions

Variables and indicators derived from the research questions (RQ) and the interview questions formulated based on these variables and indicators (Source: own representation).

		Variables	Indicator	Questions
RQ 1: On-farm tree utilization		Availability of on farm trees Utilization Trade offs	Specific purposes/ benefits of on-farm trees On-farm charcoal production	How many trees do you have on your farm? What benefits do you derive from the trees on your farm? Do you sell the products from the trees on your farm? What do you use the money for? Do you produce charcoal with the trees on your farm? Do you use harvest residue from your farm? If yes, which and why? If no, why not?
RQ 2: Possible Opportunities & Challenges		Agroforestry, perception of trees	Tree management Interest in tree planting	How do you manage the trees on your farm (pruning, weeding, harvesting, etc.)? Would you consider planting trees on your farm for charcoal production? Why yes/no?
		Access to land, tenure security	Land size Land ownership	What is the size of your farm? Have you planted trees on your farm? why yes/no? Do you consider replanting trees in the forest/ on your farm that you harvested? Why yes/no?
			Knowledge about tenure rights system	Who owns the land that you farm? Is there a formal contract? Is tenure limited for a certain period or practice?
RQ 3: Human Capital and Social Capital	Human Capital	Human Capital in charcoal production	Knowledge, skills and experience about charcoal production	How did you learn how to produce charcoal? Has your production technique changed over the years? How? Have you taught other family members or people? What is the most common practice for wood sourcing (where, what, how, how much)? Do you use the same practice or a different one? Why?
			Knowledge about tree species for production of quality charcoal	How do you decide where to harvest the wood? How do you decide which trees (species, location) to fell? Are there enough trees of those species nearby? Would the trees on your farm produce good quality charcoal?
			Knowledge about environmental impact, perception about scarcity	How do you think your practice impacts the environment? Do you think the forest provides enough resources for everyone (charcoal and other)? Do you think, the forest can regenerate enough? Would you say the forest has increased, decreased or stayed the same over the last few years?/ Do you think the forest has changed in the last few years? And if yes, how? What do you think you could do about it?
			Labor for charcoal production	When do you produce charcoal (year around, seasonally, occasionally) and why? How much time does charcoal production take up?
		Human Capital in farming	Labor for farming	How much of your work time do you need for farming?
			Farming skills and knowledge	How did you acquire your farming skills and knowledge? How long have you been a farmer? Have you ever received any training? Are there training programs?

		Access to the forest	Knowledge about social hierarchies	How is forest access regulated? Who gets access? Are there people who don't have access? What do you think about these access regulations?
	Social Capital	Social capital in charcoal production	Ties to other individual charcoal producers Membership in associations	Who do you talk to or share your knowledge about charcoal production? Is there a charcoal association or union that you know of? Are you a member and why? Do you work together with other producers during charcoal production? With whom? Why with these persons?
			Social bonds, shared norms and values, pressures that influence harvest decision	Where do others source wood? What do you think about that? Do you know anyone who produce charcoal in a different way? What do you think about that practice? Who uses forest resources and for what? What do you think of these uses?
		Social capital in farming	Ties to other individual farmers Membership in associations	Which other farmers in the village do you talk to about farming? What other topics do you discuss? Are you in a framers' association (why/not)? If yes, how often do you meet? Do you cooperate with other farmers in farming activities? With whom? Why these persons? What do you discuss with other farmers/ in the association?
		Social Capital with other villagers in general	Social bonds, shared norms and values	Do you discuss the state of the forest with others? With whom? Are you in any community organizations (other than charcoal or farming)?
		Power dynamics, access	Links/ bonds to person/ committee in the village government Inclusion/ exclusion	Who do you know from the village council? How well do you know them? Who has the power to allocates land in the village? Who do you go to with land disputes? Who decides over access to the community forest? Does everyone have the same rights to access the forest?

B. Survey Questionnaire for Charcoal Producers (after pre-testing)

1. Personal data, background and setting

<table>
<tr><td colspan="2">1.1 Charcoal producer name:

_____</td><td>1.2 Gender:

Male / Female</td><td>1.3 Education level:
o Primary education
o Secondary education
o Vocational training
o College education
o University education
o No formal education</td></tr>
<tr><td colspan="2">1.4 Household size:

1 / 2 / 3 / 4 / 5 / 6 / 7 / 8 / 9 / 10 / 11</td><td>1.5 Do you need a permit for charcoal production?</td><td>1.6 If 1.5 = yes; Are you in possession of a charcoal production permit?

Yes / No</td></tr>
<tr><td>1.7 How did you become a charcoal producer?</td><td>1.8 What is the reason you became a charcoal producer?</td><td>1.9 Are you satisfied with your work as a charcoal producer? (Why?/Why not?)</td><td>1.10 Would you like to remain a charcoal producer in the future? (Why?/Why not?)</td></tr>
<tr><td colspan="2">1.11 Do you produce charcoal from trees in the village forest? (Why these trees?)

Yes / No</td><td>1.12 How many trees do you have on your farm?

a)Number of planted trees____

b)Number of naturally growing trees___</td><td>1.13 Do you produce charcoal full-time or part-time?

o Full-time
o Part-time</td></tr>
</table>

2. Farming

<table>
<tr><td>2.1 If 1.10 = farming; Who owns the land that you farm?

o Yourself
o A family member
o Village government
o National government
o Company
o Other: _____</td><td>2.2 What is the approximate size of the land that you farm?

_____</td><td colspan="2">2.3 Do you have a formal certificate of ownership or tenure for your land?

Yes / No</td></tr>
<tr><td>2.4 a. Is your tenure or ownership certificate limited for a certain period?

Yes / No
2.4 b. Is your tenure or ownership certificate limited for a certain practice?

Yes / No</td><td>2.5 How long have you been a farmer?

_____ years</td><td colspan="2">2.6 How did you acquire your farming skills?</td></tr>
<tr><td>2.7 Did you receive any training in agriculture?

Yes / No</td><td>2.8 If 2.7 = Yes; What training in agriculture did you receive and by whom? (Indicate whom below)

_____

_____</td><td>2.9 Do you share your knowledge about agriculture with others?

Yes / No</td><td>2.10 If 2.9 = yes; What knowledge about agriculture do you share with others?</td></tr>
</table>

2.11 *If 2.9 = Yes*; With whom do you share your knowledge about agriculture? o Family o Friends o Other farmers o Village council o Others: _____	2.12 Has the way you farm your land changed over the past 5 years? (In what way?; yield, crops, climate, pests, diseases) Yes / No	2.13 How many of your family members help you farm? _____ members
2.14 How much time do you devote to farming? a. hours per day____ b. days per week_____	2.15 Which months of the year do you devote to farming? _____ _____	2.16 Do you have enough time to produce charcoal and farm at the same time? Yes / No
2.17 Would you consider to plant trees specifically for charcoal production on your farm land? Yes / No	2.18 Under what circumstances would you consider planting trees for charcoal production on your farm land?	2.19 Which trees would you be interested in planting on your farm land for charcoal production? (Why these trees?)

3. Agroforestry (if 1.12 = Yes)

3.1 What do the trees on your farm provide you? o Fruit, o Shade o Firewood, o Charcoal o Medicine o Other: _____	3.2 Do you produce charcoal from trees on the land on which you practice agriculture? (Why / Why not?) Yes / No	3.3 Do you sell products derived from the trees on your farm? (Why? / Why not?)
3.4 *If 3.3 = Yes*; What do you invest the money in that you obtain by selling the products derived from the trees on your farm?	3.5 Do you trade the products derived from the trees on your farm with your neighbors? (Why? / Why not?) Yes / No	3.6 How do you manage the trees on your farm? (Pruning, harvesting etc.)
3.7 What part of the tree do you harvest on your farm (logs, branches e.t.c)?	3.8 a. Do you plant new trees on your farm? Yes / No b. If yes, which kind and why?? If not, why not?	3.9 How many of your family members produce charcoal from the trees on your land? _____ members
3.10 Do other people than your family produce charcoal from the trees on your land? Yes / No	3.11 Do you hire people to produce charcoal for you from the trees on your land? (Why? / Why not?) Yes / No	3.12 *If 3.11 = Yes*; How many people do you hire per year to produce charcoal for you from the trees on your land? _____ people

4. Data on charcoal production

4.1 How many years of experience in charcoal production do you have? _____ years	4.2 a. How do you decide, when to produce charcoal(wood availability, need for cash, off-season etc.)? b. How do you decide quantity of charcoal to be produced?(wood availability, need for cash, off-season etc.)	4.3 How many charcoal kilns do you make per month? _____ kilns
4.4 How many kilns do you make per year? _____ kilns	4.5 How many months of the year do you produce charcoal? (Which months?) _____ months	4.6 How big is the charcoal kiln you usually build? (Ask for ranges) _____ length _____ width _____ height
4.7 How much time does the process of charcoal production from cutting trees to collecting charcoal take? _____ days	4.8 With how many people do you make a kiln? _____ people	4.9 What equipment do you use when producing charcoal?

5. Sales and income

5.1 Do you know what share of the wood you put into a kiln comes out as charcoal that can be sold? Yes/ No If yes; What share? _____	5.2 How many bags of charcoal do you produce per kiln? _____ bags	5.3 How much money do you make per bag of charcoal? _____ TZS
5.4 What is the net amount of money you make per bag of charcoal? (considering sharing the revenue) _____ TZS	5.5 Who do you sell the finished charcoal to? o Transporter o Middle man o Wholesaler o Directly to customers o Other: _____	5.6 How do you know the person you are selling charcoal to?
5.7 Which other activities are you involved in besides charcoal production? - Farming - Livestock keeping - Business - Others: _____ _____	5.8 How much income do you make from other activities per year? _____ TZS	5.9 What do you use your income money for? o Food and housing o Clothing and furniture o Agricultural inputs o School fees o Health care o Others: _____ _____

_____		
5.10 How much taxes do you pay per bag? _____ TZS Give explanation, if you are not paying any tax _____	5.11 How much does a charcoal production permit cost you? _____ TZS	5.12 Are you able to save money from the income you derive? Yes / No
5.13 *If 5.12 = Yes*; On average, how much money do you save per year? _____ TZS	5.14 *If 5.12 = Yes*; What do you use this money for? o Food and housing o Agricultural inputs o School fees o Health care o Others: _____	

6. Health

6.1 Does charcoal production pose a risk for your respiratory health (How?) Yes / No	6.2 Does charcoal production pose a risk for your physical health? (How?) Yes / No	6.3 a. Do you take any safety precautions? (Why? / Why not?) Yes / No b. If Yes; which precautions?
6.4 a. Have you had any injuries from charcoal production? Yes / No b. If Yes; which kind of injuries?	6.5 *If 6.4 = Yes*; Can you tell us how you obtained this injury?	6.6 *If 6.4 = Yes*; How long did your injury reduce your ability to work? _____
6.7 Have you had any injuries from farming? Yes / No b. If Yes; which kind of injuries?	6.8 *If 6.7 = Yes*; Can you tell us how you obtained this injury?	6.9 if 6.7 = Yes; How long did your injury reduce your ability to work? _____
6.10 Do you know of other producers who have been injured during charcoal production? Yes / No	6.11 *If 6.10 = Yes*; How did other charcoal producers get injured during charcoal production?	

7. Techniques and knowledge

7.1 How did you acquire your charcoal production skills?	7.2 Where do you harvest wood for the charcoal you produce?	7.3 How do you decide where to harvest the wood from?

7.3 a. how to decide which part of the tree to harvest for charcoal production(trunk, branches etc)? b. How do you decide which tree species to harvest for charcoal production?

7.4 Do other charcoal producers use different sources of wood for charcoal production? (Yes / No b. If Yes; which different sources of wood? c. If No; why not?	7.5 Did you change your technique to improve the efficiency of charcoal production? Yes / No a. If Yes; How? b. If No; why not?	7.7 Do you consider any techniques to improve the quality of your charcoal? Yes / No b. If Yes; which and why?
7.7 Do other producers in the village use a different technique? (Why / Why not?) Yes / No	7.8 What do you think about the techniques that other producers use?	7.9 Does the village forest contain trees that can be used to produce quality charcoal? (Which?) Yes / No
7.10 Do you consider the species of a tree when you produce charcoal? (Why?) Yes / No	7.11 Do you take the state of the forest into consideration when you produce charcoal? (Why?) Yes / No	7.12 Do you know how to minimize the impact of charcoal production on the village forest? (How?) Yes / No

8. State of the forest & forest access

8.1 How far is the nearest forest from your house? _____	8.2 Do you own or have rights to manage any forested land? Yes / No
8.3 *If 8.2 = yes*; How did you obtain the rights to manage the forested land (that you own)?	8.4 *If 8.2 = yes*; What is the size of the forested land that you own or have the right to manage? _____
8.5 *In your view*; Is there enough wood available to you in the village to continue producing charcoal over the next 10 to 20 years? (How can you tell?) Yes / No	8.4 *In your view*; Does the village forest regenerate fast enough for charcoal production to continue over the next 10 to 20 years? (How can you tell?) Yes / No
8.5 In your view; Did the amount of wood in the forest change over the past 5 years? (How, Why? / Why not?) o Decreased significantly o Decreased slightly o Increased slightly o Increased significantly o Unchanged	8.6 *In your view*; Did the amount of trees that produce quality charcoal change over the past 5 years? (How, Why? / Why not?) o Decreased significantly o Decreased slightly o Increased slightly o Increased significantly o Unchanged

8.7 Do you know how much charcoal you are allowed to producer per year? (If yes; how much?) Yes / No _____ kg	8.8 Who decides the quantity of charcoal you are allowed to produce per year? (Why this institution?) ○ Do not know ○ Village council ○ District ○ NGO / Company	
8.9 Is everybody in the village allowed to produce the same quantity of charcoal? Yes / No	8.10 *If 8.9 = No*; Who is allowed to produce more charcoal and who is allowed to produce less charcoal? (Why?) _____ _____ _____	
8.11 *In your view*; Are the restrictions on the amount of charcoal that can be produced per person respected by all users? (Why? / Why not?) Yes / No	8.12 What sanctions are in place to prevent that producers exceed the amount of charcoal that they are allowed to produce?	8.13 What sanctions are in place to prevent charcoal production without a permit?

9. Interactions with other charcoal producers

9.1 Do you work together with other charcoal producers? (Why? / Why not?) Yes / No	9.2 With whom of the charcoal producers do you prefer to work? (Why them?) _____ _____ _____ _____ _____ _____
9.3 Are there other charcoal producers you work with? Yes / No	9.4 Who are the other charcoal producers you work with? _____ _____ _____ _____ _____ _____

9.5 How many charcoal producers do you work with in total? _____ producers	9.6 How many times do you generally see them per week? → **Indicate with a number in 7.2 and 7.4**	9.7 Whom of these producers are your family or neighbors (indicate with F or N)? _____ _____ _____ _____

9.8 How did you meet the charcoal producers you work with?	9.9 With whom of the charcoal producers do you exchange skills and knowledge about charcoal production? _____ _____ _____ _____ _____

9.10 With whom do you talk about the state of the forest and its species? _____ _____ _____ _____	9.11 Which other topics do you talk about together?

9.12 Whom would you be willing to help out financially? _____ _____

10. Interaction with other farmers

10.1 Do you work together with other farmers? (Why? / Why not?) Yes / No	10.2 *If 10.1 = Yes*; With whom of the farmers do you prefer to work? (Why them?) _____ _____ _____ _____ _____ _____ _____ _____
10.3 How many times do you generally see them per week? **→ Indicate with a number in 10.2**	10.4 Whom of these farmers are your family or neighbors (indicate with F or N)? _____ _____ _____ _____

10.5 With whom of the farmers do you exchange skills and knowledge about farming?	10.6 Which other topics do you talk about together?
_____ _____ _____ _____	

10.7 Who of the other farmers has helped you with farming? (In which way?)	10.8 Who have you helped out with farming? (In which way?)
_____ _____ _____ _____ _____	_____ _____ _____ _____ _____

11. Interaction with village council

11.1 Do you interact with members of the village council? (Why? / Why not?) Yes / No	11.2 *If 11.1 = Yes*; Whom from the village council do you interact with? _____ _____ _____ _____ _____		
11.3 How many members of the village council do you interact with in total? _____ members	11.4 How many times per month do you interact with these council members? → **Indicate with a number in 11.2**	11.5 Which topics do you talk about with members of the village council?	11.6 Whom of the village council are your family or neighbors (indicate with F or N)? _____ _____ _____ _____
11.7 Whom of the village council decides over charcoal production within the village forest? _____ _____ _____			11.8 How many times per month do you interact with the members of the village council that decide over charcoal production within the forest? → **Indicate per person in 11.7**
11.9 Would you get in contact with village council members if illegal charcoal production takes place in the village forest? (Why? / Why not?) Yes / No	11.10 *If 11.9 = Yes*; Who of the village council would you contact to notify them about illegal charcoal production in the village forest? _____ _____ _____		
11.11 Can you tell us how you would be able to obtain (more) land for farming or forestry?	11.12 Who of the village council can allocate land for farming or forestry? _____ _____ _____		11.13 How regularly do you interact with the members of the village council that have the right to allocate land for farming or forestry? → **Indicate per person in 11.12**

12. Interaction with TFCG

12.1 Do you interact with TFCG officials? (Why? / Why not?) Yes / No	12.2 Whom of TFCG do you interact with? _____ _____ _____ _____ _____	
12.3 How many TFCG officials do you interact with in total? _____ members	12.4 How many times per month do you interact with these TFCG officials? → **Indicate with a number in 12.2**	12.5 Which topics do you talk about with TFCG officials?
12.6 Who of TFCG decides over charcoal production within the village forest? _____ _____ _____		12.7 How regularly do you interact with the members of the TFCG that decide over charcoal production within the forest? → **Indicate in 12.6**
12.8 Would you get in contact with TFCG officials for questions about charcoal production? (Why? / Why not?) Yes / No	12.9 *If 12.8 = Yes*; Who of TFCG would you contact for more information about charcoal production? _____ _____ _____	
12.10 Would you get in contact with TFCG officials if illegal charcoal production takes place in the village forest? (Why? / Why not?) Yes / No	12.11 *If 12.10 = Yes*; Who of TFCG would you contact to notify them about illegal charcoal production in the village forest? _____ _____ _____	

13. Interaction with the Kilosa District Government

13.1 Do you interact with members of district government? (Why? / Why not?)	13.2 Whom from the district government do you interact with? _____

Yes / No	_____ _____ _____ _____	
13.3 How many members of the district government do you interact with in total? _____ members	13.4 How many times per year do you interact with these district government members? → **Indicate with a number in 13.2**	13.5 Which topics do you talk with them about?
13.6 Would you get in contact with district officials to acquire information about rules and regulations for charcoal production? (Why? / Why not?) Yes / No	13.7 *If 13.6 = Yes*; Which district official(s) would you contact to acquire information about rules and regulations for charcoal production? _____ _____ _____	
13.8 Would you get in contact with district officials if illegal charcoal production takes place in the village forest? (Why? / Why not?) Yes / No	13.9 *If 13.8 = Yes*; Which district official(s) would you contact to notify them about illegal charcoal production in the village forest? _____ _____ _____	

14. Interaction with Tanzania Forest Service

14.1 Do you interact with members of Tanzania Forest Service? (Why? / Why not?) Yes / No	14.2 Whom from Tanzania Forest Service do you interact with? _____ _____ _____ _____ _____	
14.3 How many officials of the Tanzania Forest Service do you interact with in total? _____ members	14.4 How many times per year do you interact with these officials of Tanzania Forest Service? → **Indicate with a number in 14.2**	14.5 Which topics do you talk with them about?

14.6 Would you get in contact with officials of Tanzania Forest Service to acquire information about rules and regulations for charcoal production? (Why? / Why not?) Yes / No	14.7 *If 14.6 = Yes*; Which Tanzania Forest Service official(s) would you contact to acquire information about rules and regulations for charcoal production? _____ _____ _____	
14.8 Would you get in contact with Tanzania Forest Service if illegal charcoal production takes place in the village forest? (Why? / Why not?) Yes / No	14.9 *If 14.8 = Yes*; Which Tanzania Forest Service officials would you contact to notify them about illegal charcoal production in the village forest? _____ _____ _____	

15. Associations, life goals and support

15.1 Are you a member of a charcoal producer association? (Why? / Why not?) Yes / No	15.2 *If 15.1 = Yes*; Which tasks do you have in the charcoal producer association?	15.3 Do you take part in the decision making process of the charcoal producer association? (In what way?) Yes / No
15.4 Are you a member of another community association? (Why / Why not?) Yes / No	15.5 If 15.4 = Yes; Which community association is this and what are your tasks?	15.6 Do you take part in the conventional decision making process within the village? (In what way?) Yes / No
15.7 How many associations are you a member of in total? _____ associations	15.8 Do you feel like you have similar goals in life as other villagers (Why? / Why not?) Yes / No	15.9 Do you feel supported by other villagers (Why? / Why not?) Yes / No
15.10 Do you feel supported by the village committee (Why / Why not?) Yes / No	15.11 Do you feel supported by TFCG (Why? / Why not?)? Yes / No	15.12 Do you feel supported by the district government? (Why? / Why not?) Yes / No
15.13 Do you feel supported by the Tanzania Forest Service? Yes / No	15.14 a. *In your view*; How can the village committee increase its support to you in the future?	15.15 *In your view*; How can the district government and Tanzania Forest Service increase their support to you in the future?

	b. . *In your view*; How can TFCG increase its support to you in the future?	

16. Physical capital

16.1 Do you own a house? Yes / No	16.2 How many houses do you own? 1 / 2 / 3 / 4 / 5 / 6	16.3 How many new houses did you construct over your lifetime? _____ houses
16.4 What material are your walls made of? o Mud o Unburned bricks o Burned bricks o Cement bricks	16.5 What material is your roof made of? o Grasses/palm leaves o Corrugated iron sheets o Tiles	16.6 What material is your floor made of? o Sand / Dust o Cement / Tiles
16.7 How many rooms does the house(s) you live in have? _____ rooms	16.8 How many bicycles do you have? _____ bicycles	16.9 Do you own a motorbike? Yes / No
16.10 *If 16.9 = Yes*; How many motorbikes do you own? _____ motorbikes	16.11 Do you use your bike or motorbike to transport the charcoal you produce? Yes / No	16.12 Do you own a car? Yes / No
16.13 Is you house adjacent to a road? Yes / No	16.14 *If 16.13 = Yes*; Is the road adjacent to your house a main road? Yes / No	16.15 *If 16.13 = Yes*; Is the road adjacent to your house made of asphalt or other hard materials? Yes / No
16.16 *If 16.13 = Yes*; Is the road adjacent to your house being maintained by the village, district or national government? Yes / No	16.17 Do you have access to drainage in your house? Yes / No	16.18 Do you have a toilet in your house? Yes / No
16.19 *In your view*; Did the amount of possessions you have change over the past 5 years? o Decreased significantly o Decreased slightly o Increased slightly o Increased significantly o Unchanged	16.20 *In your view*; Did the quality of the road adjacent / near your house change over the past 5 years? o Decreased significantly o Decreased slightly o Increased slightly o Increased significantly o Unchanged	16.21 *In your view*; Did the condition of your house change over the past 5 years? o Decreased significantly o Decreased slightly o Increased slightly o Increased significantly o Unchanged

17. Notes (Indicate the topic of the note and write down keywords)

Notes 1:

Notes 2:

Notes 3:

C. Indicators for the Wealth Categories in Village A, B, C and D

WEALTH CRITERIA			
VILLAGE A			
STATUS	**NON-POOR**	**POOR**	**POOREST**
House	Corrugated iron sheets, burnt bricks/Cement bricks, cement/tiles floor, sink toilets /Pit toilets	Corrugated iron sheets, burnt bricks, dust floor, pit modern toilets (with plastic sick)	Grasses roof, mud & trees walls, Dust floor, Pit toilets
Farm size	20 acres or more	From 1 to 5 acres	≤ 2 acres
Source of income	Crops grinding machine, Shops & Rental tractors, & Passengers cars	Small miners, Vegetables shops, small crops business, small restaurant, Charcoal Producer	Farm labors, Charcoal Producer. Fire wood producers
livestock	**Farming communities** ≤ 10 cows 10 to 50 goats 30 to 70 chickens. **Pastoralist communities** 50 to 100 goats 5 to 20 chickens 100 to 500 cows	**Farming communities** 5 to 30 goats 5 to 20 chickens ≤ 3 pigs **Pastoralist communities** 30 to 70 goats 5 to 20 cows 5 to 20 chickens	**Farming communities** ≤ 5 chickens **pastoralist communities** ≤ 10 goats ≤ 4 cows ≤ 5 chickens
Agricultural equipment & farm tools	Tractors, ox plow, & hand plow (labors)	Tractor, Few use Ox plow, hand plow, & labors	hand plow

WEALTH CRITERIA			
VILLAGE B			
STATUS	**NON-POOR**	**POOR**	**POOREST**
House	Corrugated iron sheets/ tiles roof, burnt bricks/Cement bricks, cement/tiles floor, sink toilets	Corrugated iron sheets, burnt bricks, sand floor, pit toilets	Grasses roof, mud & trees walls, Dust floor, Pit toilets / and most they don't have toilets
Farm size	**Farming communities** From 10 to 50 acres or more **Pastoralist communities** From 1 to 5 acres or more	**Farming communities** From 5 to 10 acres **Pastoralist communities** From 1 to 5 acres	**Farming communities** ≤ 1 acres **Pastoralist communities** Null
Source of income	Crops grinding machine, Shops & Livestock trade at auctions,	Vegetables shops, small business, small restaurant,	Grazing & Farm labors, Charcoal Producer.
livestock	**Farming communities** 50 to 100 cows 20 to 50 pigs 10 to 20 goats 10 to 50 chickens 10 to 20 donkey **Pastoralist communities** 500 goats and more 2000 cows and more 2 to 10 donkeys to 20 chickens	**Farming communities** 10 to 20 cows 5 to 10 goats 10 to 20 pigs 20 to 50 chickens **Pastoralist communities** 150 to 150 goats 100 to 500 cows 5 to 10 chickens. 1 to 5 donkey	**Farming communities** ≤ 6 chickens **Pastoralist communities** 1 to 10 goats 1 to 5 cows
Agricultural equipment & farm tools	Tractor, ox plow, & hand plow	Tractor, ox plow, & hand plow	hand plow

WEALTH CRITERIA			
VILLAGE C			
STATUS	**NON-POOR**	**POOR**	**POOREST**
House	Corrugated iron sheets, burnt bricks/Cement bricks, cement floor	Corrugated iron sheets, burnt bricks, cement floor, cement toilets.	Grasses roof / palm leaves mud & trees walls, Dust floor, Pit toilets made of grasses
Farm size	From 5 to 10 acres or more	From 2 to 4 acres	½ to 1 acres
Source of income	Retail shop, grinding machine, rental tractors, seasonal crop trade, cattle rental for farming.	Vegetables shops, Produced Charcoal 20 to100 bags, Season crops trade, Few rent cattle for farming. Charcoal producers	Farm labors, Produced Charcoal 5 to 20 bags Selling fire woods, Selling crops in small amount.
livestock	≥ 10 cows, ≥ 20 goats ≥ 15 chickens.	2 to 9 cows 10 to 19 goats, 5 to 10 chickens	≤ 5 chickens
Electricity	Source from National grid	Source from National grid / Solar power	No electricity
Resources	≥ 10 bicycles, ≥ 1 motorcycles, Few own 1 car, Few own 1 tractor, Grinding machine 1 to 3	1 to 4 bicycles, ≤ 1 motorcycles,	½ to 1 acres for farming
Agricultural input	Fertilizer pesticides good seeds	Manure pesticides good seeds	Only use manure
Types of Crops	**Seasonal crops** Maize, cotton, sesame, common sunflower, beans, mung beans, rice & peas **Permanent crops** Coconut, oranges, lemons, bananas, sugarcane, palm fruits	**Seasonal crops** Maize, beans, rice sesame, millet (but not in high level) **Permanent crops** Coconut, bananas & palm fruits	**Seasonal crops** No seasonal crops **Permanent crops** 3 to 4 bananas trees & 3 to 4 oranges trees

WEALTH CRITERIA VILLAGE D			
STATUS	**NON-POOR**	**POOR**	**POOREST**
House	Corrugated iron sheets/ tiles roof, burnt bricks/Cement bricks, cement/tiles floor, sink toilets located inside or outside the house	Corrugated iron sheets, burnt bricks, cement/sand floor, pit toilets located outside the house	Grasses roof, Unburnt bricks /mud & trees walls, Dust floor, Pit toilets /no toilets
Farm size	From 5 to 10 acres or more	From 2 to 5 acres	¼ to acres
Source of income	Retail shop, grinding machine ≤ 3, rental motorcycle or bicycles	Vegetables shops, Few join in VICOBA, and few produce charcoal in EDU (designated forest block)	Farm labors, Charcoal producer in EDU (designated forest block), Few join in VICOBA
livestock	**Farming communities** 1 to 5 cows 1 to 8 pigs 10 to 15 goats 10 to 30 chickens **Pastoralist communities** 30 to 100 goats 10 to 100 cows 2 to 5 donkeys 10 to 30 chickens	**Farming communities** ≤ 15 goats ≤ 6 Pigs ≤ 6 rabbits 10 to 50 chickens **Pastoralist communities** 10 to 30 goats, 5 to 10 cows	**Farming communities** ≤ 10 chickens **Pastoralist communities** 2 to 10 goats, 2 to 5 cows
transport	Few own rental Bicycles ≤ 40 Motorcycle ≤ 1 Very few own a car ≤ 1	Bicycles ≤ 2 Motorcycle ≤ 1	null

D. Stratified Sampling

		Wealth Category			
	Total	**non-poor**	**poor**	**poorest**	**not ranked**
Village A	16	0	6	9	1
Village B	25	1	10	11	3
Village C	37	0	24	13	0
Village D	26	0	17	9	0

E. Topic Guide for the Expert Interviews

Topic	Question	Follow-up/ Specification
Charcoal Production	- Which regulations are currently in place that limit charcoal production? - How are policies and regulations on charcoal production made? - To what extent are livelihood implications for rural smallholder producers of these policies and regulations considered when put together? - How are policies and regulations on charcoal production implemented? - How well are local charcoal producers informed about the regulations, their own rights etc.? - Why is the charcoal sector so stigmatized as a negative activity? - Do you think in the next 10-20 years changes are possible where the economic potential of smallholder charcoal production could be utilized for poverty reduction on a national level? - What would need to change in order to enable that? - What is your future prognosis based on the current situation for charcoal production?	- Process, sources of information - Information of stakeholders, monitoring etc.
Farming practices & Agroforestry	- Which are the most commonly used farming and agroforestry practices in the research areas? - How are the farming and agroforestry practices different from regions where most charcoal is produced from Agroforestry (coastal regions, Rwanda & Burundi)? - Which regulations and policies are currently in place for agroforestry farming? - How are policies and regulations on farming and land tenure made? - To what extent are livelihoods implications for rural smallholder farmers of these policies and regulations considered when put together? - How are policies and regulations farming and land tenure implemented? - What is the state of the National Agroforestry Strategy? - How well are local (agroforestry) farmers connected to information sources about the regulations, new technology/ knowledge, their own land rights etc.? - Do you think in the next 10-20 years the recognition of the potential of agroforestry could change? If so, how? - What is the potential of using synergies between (agroforestry) farming and charcoal production? - What would need to change in order to enable/ promote these synergies? - What is your future prognosis based on the current situation for agroforestry farmers? - What is your future prognosis based on the current situation for the use of agroforestry in charcoal production?	
Livelihoods	- Which rural livelihood strategies in general and of charcoal producers have you observed? - Which practices of combining farming and charcoal production have you observed in the field?	- Key features, combinations - Dependence on forest resources, role of agroforestry

	- Which are the most dominant power structures in the villages for the farmers/charcoal producers? - To what extent are livelihood implications of these policies and regulations for rural smallholder farmers and or charcoal producers considered when put together? - What is your future prognosis based on the current situation for rural livelihoods?	- Plurality or homogeneity
Other aspects	- Would you like to add anything about charcoal production, farming/ agroforestry, livelihoods, institutional context or additional topics?	

F. Questionnaires for Members of Village and District Government

Village council members

1) Can you tell us how the village is governed?
2) Which committees are operating in the village and what are their tasks?
3) How often does the village council come together to discuss?
4) How often do you have elections?
5) How are the village elections arranged?
6) How and by whom is land allocation handled in your village?
7) Who has the right to acquire land?
8) Does everybody have the same right to acquire land in the village?
9) Who has access to the forest?
10) Do all these people have the same degree of access to the forest?
11) *For project villages*; Do you have any regulations for the management of charcoal production that differ from those suggested by TFCG? (If so; Can you tell us about them?)
12) *For project villages*; What is your opinion on the TTCS project?
13) *For project villages*; What is your opinion on the way TFCG manages the TTCS project?
14) *For project villages*; Do you feel that you receive enough support from TFCG?
15) *For project villages*; Do you feel that you receive enough support from district council?
16) *For project villages*; How do you see technical support for forest management/charcoal production once the TTCS project ends?
17) How much income does the village derive from taxes?
18) Has the income derived from taxes changed over the past 5 years? (Why? / Why not?)
19) How much of the income from taxes comes from charcoal production?
20) Has the tax derived from charcoal changed over the past 5 years? (Why? / Why not?)
21) What has the village been able to accomplish from the village fund over the past 5 years?
22) What challenges has the village faced over the past 5 years?
23) How did the village manage those challenges?
24) What challenges does the village face at the moment?
25) How does the village manage those challenges?
26) For project villages; Do you contact TFCG for advice or help? (If yes; About what?)
27) Do you contact District officials for advice or help? (If yes; About what?)
28) Do you contact Tanzania Forest Service for advice or help? (If yes; About what?)
29) *For project villages:* How have the livelihoods of people in these villages changed through the project? (improvements, limitations)
30) *For project villages:* How has the project changed wood sourcing for charcoal production (new sources, use of own trees?)
31) *For project villages:* How has the project affected farming practices?
32) What is your view on the protection of forests in the village?
33) Has your view on forest protection changed over the past 5 years?
34) For project villages; Has you involvement in the TTCS project altered your opinion/knowledge on forest protection? (If so; In what way?)
35) What are your plans for the village for the future?

District officials

1) Can you tell us how you manage forests in the district of Kilosa?
2) Which practices have you observed in regard to wood sourcing for charcoal production?
3) How and by whom is land allocation handled in your district?
4) Who has the right to acquire land in the district?
5) Does everybody have the same right to acquire land in the district?
6) Who has access to the forest?
7) Do all these people have the same degree of access to the forest?
8) Can you tell us how you monitor charcoal production within the different villages of the Kilosa district?
9) How many people from the district monitor charcoal production?
10) How many permits do you hand out per year?
11) Would you be willing to share official records of the amount of permits you hand out?
12) How often do you deny permits and why?

13) How many fines do you approximately hand out per year for illegal charcoal production? Has this trend change over the last 5 years (why or why not)?
14) How are charcoal producers informed about new regulations?
15) Do you communicate directly with charcoal producers? (If yes; About what?)
16) Do charcoal producers contact you for information about rules and regulations for charcoal production? (If yes; What is asked?)
17) Do villagers contact you about illegal charcoal production within their village forest? (If yes; What do they communicate?)
18) Do TFCG members operating in the Kilosa District contact you for advice or help? (If yes; About what?)
19) Do you contact TFCG members for advice or help? (If yes; About what?)
20) What is your opinion on the TTCS project?
21) Do officials of Tanzania Forest Service operating in the Kilosa District contact you for advice or help? (If yes; About what?)
22) Do you contact the Tanzania Forest Service for advice or help? (If yes; About what?)
23) What challenges did you face when monitoring charcoal production over the past 5 years? Are the challenges similar across all villages (why or why not)?
24) How did you manage those challenges?
25) What challenges do you face when monitoring charcoal production at the moment? Are the challenges similar across all villages (why or why not)?
26) How do you manage those challenges?
27) What are your plans for charcoal monitoring in the future?
28) What are you plans for forest management in the future?

G. Content Analysis: Codes and Category Systems

Code System Charcoal Producers	
Quotes	204
Unclear/ Conflicting Statements	12
physical capital	28
change in wealth/posessions	18
bicycle	34
social capital	2
hiring labor for charcoal production	19
closest social tie	14
learning from others	23
social capital for farming	62
shared norms/values/goals in village	44
farming and community associations	33
sharing of farming knowledge	61
perceptions and interaction with VG/ DG/ TFS/ TFCG	0
village government structure	11
interaction with village council	73
reporting illegal production	6
perceptions about village government	50
governance of village lands/forest	48
land conflict A and F	1
goernance of charcoal sector at village level	58
block allocation	27
perceptions about the district government	39
interaction with district government	9
report illegal production	4
aquire knowledge	4
perceptions about TFS	32
perceptions about TFCG	39
interactions with TFCG	31
inclusion/ exclusion	17
interaction with pastoralists	7
state of the forest	19
regeneration	30
availability of trees	61
(minimize) impact of cc on forest	27
discussions with others about state of the forest	15
increased	5
unchanged	8
decrease	30
distance to forest	24
livelihood activities	22
charcoal production	0
charcoal production process	27
charcoal markets	136
selling location	16
market conditions	34
customer/buyer	62
"charcoal production is hard work"	22

Code System Village and District Government Members	
Qutoes	36
production in the future	6
changes in market conditions	14
TFCG Project	38
TFCG project guidelines	11
interaction with TFS	17
producers from outside the village	6
inclusion/ exclusion	13
interaction with producers	16
informing producers	11
interaction between district and village government	50
district member responsible for cc production	1
district gov challenges	11
Knowledge about regulations/ no clear information	8
village revenue/ general taxes	44
taxes for charcoal	18
investment/ development	30
village challenges	31
issues with land ownership	30
issues with pastoralists	9
dealing with challenges	20
village governance structure	23
committee	10
committee formation	8
village council meetings	12
VNRC	6
governance of land/ allocation	40
large-scale farms	9
governance of charcoal	14
access to village forest	11
collection of firewood	10
state of the forest	15
sustainability	32
forest regulations	9
amount per year	4
forest management / enforcement of regulations	41
fees for forest use & charcoal	10
production in village forest	11
prohibited area	9
patrol	4
charcoal association	4
training	9
EDU/ Block	8
permit application process	34
compliance with regulations	17
bribery	4
sanctions	13
on-farm production	20

"everyone produces the same way"	28
own consumption of charcoal	4
equipment for charcoal production	27
frequency of charcoal production	27
charcoal seasonality	42
part time	21
production quantity	59
tree harvesting for charcoal	36
parts of the tree	32
source for harvesting	49
off-farm charcoal production	25
on-farm charcoal production	51
charcoal production during land clearing	24
charcoal production on other peoples' farms	11
tree species for charcoal production	49
human capital in charcoal production	0
health and charcoal production	49
injuries from charcoal production	52
safety percautions	33
knowedge about regulations	35
compliance with charcoal regulations	92
bribes/ corruption	7
illegal production	3
sanctions	31
max. amount	21
permit for charcoal production	65
restricted areas	7
Beekeeping	4
taxes for charcoal	27
knowledge about charcoal production	15
kiln construction	51
wood-to-charcoal (kiln efficiency)	28
knowledge about sustainability	66
skills fro charcoal production	26
training	50
reasons for becoming a charcoal producer	17
"not my official job"	3
for land clearing	8
hardship/difficulty in life	19
income from charcoal production	19
$$$ amount	40
investment of charcoal money	50
reason for producing charcoal	146
"not my official job"	7
customers available/demand	2
hardship/difficulty in life	18
income generation	34
satisfaction with charcoal production	20
continue NO	8
continue YES	18
season	5
through TFCG projcet	5
tree planting	5
farming	5

Code System Academic Experts	
Charcoal Production	0
CC production in the future	4
development potenital of charcoal	3
reasons for charcoal making (+)	6
low entry cost for charcoal produciton	1
advantage of being foreign researcher	1
governance of charcoal production	15
taxes	7
lack of enforcment capacity	6
sustainable charcoal production project	16
sustainability of projects (+) (+)	14
CBFM/CBNRM/PFM	3
conflict of interest between certification and TFS	3
workshops	4
reinforcment of inequalities	5
livelihood implications	8
evictions	5
village land use plan	3
land allocation	3
inromtation platform	2
village assemblies	1
compliance with charcoal regulations	12
forest resources / NTFPs (+) (+)	5
farmland expansion/ land clearing	1
off farm charcoal production	8
distance to forest	2
firewood	2
power structures in villages	15
corruption (+)	4
customary land use rights	3
hidden domination by few ethnic groups	1
nepotism	1
transition to modern fuels	4
social capital	7
sharing of knowledge and information	2
charcoal producers association	3
farmers association	1
strong institutions	4
norms and values	3
motivation for tree planting	10
planting materials	5
products/ benefits	1
on-farm fuelwood production (+)	12
charcoal	7
bee keeping	1
Wood production	4
countour trees	2

social capital for charcoal production	100
charcoal producers' association	33
sharing of charcoal knowledge	23
charcoal producers from outside the village	13
farming	14
hazards/risks	33
farming seasonality	38
labor for farming	47
health and injuries from farming	25
farming skills	49
training	21
knowledge about farming	20
income from farming	49
investment of farming income	40
subsistence farming	16
Food security	12
land ownership	48
farm size	24
move to obtain land	5
other farming activities	46
shifting cultivation	1
Agroforestry	1
interest in planting trees for charcoal production	53
NOT for charcoal	7
fruit	4
timber	11
YES	23
conditions	0
training	2
favorable market	1
land tenure	4
financing	1
land size	9
seeds/ seedlings available	7
challenges	0
tree-crop interaction	7
establishment period	16
opportunities	1
multipurpose trees	9
tree species	22
on-farm trees	3
benefits from on-farm trees	37
fresh air	1
insurance	7
"manure" (fertilizer trees)	4
income	21
"rain"	3
timber/ construction material	18
fruit	19
medicine	5
charcoal	15
firewood	12
legumes for soil fertility	1
counter degradation	5
challenges for tree-planting	16
land size	4
invasive species	2
waiting period for direct benefits	2
no scarcity	10
competition	2
commercialization	1
livelihood diversification	8
Agroforestry Systems	2
synergies between AF and CC	4
AF policies and regulations	13
recognition of agroforestry	2
livelihood implications	3
governance structure	5
implementation	23
self determination vs. projects	1
tree species	9
agroforestry practices	1
livestock integration	3
individual trees on farm	5
Fruit Trees	1
improved follow	2
conservation agriculture with trees	1
woodlot	7
Intercropping	4
Farming practices in general	6
shifting cultivation	7
farmer managed natural regeneration	3
irrigated farmland	2
pastoralism	6
symbiotic solution between pastoralists and farmers	1
farmer-pastoralist conflicts	1
Maasai	1
Sukuma	1
large scale farming	1

shade	14
on-farm tree management	32
planted on-farm trees	44
naturally grown on-farm trees	28
household size	20
education level	20

Personal Declaration

I hereby declare that the submitted thesis is the result of my own, independent work. All external sources are explicitly acknowledged in the thesis.

Winterthur, 02.12.2020

Place, Date

Mena Seifert