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Perceived multifunctionality of agroforestry trees in Northern Ethiopia

– A case study of the perceived functions and associated personal values of trees for farming households in Tigray

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Upplevt multifunktionalitet av skogsjordbruksträd i Norra Etiopien
– En fallstudie på upplevda funktioner och förknippade personliga värden av träd i jordbrukshushåll i Tigray

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Abstract

This case study explored perceptions on the beneficial and detrimental functions obtained from agroforestry trees in two sites in Northern Ethiopia. These perceived functions were contextualized and their contribution to a multifunctionality in agriculture discussed. 55 farming household heads and five informants in two study sites, Abreha we Atsbah and Mayberazio, participated in the study. Semi-structured interviews were conducted with participants in March 2016. Using a Means-End Chain framework, cognitive structures around the perceived functions were revealed. It was investigated which attributes are seen as provoking certain functions and how the functions contribute towards the achievement of personal values. The most mentioned beneficial functions of agroforestry trees were wood for construction (98% of households), fuel (95%), sale (84%), fodder (82%), land improvement (69%), and fencing material (47%). The most mentioned drawbacks of agroforestry trees were detrimental shade (78% of households), resource depletion (16%), and barrier for cultivation (13%). Farming households were found to carefully design their agroforestry system in order to obtain the requested functions. The results of the study show that functions can contribute to three spheres: (i) to support the household's livelihood, (ii) to serve as business incentive, or (iii) to the personal satisfaction of the household members. A comparison of the personal values related to function indicate that agroforestry trees are perceived as particularly beneficial if they contribute to more than one of these spheres. Thus, participants of this study were found to be interested in a multifunctional portfolio of agroforestry tree functions which is aligned with their household farming goals.

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List of abbreviations

CSA – Climate smart agriculture

DA – Development agent

FAO – Food and Agriculture Organization of the United Nations

FD – Functional diversity

HH – Household

HVM – Hierarchical value map

ISD – Institute for Sustainable Development

MEC – Means-end chain

NGO – Non-governmental organization

OECD – Organization for Economic Co-operation and Development

PRA – Participatory rural appraisal

SOCLA – The Latin American Scientific Society of Agroecology

USD – United States Dollar

Foreword

It all started with learning. Not very understandable at the time, but Kolb's learning cycle was one of the first concepts we took up in this MSc program. It's a concept I have grown to like quite a bit because like few others, it relates immediately to my life.

No, I did not really see the point of reading about agroecological education of experimental learning in the beginning. With a tight schedule it just felt like a waste of time. But in hindsight I see what it did. It opened up the teacher-student structure. There were no wrongs or rights, or they were at least not coming from the teacher as a word of power. In this way, I think that the program has been an open and honest education, a room for learning rather than for studying. I consider this to be a major accomplishment of everybody that was involved in the MSc program, and want to thank all teachers for their patience and openness.

Sticking to the topic of learning, I have to thank all of the people along the way. There is no way of exemplifying the concept of co-learning in any better way than what we experienced together in Alnarp. Classes rarely ended with the ring of the bell, but extended into various kitchens, computer rooms, attics or BBQ areas. These were the real classrooms and the knowledge I have gained in numerous discussions with you, my classmates, is indispensable. We reflected, we thought, we planned and we did – as a group.

One of the major challenges of this thesis work has been to produce something very static like a piece of text out of a very fluent process like learning. My ideas and thoughts on topics have changed over time, so what I thought when I wrote one part of the thesis does not necessarily and accurately reflect what I think about that now. I feel happy to have had Kolb's learning cycle by my side, because it gives me an explanation and assurance that this is not at all a negative outcome, but rather a beneficial one. I have been learning while writing the thesis.

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1. Introduction

Food security has been a topic of high importance in the Horn of Africa and especially in Ethiopia for decades. The country has in mainstream media become associated with reoccurring famines and notorious food insecurity to a level where the Lonely Planet tourist guidebook dedicates an own textbox to the topic, and mentions the term 'famine' 21 times throughout the book (in comparison: in the Lonely Planet tourist guide for India, the word appears once) (Carillet *et al.*, 2013; Singh *et al.*, 2013).

Although major famines have in fact become more seldom, Ethiopian agricultural production still faces a number of challenges: Ecological disturbances complicate farming in the region. On one hand, severe soil erosion, often occurring due to heavy downpours, has led to the loss of fertile topsoil (Tamene & Vlek, 2008). On the other hand, erratic rainfalls and regular droughts have resulted in the loss of harvests and decline of yields (Teka *et al.*, 2012). Current agricultural systems have not been able to provide sufficient resistance and resilience in face of these climatic events. Instead, in the past decades, droughts have repeatedly led to famines.

However, the lacking resilience cannot be ascribed to ecological causes alone. Socio-economics and politics have played an important role, especially in rural Northern Ethiopia, where famines have been most severe (Graham *et al.*, 2012). Agricultural production is based on a small-holder system with an average farm size of only a couple of hectares (Taffesse *et al.*, 2012). Subsistence farming is common and techniques are largely artisanal, based on rain-fed systems (Tegebu *et al.*, 2012). As a result, economic output for the households is low which impedes offsetting of yield fluctuations.

In combination, low economic resources and ecological disturbances have laid the foundation for a prevailing food insecurity. Furthermore, the region's trends of increasing soil degradation and predicted future climate change, which will likely see a higher probability and severity of extreme events such as droughts and heavy downpours (Niang *et al.*, 2014), is assumed to aggravate socio-ecological instability.

A popular approach to targeting these issues has been the integration of trees within agriculture. This so-called agroforestry is by many advocated as a sustainable solution for Sub-Saharan African small-holder agriculture in general (see e.g. Garrity *et al.*, 2010; Garrity, 2004). In a Northern Ethiopian context, agroforestry is encouraged through the government (Hassan *et al.*, 2016) and praised as core principle of a climate-smart agriculture (CSA) (FAO, 2016). As such, it is understood as an example of multifunctional agriculture: More than just providing food or fibre, the integration of trees into agricultural plots promises environmental, economic, and social benefits. From a scientific perspective there is considerable evidence that trees can contribute to improved sustainability of agricultural landscapes.

Agroforestry is oftentimes advocated because it is a multifunctional way of agriculture (Asaah *et al.*, 2011), meaning that it, as a system provides more than just food and fibre (OECD, 2001). These other functions can be e.g. carbon storage, creation of beneficial microclimates, economic diversification, etc. Within the last 20 years, agriculture is viewed more in this way of provision of multiple functions, something that is closely related to providing different ecosystem services (Wood *et al.*, 2015).

However, planting or retention of trees on agricultural fields is largely dependent on the actions of the farmers themselves. Thus, behaviour towards trees relates to the household level of farmer decisions. Farming system research, and not least the field of agroecology, have for a long time provided evidence of the importance of the so-called soft system in agriculture, meaning the management choices, ideas, and purpose of agricultural actors (Dalgaard *et al.*, 2003; Bawden & Packham, 1993). As such, Northern Ethiopian farmers and their motivations and motives are crucial for the success of any agroforestry systems or programmes in the region.

Personal values can be a concept that enables looking at such soft system structures. They are underlying guidelines that shape decision making by providing a map of what are desirable and what are undesirable states of being (Rohan, 2000). Individuals are then assumed to make decision that move them to desirable states (Gutman, 1982).

1.1 Aim & Research questions

The theoretical advantages of trees within agriculture have been discussed in a variety of contexts. Yet in general and specifically in the area of concern there is fairly little published research on farming households' motivations for integrating trees into their agriculture. Thus, building on a Means-End Chain (MEC) model, this case study's aim is to investigate the perceived household functions of agroforestry trees in agricultural systems of Northern Ethiopia in relation to farmers' personal values.

Research question: What are perceived household functions of agroforestry trees in Northern Ethiopia and what attributes, consequences and personal values do local people associate with them?

- Which trees are prevalent within or in proximity to agricultural fields in the study sites?
- Which attributes of the trees are causing these functions from the perspective of the participants?
- What functions and drawbacks are associated with these attributes?
- What personal values are associated with these functions?
- How do the attributes, functions, and values relate to the idea of multifunctional agriculture?

1.2 Outline

Following the introductory section 1, in section 2 the general background of the field is presented, encompassing the topics Ethiopian agriculture and agroforestry.

Furthermore, relevant concepts such as agroecology, multifunctionality, local knowledge and personal values are introduced. In the following section 3, these ideas are formed into a more specific conceptual framework and research design. Materials such as the study site, and methods divided along issues of sampling, collecting, and analysing, are presented here. The subsequent result section (section 4) is introduced with a general description of the study case, to then move on to a general description of agroforestry in the case, which in turn is followed by a detailed tree-by-tree review of attributes, functions, and values. The discussion (section 5) continues there and sheds first some light on several remarkable functions and values, which are in a second step put into relation to each other. Then, it develops towards discussing more generally the idea of multifunctionality and its relevance in this case. The discussion is concluded by critical reflections on the methodological approach of this study.

2. Background

2.1 Agriculture in Ethiopia and Tigray

Ethiopia is a very diverse country in terms of culture, ethnic backgrounds, and ecology. The region has been described as a "centre of origin" (Vavilov & Verdoorn, 1951, p. 37) or at least "centre of diversity" (Hummer & Hancock, 2015, p. 782) for plant cultivation. "In spite of the limited agricultural territory, an astonishing wealth of varieties exist here" (Vavilov & Verdoorn, 1951, p. 38). With regards to agriculture, Hurni (1998) has developed a classification into, what he calls, "agro-ecological[1] belts" (p. viii), thus different zones with similar preconditions for agriculture. This zonation follows two axes, rainfall and altitude. According to this, areas are classified in a two-dimensional matrix from dry and low-lying (bottom left) to wet and high (top right). Climatically, the South is wetter and tropical, the East is dry and desert-like, and the Centre to North is semi-arid and highland. As a result, agriculture differs a lot from region to region.

In Tigray, the most common farming system is a mixed crop and livestock which depends largely on rainfall and caters for the subsistence of the household (Tegebu *et al.*, 2012; Hadgu, 2008). "Agriculture is the main economic stay in the region" (Tegebu *et al.*, 2012, p. 134) and the majority of the population is rural. Agricultural plots do usually not exceed one hectare per household (Tegebu *et al.*, 2012) and cultivation methods are artisanal and involve ploughing by draft animals. The most commonly grown crops "include sorghum (*Sorghum bicolor L.*), teff (*Eragrostis tef*), maize (*Zea mays L.*), finger millet (*Eleusine coracana*), wheat (*Triticum aestivum L.*), barley (*Hordeum vulgare L.*) and pulses" (Teka *et al.*, 2012). Ruminant livestock such as cattle, sheep, and goats, plus some chicken are kept.

Nowadays, especially due to major famines in the 1970's and 1980's, Ethiopia has become internationally recognized as a country of constant food insecurity. Recent

[1] The use of the term "agro-ecology" by Hurni (1998) differs from how it is used elsewhere in this thesis. See chapter 2.4 Agroecology.

research supports that especially rainfall patterns have large negative impacts on rural Ethiopian households (Porter, 2012). The most recent drought, aggravated by the El-Niño, occurred in 2015-2016 and is anticipated to have been the worst in 50 years (Government of Ethiopia & Humanitarian Partners, 2015). Especially the North has endured droughts and famines. Research has shown that rural Tigrinyans recognize rainfall to be more erratic and diminishing (Teka *et al.*, 2012).

Apart from droughts, soil degradation has been a large problem in Tigray. Hengsdijk *et al.* (2005) introduce their article by stating that "perhaps nowhere in the world land degradation problems, i.e. erosion and soil nutrient depletion are more manifest than in the marginal highlands of Tigray" (pp. 29-30). Much work is going on to reduce erosion (e.g. through contour bunds) but their efficacy is disputed (Nyssen *et al.*, 2006; Hengsdijk *et al.*, 2005). An undeniable driver of land degradation and even famines in the past has been politics (Kebbede & Jacob, 1988). Land rights and land allocation, combined with the lack of support for rural people during large parts of the 20th century have had negative effects especially on the management of marginal lands (Lanckriet *et al.*, 2015).

In Ethiopia, all land is owned by the government and allocated to citizens. In the past, there have been regular reallocations in connection to political events. This has led to a certain insecurity in terms of investing on one's farmland (Gebremedhin *et al.*, 2003; Gebremedhin & Swinton, 2003).

2.2 Agroforestry and the role of leguminous trees

Several studies provide evidence that trees in general and leguminous trees in particular improve the resilience of agroecosystems through diversification (Altieri *et al.*, 2015), deepened ecological integration (Gliessman, 2007), and increased productivity (Atangana *et al.*, 2014; Garrity *et al.*, 2010). Leguminous tree species possess the function of being able to fix atmospheric nitrogen in symbiosis with bacteria and thus offer potential benefits to agriculture by increasing nitrogen availability (Munroe & Isaac, 2014). In addition to the fixed nitrogen, trees in general prevent soil erosion as their perennial root networks stabilize the soil and are able to recover nutrients from deeper soil layers (Atangana *et al.*, 2014). Furthermore, trees have proven to be applicable as means of both climate change mitigation, due to an increased carbon sequestration, and adaptation, due to the creation of more favourable microclimates on agricultural fields (Atangana *et al.*, 2014; Mbow *et al.*, 2014). Thus, agricultural systems with trees are often advocated as an example of climate-smart agriculture (CSA). Yet another benefit of these systems is their addition to livelihood strategies (Dawson *et al.*, 2014). By diversifying production, farmers can offset crop failures. In practice, trees can e.g. be used as forage feed for livestock (Atangana *et al.*, 2014), enabling the farmer to include animals in their agricultural system thus creating additional income and food for times when crop harvest are low.

There are different names and conceptualizations for cropping systems that include trees. Some systems include tree rows throughout the fields, so called alley cropping (Nair, 1985). Others find trees more in block structure, or in the edges of fields only.

When trees are incorporated extensively scattered in agricultural plots common names are evergreen agriculture (Hadgu *et al.*, 2011; Garrity *et al.*, 2010), or parkland agroforestry (Mokgolodi *et al.*, 2011; Sanchez, 1995). Depending on the farming systems, different terminology is oftentimes used, such as “agrisilvicultural, silvopastoral, agrosilvopastoral systems” (Nair, 1985, p. 102), or home gardens (Gliessman, 2007).

In this study, all are classified as agroforestry, which is defined as being “the introduction, or deliberate retention, of trees on farms through either spatial or temporal arrangements” (Atangana *et al.*, 2014, p. 35). Generally, for a system to be classified as agroforestry, there is a requirement for a certain level of deliberate management, be it introduction, retention, or use in agriculture (Atangana *et al.*, 2014; Lundgren & Raintree, 1982).

Still, the definition leaves some room for interpretation: This study considers trees and woody perennial shrubs to be relevant for agroforestry systems. The decisive criteria for this study is whether these species are linked to agricultural fields. Specifically, trees and shrubs within or in immediate proximity to agricultural fields are considered to be agroforestry trees. This could include homestead trees if they are close to plots, but excludes fruit tree plantations.

2.3 Agroforestry in Ethiopia and Tigray

Agroforestry is widely researched in Ethiopia and Tigray, and possible agroforestry trees are listed in detail in Bekele-Tesemma *et al.* (1993) or Orwa *et al.* (2009). Several studies have addressed benefits of agroforestry systems in relation to coffee production in Southern Ethiopia (see e.g. Dawson *et al.*, 2014; Kebebew & Urgessa, 2011). Other research has been directed towards systems with more scattered trees:

In terms of soil improvement, Asfaw and Ågren (2007) have shown that in Southern Ethiopia *Cordia Africana* has significantly more nutrients in the topsoil underneath its canopy than *Eucalyptus camaldulensis*. Furthermore, their study highlighted that farmers perceive the *E. camaldulensis* as a species that is harmful to soil. Along the same line Hadgu *et al.* (2009) have shown that *Faidherbia Albida* improves barley productivity in Tigray unless it is planted in a system together with ***E. camaldulensis.***

F. Albida is generally one of the most researched agroforestry species in Ethiopia. Poschen (1986) and Kamara and Haque (1992) have already decades ago suggested that it has positive effects on crop performance and nutrient availability respectively in Ethiopian highlands. More recent research projects indicate that *F. Albida* is a common and traditional agroforestry species in some agricultural systems in Tigray (Noulekoun *et al.*, 2016), and that it improves soil quality in these sites (Gelaw *et al.*, 2015).

In two journal articles Mekoya *et al.* (2008a; 2008b) have looked at the differences between exotic and indigenous multipurpose fodder trees. They found that oftentimes exotic trees are too specialised and scrutinised by farmers for their feed value. Combined with a lack of farmer involvement, adoption of exotic trees is often slow. Mulubrhan and Eniang (2009) came to the conclusion that in Northern Ethiopia indigenous multipurpose fodder trees are valued amongst others for their good feed value.

For Central Ethiopia, Mekonnen *et al.* (2009) have used a participatory rural appraisal (PRA) approach to identify preferred tree species for fodder and soil improvement. Their research highlights that "for fodder trees, farmers prefer *Hagenia abyssinica, Dombeya torrida*, and *Buddleja polystachya*" (Mekonnen *et al.*, 2009, p. 175). For soil improvement "farmers selected *Senecia gigas*, *Hagenia abyssinica*, and *Dombeya torrida"* (Mekonnen *et al.*, 2009, p. 175). Thus, their study showed that farmers have deep knowledge on different possibly beneficial properties of trees and choose trees in their farming system accordingly.

In terms of household functions derived from trees, two significant studies have been conducted in Tigray. As part of a larger study with the focus on the extent of *F. Albida* across different ecological zones of Ethiopia Hadgu *et al.* (2011) found through that farmers derive the following benefits from the tree: "fertility improvement (95%), soil moisture retention (90%), rain water infiltration (88%), bee forage (80%) and livestock feed (88%)" (p. 9). In a more recent study, Guyassa and Raj (2013) conducted a focused questionnaire survey with 35 participants in Abreha we Atsbah, that found that the major benefits derived from trees in general were "fuelwood, conservation, shade, fencing, construction, farm tools, fodder, fruit and medicine" (p. 829). However, the functions are only named, not discussed or contextualized.

2.4 Agroecology

In this thesis, agroecology is understood as a combination of the definitions by Francis *et al.* (2003, p. 100) and Gliessman (2007, p. 18) below:

> "*We define agroecology as the integrative study of the ecology of the entire food systems, encompassing ecological, economic and social dimensions*" (Francis *et al.*, 2003, p. 100)
>
> *"[...]the application of ecological concepts and principles to the design and management of sustainable food systems"* (Gliessman, 2007, p. 18).

Both refer to the food system as an area of interest and both recognize the interdisciplinarity of agroecology. Thus, this study does not view agroecology as only descriptive of different ecological zones and their agriculture (see e.g. the usage of the term agroecology in Hurni, 1998).

2.5 Multifunctionality

Functional traits, functional biodiversity, and functional groups

On a plot or field scale the idea multifunctionality is often related to ecology. It is argued that different organisms provide different ecological functions due to their specific functional traits (de Bello *et al.*, 2010). Thus, if a field is biodiverse, it is more likely to provide multiple functions (Byrnes *et al.*, 2014). To design a multifunctional field, organisms can be chosen due to their functional traits (Costanzo & Barberi, 2014; Moonen & Bàrberi, 2008). The easiest way of doing so is by dividing them into functional groups, though grouping all those organisms with similar functional traits together (de Bello *et al.*, 2010; Moonen & Bàrberi, 2008). Then, different functional groups can, depending on the management goals of the designer, be combined to achieve the right level of multifunctionality (Diaz *et al.*, 2011; Moonen & Bàrberi, 2008).

Along this line, Diaz *et al.* (2011) have established a framework to connect ecosystem services and social actors. This starts with having social actors involved in developing criteria for relevant functional diversity and traits that can be associated to this diversity. This is then compared with expert information on ecosystem services. In consecutive steps, the ecosystem services are prioritized and then integrated with suitable land use systems.

Multifunctional landscapes

The concept of multifunctional landscapes refers to landscapes that provide more than just one output. Most commonly this is applied on rural or agricultural landscapes. Here it means that an agricultural landscape should not only provide food and fibre, but even other functions such as cultural, aesthetic, or environmental functions (O'Farrell & Anderson, 2010). As an example, Asaah *et al.* (2011) discuss in their study how a multifunctional landscape approach for agroforestry in Cameroon attempts to not only produce more food but also restore degraded lands and generate economic activities. Multifunctional landscapes are oftentimes the goal of top-down policy decision within rural development, but there have also been examples of bottom-up initiatives to increase the multifunctionality of landscapes (Hart *et al.*, 2015).

Multifunctional agriculture

According to the OECD: "Beyond its primary function of producing food and fibre, agricultural activity can also shape the landscape, provide environmental benefits such as land conservation, the sustainable management of renewable natural resources and the preservation of biodiversity, and contribute to the socio-economic viability of many rural areas. Agriculture is multifunctional when it has one or several functions in addition to its primary role of producing food and fibre." (OECD, 2001, p. 10). These alternative functions (meaning except of production of food and fibre) are oftentimes understood as "non-commodity outputs" (Buttel, 2003, p. 9; Wiggering *et al.*, 2003, p. 8; OECD, 2001, p. 17). This means that farmers have become providers of public goods (Daugstad *et al.*, 2006). Consequently, much policy-making related to multifunctionality has focused on internalizing these externalities (Wilson, 2007).

A common question within this understanding of multifunctionality is whether multifunctionality is something that is automatically supplied as a by-product (supply vision) or whether multiple functions should be supplied in response to a societal demand (demand vision) (Huylenbroeck *et al.*, 2007). There are several ways of classifying the different functions that agriculture can supply. One of the most common ones argues for three different functions: the economic function; the social function; and the environmental function (Huylenbroeck *et al.*, 2007, pp. 16-17; FAO, 1999). However, according to other authors, even such things as food security and safety can be considered functions of agriculture.

Postproductivism and multifunctionality

Multifunctional agriculture is often described as a new paradigm for agricultural policies, especially in Europe (see Huylenbroeck *et al.*, 2007; Losch, 2004), as it opposes the earlier paradigm which put the main goal of agriculture on the production of food or fibre (Wiggering *et al.*, 2003).

Several authors have used this idea of a paradigm shift to relate to questions of productivism and postproductivism. They argue that with the trend towards multifunctionality, the focus of agriculture lies no longer on maximisation of production (Rasmussen & Reenberg, 2015; Wilson, 2009; Wilson, 2007; McCarthy, 2005). One argument for the paradigm shift is that, in fact, multifunctional agriculture is nothing new (McCarthy, 2005). Agriculture and land use have always been multifunctional. Rather, the emphasis of agriculture is shifted from the purpose of producing food and fibre to producing other functions. Wilson (2007) continues on the idea of the paradigm shift and argues that instead of the binary choice, multifunctional vs not not-multifunctional, farming systems should be classified along a "multifunctionality spectrum" (Wilson, 2007, p. 228), from weak to strong multifunctionality. This spectrum has as its absolute extremes at a fully productivist and at a fully non-productivist farm, both of which are practically impossible.

Wilson's theory puts a lot of emphasis on decision-making, especially on the farm level (see Wilson, 2009, p. 272; Wilson, 2007, p. 257). For him, "Multifunctionality is (…) about the link between human decision-making and spatial expression of these decisions on the ground" (Wilson, 2007, p. 257). This idea links back to the paradigm shift: What characterizes multifunctional agriculture is not that it is multifunctional, but that its productive function is considered less important than in other forms of agriculture. So, the main *purpose* of agriculture is shifted. To measure this relative importance of the productive function, Wilson (2007) proposes a temporal transition perspective that takes into account development pathways of farming systems (p. 380). Rasmussen and Reenberg (2015) followed this approach and connect multifunctionality to 'cultivation outcomes'.

Scale and multifunctionality

Scale plays a crucial role for the understanding of multifunctionality. Generally, there are two levels that have to be distinguished: Multifunctionality on a field level, and multifunctionality on a farm or landscape level. On a field level, multifunctionality refers to the effects of functional biodiversity; on any larger level, multifunctionality refers to multifunctional agriculture.

The reason for the divide is that the idea of a function changes between the levels. On the field level a function is an interaction: A legume fixes nitrogen. This function, or functional trait, of legumes can be used by the farmer for his/her management purposes. On any larger level, this function is put into a normative context: Fixed nitrogen can be seen as something beneficial due to reduced $CO2$ and $N2O$ emissions (Jensen *et al.*, 2012), or as something negative, if it contributes to leaching. On this level, it is society who decides whether fixated nitrogen is an attractive function or not. Functions above field level are socially constructed and actor-dependent. The same function might be beneficial to one and detrimental to another actor.

Some authors have tried to link functional diversity on a field level with multifunctionality on a farm or landscape level (Lovell *et al.*, 2010; Gurr *et al.*, 2003). Gurr *et al.* (2003) points out that benefits can well be synergetic along these different levels. In his example of a beetle bank, he argues that there are positive effects on all levels. Lovell *et al.* (2010) highlights that "overall performance of the agricultural system can be improved by combining or stacking multiple functions in the landscape (…), as opposed to a focus constrained by production functions" (p. 329). Consequently, they advocate designing agroecosystems in a way that combines field-scale agroecological effects with a wider landscape multifunctional approach.

2.6 Local knowledge

This study generally uses the FAO definition of local knowledge:

"*Local knowledge is a collection of facts and relates to the entire system of concepts, beliefs and perceptions that people hold about the world around them. This includes the way people observe and measure their surroundings, how they solve problems and validate new information. It includes the processes whereby knowledge is generated, stored, applied and transmitted to others*." (FAO, 2005, p. 7)

There is a number of alternative knowledge type concepts, such as indigenous knowledge, or traditional knowledge. They are very similar to the term local knowledge, however the emphasis is slightly different: Indigenous knowledge refers to the knowledge of people that are indigenous to an area, and traditional knowledge refers to knowledge that has been in the possession of a society for a long time. Both of these are narrower than the term local knowledge which is used in this paper and which in accordance to the FAO (2005) covers both of the others.

Perceptions in this study are considered to be part of knowledge, in the same way as proposed in Midgley (2000). They are understood as "*complex construction[s] by a sentient being in interaction with its environment*" (Midgley, 2000, p. 81). That means that local perceptions are ways of seeing the world for local people.

Local knowledge has become popular both in rural development practice and research. Sillitoe (1998) interprets the rise of local knowledge a little bit exaggeratedly as the beginning of a new grand era for anthropology. He demarcates the area of local knowledge as a classic anthropological interest and advocates for local knowledge to be used in development work: "*It is increasingly recognised that development initiatives that pay attention to local perceptions and ways are more likely to be relevant to people's needs and to generate sustainable interventions*" (Sillitoe, 1998, p. 224).

Most commonly research within local knowledge and the local knowledge system aims to unveil similarities or differences in the understandings of researcher or development workers and local people (Sillitoe, 1998). This has been a common approach even in Ethiopian agricultural research (see Asfaw & Ågren, 2007; Amsalu & Graaff, 2006).

An alternative is research that highlights and tries to understand local knowledge on a rather explorative basis with the intention to use this understanding later for introducing technological alternatives or development projects (Sillitoe, 1998). Even these kind of studies have been conducted in an Ethiopian context (see Mulubrhan & Eniang, 2009; Corbeels *et al.*, 2000).

Local knowledge in Agroecology

Within agroecology local knowledge has received a lot of attention. Commonly local knowledge is viewed in relation to traditional farming methods and relates thus closely to agroecological practices (Altieri, 2002). Traditional knowledge is presented as an alternative to modern technological knowledge and agroecological research into local knowledge aims to understand traditional localized agriculture with the goal of finding models to be used elsewhere (Altieri, 2002, p. 3). This trend of extrapolating successful local knowledge is common for the development work of agroecological NGOs as well (Groundswell International, 2016; SOCLA, 2016). In continuation, Altieri (1993) proposes to combine local knowledge with principles based on the academic field of ecology to achieve a locally adapted improved management system. In a similar thought, Berkes *et al.* (2000) point out that scientific and local knowledge are somehow complementary to each other.

2.7 Personal values

> "*What are personal values? Values convey what is important to us in our lives. Each person holds numerous values (e.g., achievement, benevolence) with varying degrees of importance. A particular value may be very important to one person but unimportant to another*"(Bardi & Schwartz, 2003, p. 1208).

Research on the value concept has a long history in social sciences but underwent a revival since the 1960s, much of which is attributed to Milton Rokeach. He proposed that values are "enduring beliefs that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence" (Rokeach 1973, p.5 in Gutman, 1982, p. 63). From this definition, there can be drawn three conclusions: Firstly, values are situation independent, they relate desirable and undesirable situations, and they can either be instrumental or terminal (Gutman, 1982).

Developing Rokeach's thoughts, Schwartz and Bilsky (1987, 1990) propose a new definition of values based upon five essential features:

> "*Values are (a) concepts or beliefs, (b) about desirable end states or behaviours, (c) that transcend specific situations, (d) guide selection or evaluation of behaviour and events, and (e) are ordered by relative importance*" (Schwartz & Bilsky, 1987, p. 551).

In later work Schwartz (2012) adds "*(f) the relative importance of multiple values guides action*" (p. 4). This definition distances itself from the idea of distinguishing between instrumental and terminal values. Schwartz (1994) explains that depending on the situation and personality, the same values can be used as instrumental or terminal.

How do personal values affect behaviour?

The main reason of why it is interesting to research personal values is that they ultimately relate to the behaviour and decision-making of people (Rohan, 2000). The direct connection from value to behaviour is still unclear.

Rohan (2000) suggests a system in which values underlie worldviews which in turn are the background for attitudes and decisions. He describes the value system as a "meaning-producing superordinate cognitive structure" (p. 257) which means that values are an all-time valid guide to what is to be done (Gutman, 1982). In this role, values have been used in Means-End Chain (MEC) research. MEC systems are then handled as "an excerpt from the cognitive structure" (Grunert & Grunert, 1995, p. 211), thus they connect knowledge with meaning. In this way, personal values underlie the rationale for decision-making.

There is an ongoing dispute to whether or not personal values have a conscious effect on behaviour. Rohan (2000) argues that their impact is unconscious to the decision-maker. This idea is largely in harmony with the theory of planned behaviour (Ajzen, 2011; 1991), which sees a person's "behavioural, normative and control beliefs" (Ajzen, 2011, p. 1123) at the heart of decision-making, but acknowledges that these beliefs might be based on personal values.

Value-behaviour relations are complicated as oftentimes a particular behaviour can be based on multiple values at the same time. At the same time, behaviour is influenced by many different factors and not values alone. To determine, whether only conscious decisions are influenced by value priorities, Bardi and Schwartz (2003) conducted studies to check for value-driven behaviour. They conclude that generally people behave in accordance to their values. However, there are notable exceptions: The values security, conformity, benevolence, and achievement were found to have a rather weak connection to related behaviour. Those exceptions are explained by external group pressure (Bardi & Schwartz, 2003).

Personal value priorities, social value priorities & group value systems

This opens up for a fundamental question: How personal are personal values? Rohan (2000) suggests that one should differentiate between three types of value priorities: (1) 'Personal value priorities' are internal to the individual and exclusive to their personality; (2) 'Social value priorities' refer to internal values that are grounded in the social environment, e.g. learned through socialisation; (3) 'Ideological value systems' are group systems and external to the individual. They are concerned with the value priorities that a group should adhere to. Schwartz (2012) adds the interesting thought that group structures such as norms are sometimes accepted due to the fact that individuals score high on the conformity value and not because they coincide with the internal value priorities.

Personal values & attitudes

Often when talking about decision-making, the term attitude is used. Attitudes differ from values as they are situation dependent (Schwartz, 2012; Rohan, 2000). A person can have an attitude towards something. Value priorities on the other hand are situation independent. "Values underlie our attitudes" (Schwartz, 2012, p. 16), which means that they provide a wider frame and rationale for why we have a certain attitude towards something.

Research of farmers' personal values

Whereas there is a large body of research on farmers' perceptions in general and farmers' attitudes, there have been rather few investigations into the personal value priorities of farmers. Except of the MEC studies which are highlighted in section 3.1 *Theoretical framework* (Hansson & Lagerkvist, 2015; Tey *et al.*, 2015; Okello *et al.*, 2014; Lagerkvist *et al.*, 2012), just few researchers have spent their effort on shedding light onto farmers' personal values.

In general, there is research on cognitive processes in agricultural production, especially in terms of decision-making (see Gladwin, 1989), but these most commonly use different decision tree models (e.g. Djalilov *et al.*, 2016; Darnhofer *et al.*, 2005; Darnhofer *et al.*, 1997) which do not reach deep enough into cognitive structures to talk about personal values.

The most common way of measuring farmers' values of e.g. ecosystem services or less structured elements of their environment, is by trying to translate them into monetary values (see Goebel *et al.*, 2000). Kaplowitz (2000) takes a slightly different stand, by qualitatively researching ecosystem services associated with a mangrove forest in Mexico. Still, he does not give any discussion of how to relate the association patterns to higher cognitive structures.

As one remarkable exception that has used the personal value concept on farmers, Schoon and Te Grotenhuis (2000) have done a preliminary study on the personal values that underlie decision-making in terms of farming practice such as organic or conventional. They conclude that "research into values of farmers in relation to their farming practices is possible" (Schoon & Te Grotenhuis, 2000, p. 26) and that personal values were found to have had a large impact on the decisions of some of the farmers.

Another study that sheds some light on the personal values of farmers was done by Griffin and Frongillo (2003). They interviewed New York farmers on their rationale for selling at farmers' markets. Although the study does not take a specifically developed approach towards values, the results and discussion reveal that respondents showed values such as pride and sense of belonging (Griffin & Frongillo, 2003).

3. Theoretical framework

3.1 Means-End Chain theory

Means-End Chain (MEC) theory was originally developed by Gutman (1982) to study decision-making within consumer behaviour. The theory builds on two general assumptions: (1) Personal values are a guiding instrument for behaviour, and (2) products are not desirable as themselves, but they fulfil functions and it is these functions which lead to desirable end-states (Gutman, 1982). Gutman (1982) developed this thought into a cognitive chain, in which Attributes (A) of products are associated with Consequences (C) which in turn are connected to end Values (V). As a consumer, the goal is to satisfy end values and to achieve that, a product with suitable attributes, leading to positive consequences (benefits) is selected. Costa et al. (2004) explain it using the economic concept of a utility, which according to them is ascribed to the "functional and psychological consequences" (Costa et al., 2004, p. 403) delivered by the product, and not to its attributes.

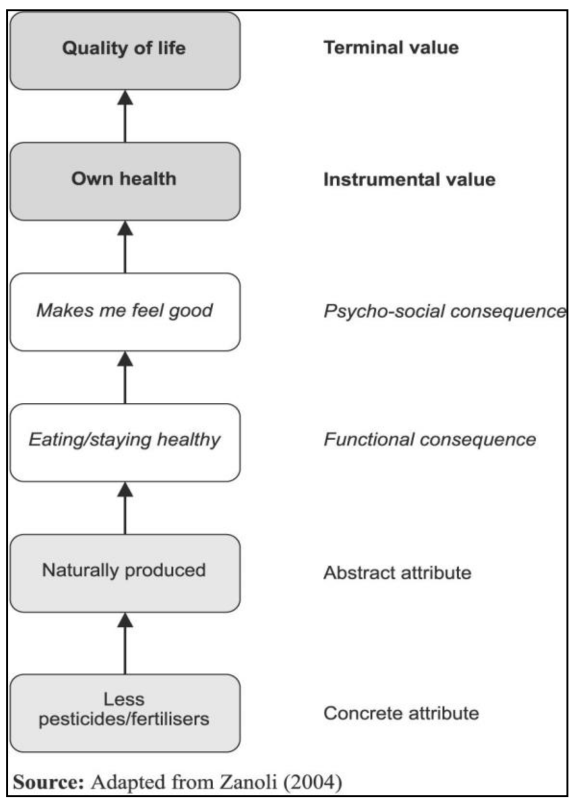

Figure 1 A means-end chain (MEC) in 6 subdivisions as presented in Padel and Foster (2005, p. 613).

Later applications of the MEC theory have sometimes subdivided the A-C-V chain into six hierarchical cognitive levels: a) concrete attributes; b) abstract attributes; c) functional consequences; d) psycho-social consequences; e) instrumental values; f) terminal values (Walker & Olson, 1991). This is illustrated along an organic consumption chain in Figure 1.

Attributes, whether concrete or abstract, are properties that are directly associated with the product. For MEC abstract attributes are oftentimes more interesting as they imply a stronger cognitive relation to consequences and values (Bech-Larsen & Nielsen, 1999).

Consequences can, based on Walker and Olson (1991) take two different forms: Functional consequences and psycho-social consequences. The functional consequences are closely linked to the participant's knowledge of the product, whereas psycho-social consequences relate to the self-image of the participant (Barrena & Sanchez, 2013; Walker & Olson, 1991). Although much literature refers to consequences as benefits (see e.g. Tey *et al.*, 2015), the original framework by Gutman (1982) explicitly highlights that consequences can be desirable or undesirable.

Values, representing the ends in MEC, in the context of the theory refer to personal values. Personal values have a large influence on behaviour (Bardi & Schwartz, 2003; Rohan, 2000) and define the difference between positive and negative consequences. They represent abstract goals, which are "transsituational and inherently desirable" (Lagerkvist et al., 2012, p. 74). Personal values combine the internal perceptions of an individual's needs with the societal expectation of desirability (Lagerkvist et al., 2012). This way, they are different for every person, but still align with a greater value system (Schwartz, 1994).

Personal values and basic needs

Schwartz (1996) has pointed out that at its core all personal values aim for the fulfilment of some basic human needs. There has been a lot of conceptual work on basic human needs (see e.g. the classic conceptualization by Maslow, 1943), which needs not be discussed here. Just for the sake of clarity: This study understands basic needs as access to food, clothing, and housing.

MEC research on farmers' decision-making

Whereas the MEC theory has been used intensively in consumption studies (see e.g. Barrena & Sanchez, 2013; Santosa & Guinard, 2011; Roininen *et al.*, 2006; Padel & Foster, 2005), its application in production decision-making is quite new. Only a handful of studies have started to look at farmers' decision-making processes: Hansson and Lagerkvist (2015) have studied different animal welfare approaches of Swedish dairy farmers using MEC. In earlier studies, Lagerkvist *et al.* (2012) and Okello *et al.* (2014) have studied motivations for the choice of pest management and soil conservation practices respectively in the context of Kenyan peri-urban kale farmers. Most recently, Tey *et al.* (2015) investigated the adoption of Best Management Practices by Malaysian vegetable growers.

The idea of these studies is that farmers make decisions on production methods (means) which provide benefits that move them towards an abstract value (end). The studies emphasize that the MEC model is used to understand the farmers' conscious choices in terms of maximizing their utility (Tey *et al.*, 2015; Okello *et al.*, 2014; Lagerkvist *et al.*, 2012). Utility here again is seen as maximizing the values that are personally important for the farmer. Because these values differ from farmer to farmer, MEC is seen as an alternative to the neoclassical approach of profit maximisation (Okello *et al.*, 2014; Lagerkvist *et al.*, 2012).

For MEC to be used in farmers' decision-making, there are some adjustments that have to be made. Compared to products, farmers' decisions usually lack the attribute component. Lagerkvist *et al.* (2012) and Okello *et al.* (2014) both chose to use the agricultural practices as attributes. This way there is just one attribute for each MEC chain. Hansson and Lagerkvist (2015) and Tey *et al.* (2015) on the other hand used the participants own definitions of attributes associated with the agricultural practice in question.

3.2 Ethnobotany

Ethnobotany falls into the larger scientific discipline of ethnobiology (Anderson *et al.*, 2011) and is at times associated with ethnoecology (Nolan & Turner, 2011). Generally, it is concerned with researching human – plant relationships (Nolan & Turner, 2011; Hamilton *et al.*, 2003). As becomes apparent already from the name, ethnobotany is a holistic (Nolan & Turner, 2011) multidisciplinary approach, stretching from natural to social sciences and using methods that range from participant observation to plant growth experiments (Hamilton *et al.*, 2003; Martin, 1995).

In its original state, ethnobotany was mainly concerned with classifying the botanical information of Native populations (Nolan & Turner, 2011), but lately its applications have found a magnitude of different areas (Hamilton *et al.*, 2003) including agroecology (Anderson, 2011; Martin, 1995; Altieri, 1993). Among ethnobiologists, and ethnobotanists, there is a general understanding that people that are intensely involved with their environment possess considerably experience or knowledge of this environment (Fowler & Lepofsky, 2011; Johnson & Davidson-Hunt, 2011; Nolan & Turner, 2011). This is very much interrelated with the idea of local knowledge, or as it is referred to within ethnobiology "traditional ecological knowledge" (Fowler & Lepofsky, 2011, p. 286) or "indigenous ecological knowledge" (Minnis, 2000, p. 4).

There are different motivations for researching this knowledge, some are more fundamental whereas others are more applied (see Martin, 1995, p. 4 for an overview). These two motivations are visible within agricultural ethnobotanical research as well: Whereas much research has been concerned with mapping agrobiodiversity, cultivars, and landraces (Anderson, 2011), there have also been studies "explaining the many different ways the same crop can be raise[d] – some of which are guided by a desire for greater income, others for sustained yield, and still others for culturally specific purposes" (Ford, 2000, p. 243). Especially in combination with agroecology, there has been an interest in using ethnobotanical/-biological research to integrate local knowledge for improved management practices (see Altieri, 1993).

In relation to multifunctionality, ethnobotanical research has been conducted on home gardens in Mexico (Neulinger *et al.*, 2013) and Southern Ethiopia (Woldeyes *et al.*, 2016), and on wild fruit trees in central Ethiopia (Seyoum *et al.*, 2015).

3.3 Research design

Case study

Case study research is one of the more common research design within social sciences, especially for qualitative research. There is a wide range of what can be considered to be a case, from individuals to organisations, communities or countries. Gillham (2010) offers the following as a definition: A case is

- “*A unit of human activity embedded in the real world;*
- *Which can only be studied or understood in context;*
- *Which exists in the here and now;*
- *That merges in with its context so that precise boundaries are difficult to draw*”

(Gillham, 2010, p. 1)

This definition covers many of the aspects that are considered to be part of case studies also by other authors. Yin (2009), e.g. defines a case study as investigating “contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (p. 18). The defining characteristics of a case from these two definitions are thus: (a) contemporary; (b) real world; (c) in relation to a context; (d) unclear boundaries to this context. Whereas the boundary between phenomenon and context is described as fuzzy, a boundary around the case is considered essential for a case study (Gillham, 2010; Yin, 2009; Cousin, 2005; Stake, 1995). Furthermore, scholars agree on the point that a singular source of evidence is not sufficient to cover enough data for a case study (Gillham, 2010; Yin, 2009).

On other features of case studies opinions differ. Whereas Yin (2009) argues that theory can be beneficial for designing case studies, Gillham (2010) advocates to start a case study with no theoretical presumptions.

Case studies are useful in dealing with a large number of different data sources (Yin, 2009) and encourage the use of different methods such as “interviews, observations, document and record analysis, work samples, and so on" (Gillham, 2010, p. 13). Case studies can cover single or multiple cases (Yin, 2009; Stake, 2006) and can be done quantitatively (Yin, 2009) although they are most commonly applied within qualitative research (Stake, 1995). Oftentimes cases are chosen because of their uniqueness, but even pragmatic considerations such as access have to be considered (Stake, 1995).

Generally, the motivation for conducting case studies is divided into three different categories: “Intrinsic, instrumental, or collective case study” (Cousin, 2005, p. 422; Stake, 1995, p. 3). Intrinsic case studies show interest in a case because the case itself is considered interesting; instrumental case studies use a relevant case to shed light onto a particular situation of which the case is part; collective case studies use instrumental cases to compare and build an overarching understanding of a context. In either way, case studies can be exploratory, descriptive or explanatory (Yin, 2009).

Because of its focus on context and interpretation (Stake, 1995), case studies are sometimes related to ethnographic work (Cousin, 2005). However, Yin (2009) points out that unlike other ethnographic work, case studies do not necessarily require the same amount of time or field work. Nevertheless, there are similarities, especially to the hermeneutic tradition of ethnography as in Geertz (1973) "thick description" (Cousin, 2005; Stake, 1995) which is a description that through the interpretation of context tries to explain behaviour rather than just present it. Both, thick description and case studies require reflexivity in research to achieve validity (Alvesson & Sköldberg, 2009; Stake, 1995).

Research design

This study is designed as an instrumental case study: A particular interesting example consisting of two villages was chosen as a case to gain further insights into agroforestry in Northern Ethiopia. The purpose of the study encompasses exploratory, descriptive, and explanatory features. The chosen sites were real life cases and throughout the study, there has been a high emphasis on the contextual aspects of the case sites. This made the choice of a case study as design appropriate.

Figure 2 conceptualizes the research design and use of concepts of this study. The researcher from the field of agroecology uses a methodology based on MEC theory and ethnobotany to gain data on chosen interest points in the case study. This data is then scrutinised using an analytical frame based upon MEC theory, ideas of multifunctionality, and the researchers own considerations. A thesis is produced with the aim of contributing both to learning in the field of agroecology (and for the researcher himself), and to development or policy work.

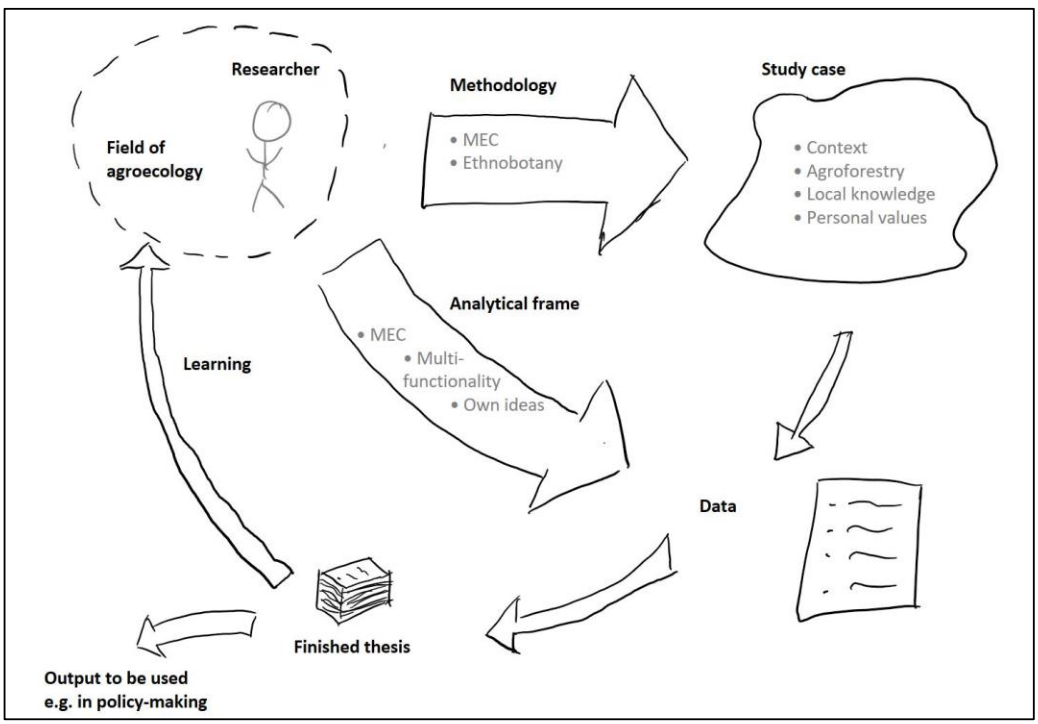

Figure 2 The specified research approach of this study, visualising the combination of different elements presented in the theoretical framework. Based on Checkland and Holwell (1998).

3.4 Materials & methods

Sampling

Data capture for this study took place in two sub-districts (Kebele; alt. Tabia) in Tigray, Northern Ethiopia: Abreha we Atsbah (13.849, 39.534) and Mayberazio (14.123, 38.549) (see Figure 3). Those sites were specifically chosen because two different systems of agroforestry are practiced there. Both sites are considered to be model sub-districts in terms of natural resource management and tree integration. 28 household heads in Abreha we Atsbah, and 27 household heads in Mayberazio were interviewed.

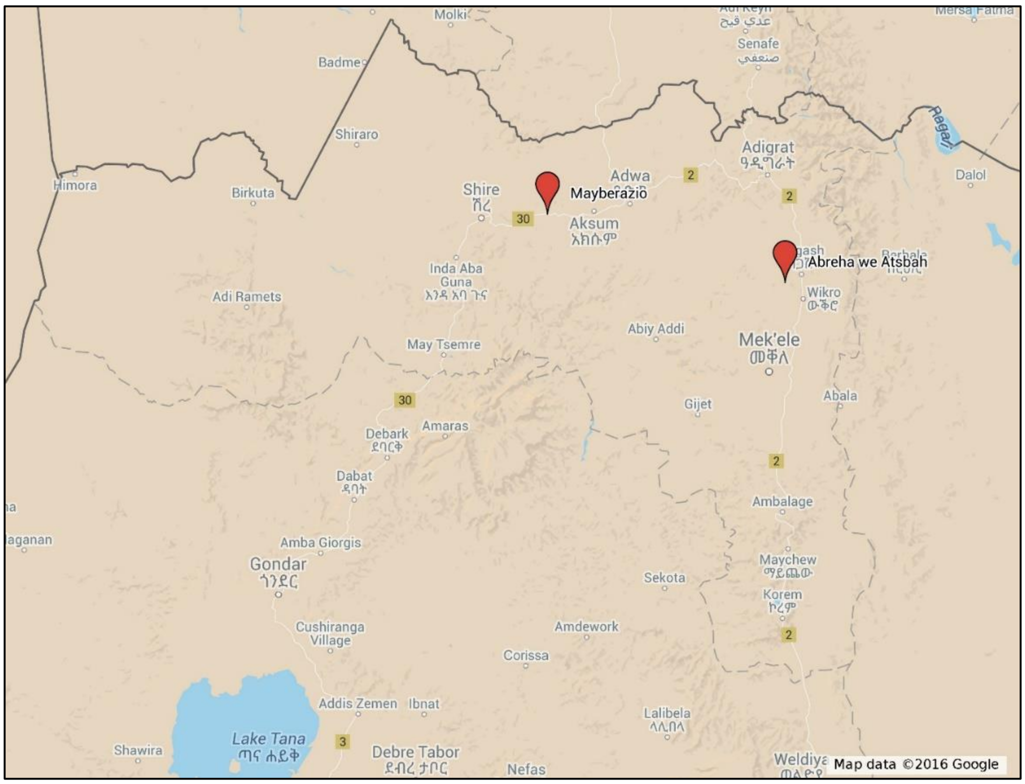

Figure 3 This map shows the location of the two different sites Abreha we Atsbah and Mayberazio in Tigray, Northern Ethiopia. Source: Google Maps.

The general goal of the sampling was to get into contact with a wide range of different households. For this, the sampling of households was stratified (Parfitt, 2005, p. 97) in three dimensions: According to performance, according to sex, and according to geography (see Figure 4). With regard to their performance, farming households in Ethiopia are classified into three different categories, model, medium, and low performers. This classification is not always specific, but local extension services rank households according to participation and implementation of governmental programmes. Male- and female-headed households were chosen from each category. Abreha we Atsbah consists of three different villages and Mayberazio consists of four different villages. Every village was visited and representative numbers of households were interviewed from each village. In each site, there were at least two people interviewed who were comparably urban. In Abreha we Atsbah, these households were classified within one of the three villages, in Mayberazio these households were external to the villages.

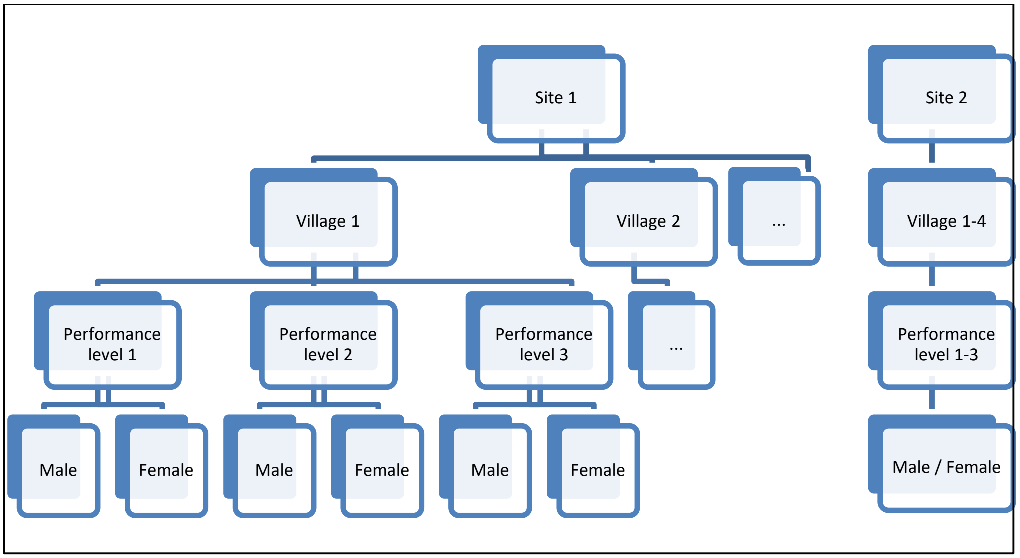

Figure 4 The figure exemplifies the stratified sampling schedule of the study. Both sites were broken down into smaller geographical areas (villages). In each village male and female household heads from three different performance levels were interviewed.

Due to demographics and the decreasing sample sizes of each strata representations are not perfect (see Table 1). Female household heads e.g. are fairly represented in both of the sites but not in all performance levels per village. As an example, in Minda, a village in Abreha we Atsbah, no female household head of the performance levels 2 or 3 was interviewed. In general, the aim was to reach a representation of sexes that is similar to the overall averages of female and male headed household. In this study females were represented with 42.1% in Mayberazio and 33.3% in Abreha we Atsbah.

Table 1 The table shows the sample of participants of the study, broken down into geographical locations, performance levels, and sex.

Site	Village	Level 1	Level 2	Level 3	Male	Female	TOTAL
Abreha we Atsbah	Abrehatsweha	5	5	2	9	3	12
	Minda	4	1	3	7	1	8
	Selam	2	3	3	5	3	8
	Subtotal	***11***	***9***	***8***	***21***	***7***	***28***
Mayberazio	Itanzere	3	3	1	6	1	7
	Adinfas	2	1	3	4	2	6
	Adelahai	2	2	2	4	2	6
	Asiataf	2	2	2	4	2	6
	Urban	1	0	1	1	1	2
	Subtotal	***10***	***8***	***9***	***19***	***8***	***27***
TOTAL		**21**	**17**	**17**	**40**	**15**	**55**

Households were identified with the help of local extension services (Development agents, DA). Initially there was an attempt to randomly pick from a list of households. However, the dataset was incomplete and only covered one of the performance levels. Furthermore, it was difficult to know whether households would be available. So instead, the research team walked out into the village and randomly approached households with the help of the DA. Whenever the household head was available, an interview was conducted.

In addition to the 55 household head interviews, and for gaining a general understanding of the sites, 5 key informant interviews were conducted. In each site, the head development agent and the elected sub-district leader were interviewed. On top of that an expert from a NGO involved with agroforestry in Tigray was interviewed.

Data collection

With a few exceptions, all interviews were conducted at the homestead. This enabled observations of farm practices and basic tree inventories as a means of triangulating information obtained during the interviews.

Picture 1 The picture shows a typical interview situation with the author in the white t-shirt, the interpreter on his left and the interviewee in front of them. In the background is the homestead of the interviewee. Source: Author.

The household interviews lasted between 25-50 minutes. Prior to the interviews, participants were informed about their voluntary anonymous contribution, the study was introduced and, in accordance to recommendations by previous MEC research (see e.g. Okello *et al.*, 2014), it was emphasised that there were no wrong or right answers, but that the study was genuinely interested in the opinions and ideas of the respondents. All interviews were voice recorded with the informed consent of participants. Additionally, notes were taken, especially for the use during the laddering.

For the household interviews an interview guide was designed (see Appendix 1: Interview guide). The guide consisted of two different parts: First, with the help of a structured checklist, key demographics and a basic understanding of the farming system of each household was recorded. During this part, the main species of agroforestry trees were identified. In cases where more than 3 species were mentioned, the three most abundant were chosen as the main species. Second, in a semi-structured interview functions and attributes of present tree species were talked about. In this part, continuous probing was used to reach underlying values that motivate perceived functions. The two themes of this semi-structured interview were: a) What are functions of this tree?, and b) What are negative effects of this tree?. These themes were covered for all main tree species present in the particular farm.

The general approach for the semi-structured interview loaned from the soft laddering interview as described by Reynolds and Gutman (1988) and was inspired by similar studies of farmers' decision-making (Hansson & Lagerkvist, 2015; Tey *et al.*, 2015; Okello *et al.*, 2014; Lagerkvist *et al.*, 2012). However, a couple of adaptations were done in this study.

In accordance with earlier MEC approaches towards farmers' decision-making, free elicitation was used as a starting point of the interview (Hansson & Lagerkvist, 2015; Tey *et al.*, 2015; Okello *et al.*, 2014; Lagerkvist *et al.*, 2012). However, elicitation did not start with attributes, but with functions. From there, "reverse laddering" (Costa *et al.*, 2004, pp. 407-408) to attributes was done. Attributes are easy to highlight when there is a comparison, as there is in most marketing related MEC studies, namely between two products. Since the study does not target a specific choice, attributes seemed difficult to elicit. Thus, the elicitation task resembled the approach employed by Hansson and Lagerkvist (2015) who used the idea of an 'entry concept' instead of eliciting for attributes.

Furthermore, probing was done differently. The general idea of a laddering interview is to continuously probe the participant into considering his/her choice. Although Reynolds and Gutman (1988) and Costa *et al.* (2004) recognize different probing techniques such as negative laddering, their main probe is the question "why is that important to you?" (Reynolds & Gutman, 1988, p. 14). However, this study required a more sensitive probing due to the nature of the research objects. Participants of this study are struggling with substantial needs. When participants reply that functions include basic supply needs such as food provision or housing, asking "why is that important to you?" might seem rather ignorant and invoke the shutting down of the participant. Thus, at some points in the interviews probing consisted largely of understanding alternative pathways and associated trade-offs to fulfilling needs, and at other points a more offensive probing similar to Reynolds and Gutman (1988) was done.

As another adaptation of the soft laddering method, this study used a different approach to qualitative data. In Reynolds and Gutman (1988) and relevant studies (see Hansson & Lagerkvist, 2015; Lagerkvist *et al.*, 2012), the ultimate purpose of the soft laddering interview is to quantify responses. To achieve this, questions are asked quantitatively, similar to a structured questionnaire. In the current study, probing was done conversationally, which means that not every function was probed for in every interview. For some functions, saturation was reached quite quickly, so that no new answers appeared on these functions. For other functions responses were much more diverse. As a result, the quantity of probe questions for the different functions differs.

On the first day of fieldwork, the interview guide was tested on two household heads and evaluated afterwards. Furthermore, after every evening of field work, the author listened to the recording of one of the interviews and evaluated whether there were any issues or changes in the interviews over time. Occasionally during an interview, a new question was tested, in case something new was revealed. A question which was added to the interview guide after a couple of interviews due to the interesting responses it generated was “do you plan to expand on tree xxx?”

All interviews were conducted by using a university staff member as interpreter. Development agents from the village were used as gatekeepers. Gatekeepers were compensated for their efforts with 150 Birr (~7 USD) per day. Participating farmers received two pens and one exercise book per household as a token of gratitude. This incentive was not preannounced but was only given after the interview was concluded. The value of the compensation equals about 1 USD per household.

Analysis

Following the literature on soft laddering interviews, this study employs a content analysis (Reynolds & Gutman, 1988). The content analysis is conducted largely according to the approach described by Costa *et al.* (2004) and Reynolds and Gutman (1988). This type of content analysis can be described as a directed content analysis (Hsieh & Shannon, 2005), also known as a deductive approach to content analysis (Potter & Levine-Donnerstein, 1999).

As a first step, the body of all interviews was divided into specific information regarding each tree species which was collected in separate documents. Then, for each species key responses of interviewees were categorized into the labels product, attribute, consequence, or value (Reynolds & Gutman, 1988). Similar responses within the same label were categorized into codes (Hansson & Lagerkvist, 2015). This was done to make the data more synoptic. In a further step, each code was categorized according to the 6 labels in Figure 1. This yielded 7 different products, 48 concrete attributes, 33 abstract attributes, 18 functional consequences, 11 psycho-social consequences, 5 instrumental values, and 12 terminal values (including basic needs) (see Appendix 2:). As part of the explorative nature of this study, it was important to keep the codes as closely as possible to the formulation of participants. For that reason, it was chosen not to generalize or classify the attributes any further although some of them show similarities.

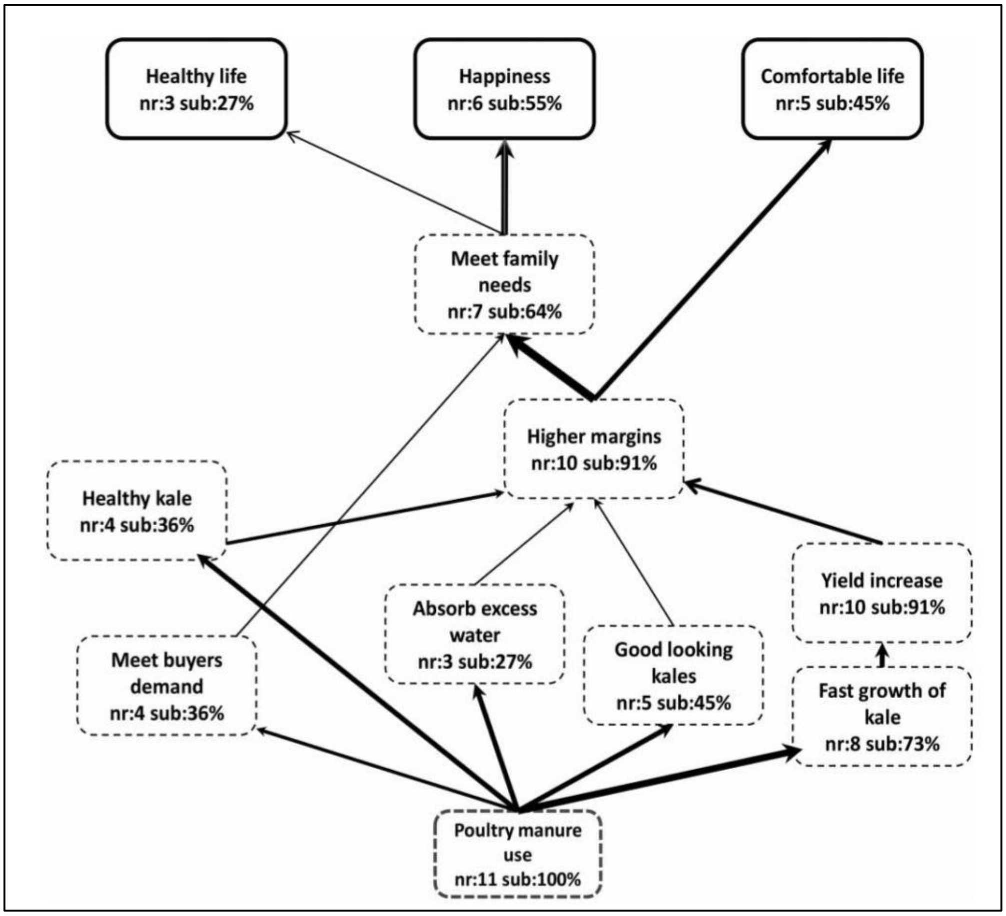

Figure 5 The figure provides an example of how a (quantified) hierarchical value map (HVM) can look like. Source: Okello *et al.* (2014, p. 194)

In the next step, this study deviates from the common MEC content analysis. Whereas other studies quantify the occurrence of codes, labels, and their linkages into a quantitative structure called a hierarchical value map (HVM, see Figure 5) (see e.g. Hansson & Lagerkvist, 2015; Okello *et al.*, 2014; Lagerkvist *et al.*, 2012), this study attempts to qualitatively design such a value map. As this study is largely exploratory, the author did not see any advantage of quantifying responses. Instead, the qualitative nature of responses was emphasized. Going back to the transcripts divided by tree species, the connection between attributes, consequences, and values was noted and translated into a hierarchical map with products at the bottom end and terminal values at the top end.

Such a map was drawn for each tree species. The maps are then described in text. In this thesis only the 9 most relevant tree species are presented. Relevance was determined by comparing the number of households that possessed of the species. This way, the 8 most common species were chosen. One other species (actually a species mix) was included because it is actively encouraged by local extension services to plant it for agroforestry purposes.

Furthermore, general information on the occurrence of tree species and their functions were analysed quantitatively. From the first part of the interviews, quantitative information about the household and relevant tree species was obtained. Such information included household demographics, income sources, as well as information on the trees, such as estimated number and type of agroforestry system. The codes as described above were used to assess the number of functions mentioned. For doing this, functional consequences were compiled into more general functions (see Table 2). There is a lot of overlap but some functional consequences were consolidated, e.g. construction. Shade on the other hand has been divided into beneficial shade and detrimental shade. This has been done to be able to make a difference of shade as a function and as a drawback.

Table 2 The table describes the classification of functional consequences into functions. Green labels signify functions and red labels signify drawbacks.

Functional consequences	**Functions & Drawbacks**
Construction (Farm Equipment)	Construction (total)
Construction (Furniture)	
Construction (House)	
Fuel	Fuel
Capital	Sale (total)
Sale	
Fodder	Fodder (total)
Stabilizes soil	Land improvement (total)
Moisturizes	
Fertilizes	
Fencing	Fencing
Food consumption	Food consumption
Shade	Beneficial shade (total)
	Detrimental shade
-	Miscellaneous
Beautification	Beautification
Bee forage	Bee forage
Resource depletion	Resource depletion
Hindrance to cultivation	Hindrance to cultivation
Housing Ghosts	Housing Ghosts

The quantitative analysis is largely descriptive and was done for three reasons: First, it enabled the author to get an overview of tree functions and drawbacks across different species. Secondly, it was used to identify the most relevant tree species for deepening the qualitative analysis. Thirdly, it gave the possibility to look at differences between sites or tree species.

3.3 Ethical considerations

Research is in any case a power relation. In most cases, the researcher is in a comparatively higher power position than the researched. Especially in the context of developing countries this has led to a general criticism towards research. As part of the reflexivity of this study, the author is fully aware of these criticisms and to a large extent in agreement with them. Large parts of designing the study have been dedicated to holding the level of power injustice to a minimum level. This has e.g. been achieved by using a local knowledge perspective, thus empowering respondents: Their very own knowledge and ideas are lifted in this study and given respectful attention. Thus, the research followed the general guideline to "learn to learn from below" (Spivak, 2013). Furthermore, the author sees that the results of this study should/could be used for a bottom-up development approach.

There had to be compromises too, though. Due to limitations in time and resources, it was not possible to conduct more than what Helmfrid *et al.* (2008) call an extractive participatory action research, although that would have been in line with the authors intentions.

In the field, the researcher employed ethical standards such as informed consent and anonymity, and reflected repeatedly on power situations and his positionality (see Valentine, 2005, p. 113). All interactions in the field were voluntarily. As an example, at a couple of occasions respondents expressed their wishes to keep the interview short. Out of respect for the participants, these interviews were kept considerably shorter than others.

4. Results and analysis

4.1 Setting the case

Site 1: Abreha we Atsbah

Abreha we Atsbah is a sub-district in the Eastern Zone of Tigray. It has a hot semi-arid climate (BSh) according to the Köppen-Geiger scale (Climate-Data.org, 2016a; Hess & Tasa, 2014, pp. 233-235). The sub-district consists of 901 households in three different villages. 219 of these households are female-headed and 682 are male-headed. The average farm acreage is 0.6 ha, and the most common crops are maize, millet, teff, and wheat. Agriculture is the most common way of making a living. Alternative or additional income sources include small businesses, and labour sale.

Abreha we Atsbah is a known model site for agroforestry and natural resource management in Tigray and Ethiopia. In fact, even the local politician from the other site referred to the people of Abreha we Atsbah: *"They are busy on development, ahead of us. So we use to go there to have shared experience"* (Local politician, Male, Site 2). Much of the model character of Abreha we Atsbah, is said to have come from their sub-district leader who has been in office for more than 20 years. According to him, the sub-district was in the end of the 1990's facing severe erosion and drought problems, to a level at which the regional government considered to reallocate the people of Abreha we Atsbah to somewhere else. Through rainwater saving methods and stepwise reforestation the sub-district turned around its water management. These measures were only possible due to the mentality, the willingness to change of Abreha we Atsbah people, and strong leadership.

According to the political leader, one important step was to encourage the natural regeneration of *F. Albida*, which according to the local leader have contributed to land improvement, fodder, and moisture management. From the extension services, this point was confirmed. The informant there raised two additional points that have influenced particularly the agroforestry development in the sub-district: First, Mekelle University demonstrated positive effects of *F. Albida* for crops and livestock in the 1990's. Second, this research was well-received in Abreha we Atsbah, where it found fertile ground in forms of the strong leadership:

"*Overall, there is a government direction, government rules and regulations. But you know, this sub-district has its own rules and regulations. That makes it different from other sub-districts. This sub-district's rules and regulations are very strong. I can tell you one example: One farmer cut F. Albida, completely cut it, claiming that it is his own, and they punish him 4000 Birr. (…) That's why this sub-district is performing better than others. It doesn't mean that F. Albida is not growing in the others."* (Extension service agent, Female, Site 1)

Site 2: Mayberazio

Mayberazio is a sub-district in the Central Zone of Tigray. It is located directly on the main highway that connects the two larger towns Axum and Shire. Although climate conditions are very similar to those in Abreha we Atsbah, it is considered as a subtropical highland climate (CwB) according to the Köppen-Geiger scale (Climate-Data.org, 2016b; Hess & Tasa, 2014, pp. 233-235). There are 1780 households divided into four different villages in the sub-district. 1240 of these households are headed by a male and 540 by females. The average farm acreage is 0.5 ha and the most commonly produced crops are teff, maize, wheat, and beans. Most inhabitants are employed within agriculture, but other livelihood strategies include off-farm labour sale within the construction or mining industries, and migration work to West Tigray.

Mayberazio was part of a programme on natural resources, held by a NGO called Institute for Sustainable Development (ISD), which started approximately 20 years ago. Within this programme reforestation and planting of trees in general was promoted. Over the years, the achievements of this sub-district in form of natural resource management have become nationally acknowledged and Mayberazio has become a model site to which people from all around Ethiopia are invited for experience sharing and learning. As a reason for this success, a positive, development-minded spirit has been ascribed to the people of this sub-district. The local political leader emphasized that his people are successful because they are open-minded towards new development projects. In combination with the natural resource management programme this has led to a very positive attitude towards afforestation: *"If people should live, trees should be there. Otherwise, this is impossible. It's going to be dry and hot, which makes living difficult"* (Local politician, Male, Site 2).

The latest step in the natural resource management of the sub-district meant the introduction of a zero-grazing policy. This policy became effective in 2014. Free grazing, in which livestock are roaming more or less unhindered in the surrounding of households, is rather common in most of Tigray. With the new policy, people are fined if their livestock is found grazing on areas that are off-limits. The local informants from the extensions services and political leadership described the implementation of the policy as challenging but important.

Beyond natural resources, irrigation was mentioned as a key factor of the success of the sub-district. Interestingly, one individual farmer has played a key role in the introduction of irrigation: This farmer used to live and work in Eritrea, where historically irrigation has been much more wide-spread than in Tigray. When he had to leave Eritrea due to the Eritrean-Ethiopian war around the year 1998, he brought his knowledge on irrigation and started the first irrigation activities in Mayberazio. Now, depending on climate between 40-70% of the area in the sub-district has access to irrigation, and the sale of irrigation products has grown to be an important income source for around a third of interviewed participants in Mayberazio. The abovementioned individual has received official awards for his promotional work and model role within irrigation but even within reforestation.

Farming system

The farming system of both sites is fairly similar so it will be discussed together in this section. The description is rather general and follows in its most fundamental steps the Peanut Model as proposed by Bawden and Packham (1993).The agricultural system of almost all participants can be described as a mixed system that includes crop production, animal husbandry, and forestry. Forestry related issues will be described and discussed in detail later.

Mainly cereals for home consumption are grown. Legumes are rather uncommon, although some farmers in Abreha we Atsbah mentioned chickpeas and some in Mayberazio were growing beans. Cereals are usually rotated with each other. Depending on the estimated rainfall, different crops are sown: Maize, millet and sorghum are preferred for wet years, wheat and barley are common in dry years. Different varieties of teff are grown almost every year. Planting starts once the rainy season starts, usually in April for wet years, and in June for dry years.

Animal husbandry is common for all households in the study case. Almost all households keep oxen, many in Abreha we Atsbah keep sheep and cattle. In Mayberazio, goats are most common, followed by cattle. Smaller animals, such as chicken are present in nearly every household. Oxen have somewhat of an exposed role in the farming system as they are mainly used as draft animals for ploughing. In Abreha we Atsbah, it is common to have at least two oxen. In Mayberazio, most households have one oxen and plough the land together with another household that has one oxen. The livestock are mainly fed with crop residue. This is substituted with whatever green fodder is available: Tree products, e.g. foliage or seeds, residues from alcoholic beverages, cactus, etc. During off-season, they are herded to graze on the agricultural plots. Generally, dung is collected. If there are sufficient alternative fuel sources available, dung is used as a manure on the nearest plot to the farmstead.

Seeds are obtained from the government, as far as this study has revealed. Some participants buy fertilizer at the market, but generally fertilizer usage depends on the liquidity of farming households. Irrigation methods rank from manual irrigation to pumping. Most common is an open irrigation canal system. Some few farmers are buying improved livestock.

Most households produce crops only for their home consumption. Surplus may be sold if there is any. An exception are households with irrigation. They commonly produce both cereals for their own consumption, and vegetables as cash crops. Livestock is sold if there is a surplus, or a need to get some cash. Some households, especially in Abreha we Atsbah, have started a business of fattening and selling livestock, either sheep or oxen.

Some participants expressed that they want their children to work with something else than farming. "*Look. Our farm scale is just ox-ploughing which is very small. You can't have radical change by farming. So I want them to have* [a] *better job"* (Male, 49y, Site 1). They acknowledged their own difficulties as farmers and hoped for their children to have some other means of living, preferably in urban areas. "*I regret that I am* [a] *farmer.* (…) *We don't have even sufficient for us to farm. We are not making good. So why should we wish for our children to be here. Rather I'm going to do everything that I can do for my children to have something better"* (Male, 41y, Site 1). However, for themselves, it seemed that they were not interested in leaving the farm.

Conditions for farming are difficult in the sites. Droughts occur regularly, latest in 2015-2016 there was a massive dry period which meant that the raining season was very limited. Culturally, there is a general trend of urbanization. Many people, especially youngsters move from the countryside to cities: *"The attitude of the children – they don't even have the intention to be here"* (Male, 58y, Site 2). As a result, the population in the sites is comparatively old. As an indicator for this: The average age of interviewed participants was 50.7 years, in a country where life expectancy at birth currently lies at 53 and 56 years for men and women respectively. Still, urbanization occurs in other ways as well. It is expected that rural areas become increasingly urban. In Mayberazio, this is visible due to its location at the highway: There are a number of shops and businesses next to the roadside. Furthermore, several household heads explained that they were constructing houses next to the roadside. Some of them were intended to serve as a second home, others were intended to be rented out. Rental houses are appreciated because they are safe investments: "*I was thinking about alternative investments. But housing is something that you always find healthy – not diseased, not dying. But if you imagine cars: you might find them crashed or in accidents. And even the livestock is with some risks. But a house is a house"* (Male, 49y, Site 2). In Abreha we Atsbah, several respondents, including the two expert informants, remarked that the main village was about to grow into a semi-urban area. An important development that is tightly connected to this urbanization is the improvement of living standards and a new lifestyle. An elderly respondent in Mayberazio explained it as followed: "*You know, before there was no infrastructure, there was no power* [electricity - Ed.] *there was no other access.*

Nowadays the power is coming and everything is coming to the rural, so we are going to improve the rural." (Male, 55y, Site 2). Modern comforts, which have existed in urban places for a while, such as electricity, television, and comfortable furniture have not gone unnoticed and a number of participants have mentioned their efforts or wishes to gain access to such comforts. "*Look, now I am in the iron bed. I want to transform, to transfer to woody bed* (…)*. And I want to have television, electric baking* (…) *equipment and the like. These are all things that I want to have for improvement."* (Female, 36y, Site 1).

4.2 Agroforestry trees in the case sites

The most prominent trees

As the most common tree species across both sites *Eucalyptus spp.* was present in 46 out of 55 HH. It was even the species which occurred in the largest numbers. An average HH had more than 285 trees (see Table 3).

The average HH of my study had 3.3 different trees. However, HH in Mayberazio showed a higher diversity of trees, with 4.1 different trees, compared to Abreha we Atsbah (2.5 different trees) which was dominated by *Eucalyptus spp.* and *F. Albida.*

Table 3 The table shows the 9 most popular tree species, their distribution over the two sites and the average number of each species that was present per household. This is calculated based only on the households where the tree species actually was present.

Tree species	No. of HH (N=55)	No. of HH Abreha we Atsbah (N=28)	No. of HH Mayberazio (N=27)	Avg. no. of trees per HH
Eucalyptus spp.	46	28	18	285.36
F. Albida	38	28	10	22.09
Acacia Lahay	26	0	26	37.76
Cordia Africana	26	4	22	4.77
Croton Macrostachyus	18	1	17	5.12
Acacia Etbaica	10	10	0	37.57
Ziziphus Mucronata	9	0	9	2.47
Ficus thonningii	6	0	6	3.40
Sesbania Sesban & Leucaena Leucocephala[2]	3	0	3	102.33
Average no. of different trees	**3.309**	**2.536**	**4.111**	

The quantitatively most elicited functions

Across all trees the most common functions derived from trees are construction material (n=54), fuel (n=52), and sale (n=46) (see Figure 6). 45 households declared

[2] *Sesbania Sesban & Leucena leucocephala* are actually two different tree species. However, they are promoted by local extension services to be planted as a mix and as a result, respondents only mention them together.

that they use some tree for fodder and 38 households see that some tree does contribute to land improvement.

For the two different sites the mentioned functions differ (see Figure 6). In Mayberazio functions such as fencing and eating were mentioned considerably more often. In Abreha we Atsbah fodder and land improvement were mentioned more often.

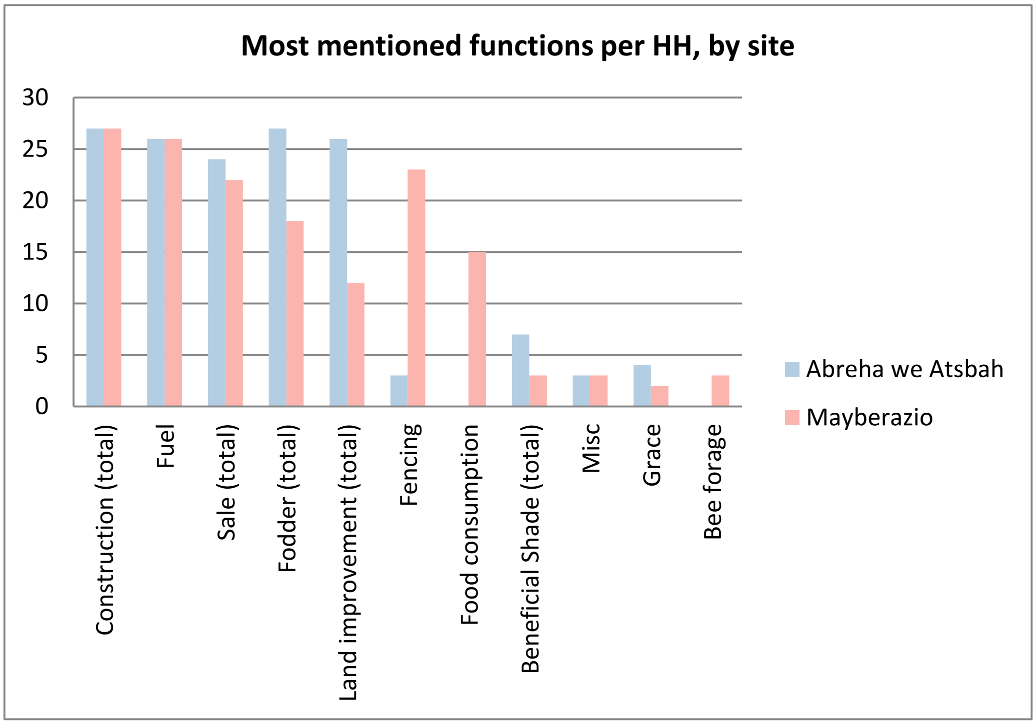

Figure 6 The figure shows the derived functions across trees for all participants in the both sites Abreha we Atsbah (N=28) and Mayberazio (N=27). Each function, even if occurring from multiple trees was counted only once per household.

The quantitatively most elicited drawbacks

Across all trees, the by far most commonly mentioned drawback was detrimental shade (n=43), followed by resource depletion (n=9), hindrance to cultivation (n=7), and housing ghosts (n=3) (see Figure 7). Detrimental shade was commonly mentioned in both sites. Resource depletion was perceived to be more of a problem in Abreha we Atsbah, whereas trees were associated with hindrance to cultivations only in Mayberazio.

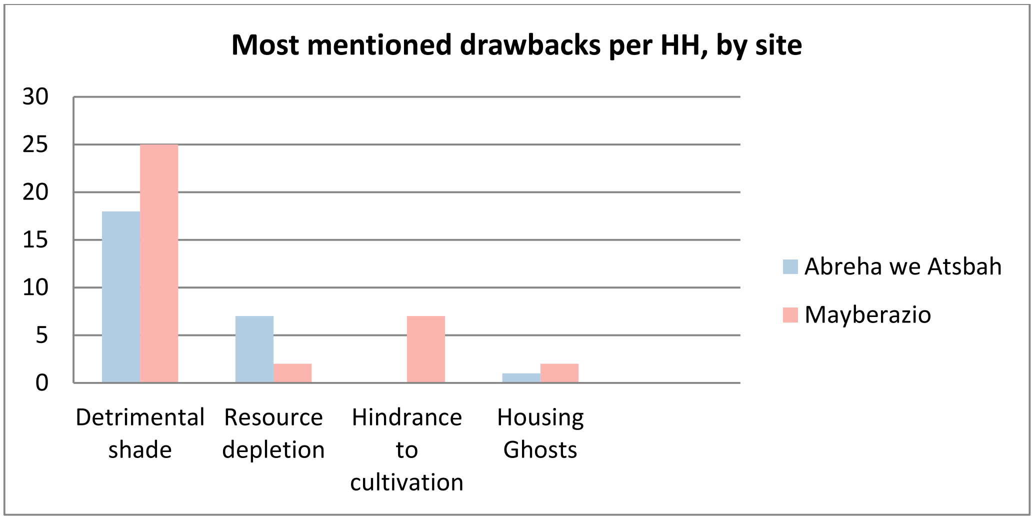

Figure 7 The figure shows the derived drawbacks across trees for all participants in the both sites Abreha we Atsbah (N=28) and Mayberazio (N=27). Each drawback, even if occurring from multiple trees was counted only once per household.

Agroforestry systems

The study classified agroforestry systems into four different categories (see Figure 8):

A. Boundary: trees are found along the borders of agricultural plots, but not within the plots
B. Alley: trees occur along lines through or in between fields.
C. Scattered: trees occur randomly throughout agricultural plots, without any specific geographic pattern
D. Block: trees occur in a larger number and depth in vicinity to agricultural plots

All of the above systems occurred. The choice of system mainly depended on the respective tree species.

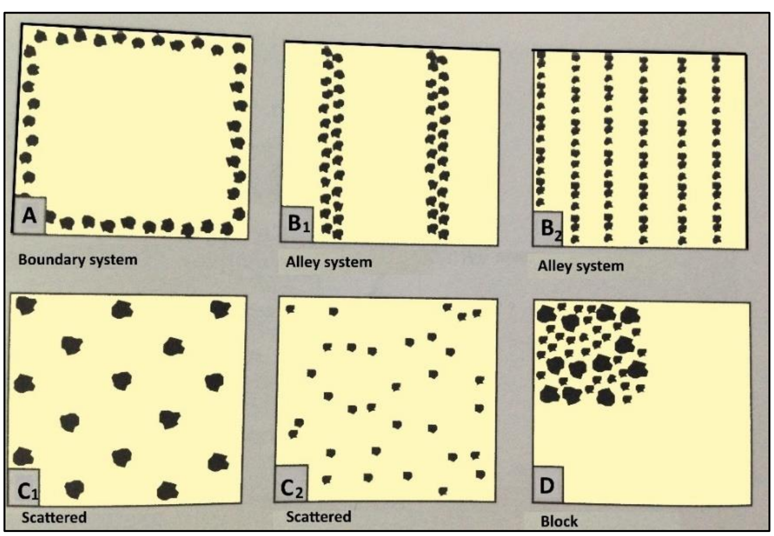

Figure 8 The figure visualises different types of agroforestry systems: Boundary systems (A), alley systems (B_1 & B_2), scattered trees (C_1 & C_2), and a block system (D). Adapted from Gliessman (2007)

4.3 Relevant tree species

Eucalyptus spp.

Quantitative

46 households had got *Eucalyptus spp.*. Numbers ranged from 6 to 2400 trees. The average amount of trees was 285.36.

All households in Abreha we Atsbah, and most households in Mayberazio (n= 18; N=27) mentioned *Eucalyptus spp.*as one of their main trees in or next to their farmland.

Quantitatively, the main functions elicited for *Eucalyptus spp.* were various kinds of construction (n=46), fuel (n=42), and sale (n=40) (see Table 4). Households mentioned on an average 2.68 different functions for *Eucalyptus spp.*.

The main drawbacks where detrimental shade (n=29), and resource depletion (n=9). Households mentioned on an average 1.28 different drawbacks for *Eucalyptus spp.*.

Table 4: The table shows the occurrence of different functions for *Eucalyptus spp.*. Every function was recorded only once per household, and not per occurrence in the interview. The total number of households that mentioned functions is N=50.

Construction (total)	46
Fuel	42
Sale (total)	40
Land improvement (total)	3
Beautification	2
Fencing	1
Detrimental shade	29
Resource depletion	9

Eucalyptus spp. is most commonly found in blocks (n=33) or in the boundaries of agricultural plots (n=30). Only once (n=1) it is found in an alley system.

Qualitative

Eucalyptus spp. provides three different products: wood, foliage, and roots (see the hierarchical value map in Appendix 3: HVM of *Eucalyptus spp.*

Foliage

The foliage of *Eucalyptus spp.* is perceived very negatively. Because of the height of the trees, it throws a long shadow, especially towards the West and East (after sunrise and before sunset). Although it is generally possible to prune the foliage, this only reduces the shade. The shade has been strongly associated with reduced crop productivity. Some participants have argued that the shade exploits resources and this way affect the crop negatively: "*The shade of the Eucalyptus spp. is not good for the crops.* (…) *The shade absorbs things that were for the crop"* (Female, 44y, Site 1). "*The shade of the plant exploits the minerals of the land"* (Female, 45y, Site 1).

Furthermore, the foliage itself is perceived to lead to reduced crop productivity. Participants described that the leaves and litterfall of *Eucalyptus spp.* do not decompose, but instead stay in the soil, similar to plastic: "*The litterfall of the Eucalyptus spp. doesn't allow to grow crops. It's because it doesn't decompose"*

(Female, 45y, Site 1). A couple of times the falling leaves of *Eucalyptus spp.* have been described as "*AIDS for the land*" (e.g. Male, 63y, Site 1) or "*AIDS for the farm*" (Male, 34y, Site 1). Other respondents wondered whether the leaves have some toxic elements that hamper crop performance. For the households, a common response to this problem is to collect all fallen leaves and burn them. Even for the burning, an area far away from agricultural fields is chosen.

The shade and litterfall of *Eucalyptus spp.* have in some instances led to neighbourhood conflicts, as the negative effects sometimes reach beyond the household's farm to the neighbour. Furthermore, respondents have explained that beyond a certain level *Eucalyptus spp.* conflicts with a farming lifestyle.

> "*From now onwards, I don't have land for Eucalyptus spp.. I can't compromise the farm land for Eucalyptus spp..* (…) *There are many things that force you not to compromise. The food for the family and the feed for the livestock are very critical for us. It is for the two of those. For both the livestock and the human, the consumption of the family.* (…) *Everybody has his own plot of land. No one is going to sell you food or sufficient feed for the livestock* (…)*. So better to be* (…) *self-sufficient."* (Male, 52y, Site 2).

> "*I'm going to reduce some of those Eucalyptus spp. that are negatively affecting the farm. I don't have any plans to expand. Because I have sufficient.* (…) *So I should invest on something that gives back soon.* (…) *That's the farm.*" (Male, 34y, Site 1)

Picture 3 The picture shows harvested stems of *Eucalyptus spp.* next to a homestead in Abreha we Atsbah. Source: Author.

Picture 2 The picture shows stems of *Eucalyptus spp.* at the roadside of Mayberazio before they're being sold on to urban areas for construction. Source: Author.

Roots

The roots of *Eucalyptus spp.* were perceived to be very long and strong. Participants explained that they exploit resources and thus lead to reduced crop productivity. "*The rooting system of the Eucalyptus spp. is very, very strong* (…) *and it takes all the nutrients"* (Male, 45y, Site 1). However, they can also stabilize soils, which is made use of in areas close to waterways.

Stems

The stems are one of the most important products of the *Eucalyptus spp.*. They are frequently used for construction and for sale.

The stems are described as light, straight, strong, and long, all of which makes them suitable for construction, particular for iron sheet roofing. However, most importantly, they are critically available:

> "*Before, there was free access construction wood from the open area, from the hillside and the like. But these days, the hillsides are already deforested and enclosed for restoration. So we are entirely depending on the Eucalyptus spp."* (Male, 46y, Site 1).

Eucalyptus spp. is appreciated because it grows quickly. Unlike most native trees, it is legally unproblematic to fell *Eucalyptus spp.*. This means also that *Eucalyptus spp.* is frequently used for different types of farm equipment, even if it's not the most suitable wood quality. *Eucalyptus spp.* is sometimes used for soil roofs or soil walls as well, but unlike other wood types, it is easily affected by termites and thus found to be less durable.

Households explained that growing *Eucalyptus spp.* stems for sale can be very profitable. There is good market demand. The cash generated from *Eucalyptus spp.* sales is associated with a variety of purposes. For some households, it is mainly used for supplementing basic needs, such as buying clothing or spices. Oftentimes, it is seen as a reserve to be used when the household faces problems. This kind of reserve function is also true for *Eucalyptus spp.* trees that haven't been harvested yet: They are sometimes retained as a capital until the household has to get some cash, and then they are felled. For others, *Eucalyptus spp.* sale is associated with a business: Some invest the revenue, either on the farm or to establish a peri-urban business. Both, the money earned through *Eucalyptus spp.* sale and the returns from possible investments are associated with a better life for the household. A common approach for this is through the education of the children. Education is expected to make things easier for the children, to give them relief from the tough farming life and to enable them to lead a life independent of the farm. "*To have some more money for my children to be educated. That's the main target. To see them* (…) *reach the best level.* (…) *To be professionals and to have skill and knowledge and to be self-employed."* (Male, 41y, Site 1)

Branches

The branches of *Eucalyptus spp.* are the most common fuel source for households in the study area. They are described to be suitable as fuel because they are easily flammable, burn without smoke, and most importantly because they are critically available, due to the quick growth of the *Eucalyptus spp.* trees. Some charcoal can be obtained from *Eucalyptus spp.* branches, but in general the charcoal is not of good quality compared to other woods. As a fuelwood *Eucalyptus spp.* is mainly intended for household consumption.

It has also been mentioned that the presence of *Eucalyptus spp.* fuel means that more dung is available to be used as fertilizer, since the dung has not to be used in cooking.

Miscellaneous

Some households grow *Eucalyptus spp.* mainly for sale, whereas most grew it for the household consumption of construction and firewood, and only sold the excess of *Eucalyptus spp.*.

It has been mentioned that a household with many *Eucalyptus spp.* trees is considered a wealthy household: "*If you have more Eucalyptus spp., you have more money*" (Male, 63y, Site 1). Another respondent explained:

> "*It's the Eucalyptus spp. that sustains the living, the livelihood of the people in this village.* (…) *People who don't have Eucalyptus spp. are poor.* (…) *If you don't have Eucalyptus spp., you don't have firewood, you don't have anything to sell which means you are in a big problem. Because the communal lands are all restricted* (…)*. So what do you have as an option otherwise if you don't have Eucalyptus spp.?*" (Male, 65y, Site 2).

Eucalyptus spp. was by one respondent described as an egoistic tree, particularly because of its negative effects on crop productivity. Despite this, even *Eucalyptus spp.* was at one occasion mentioned as a tree that provides beauty to its surrounding.

Table 5: The table shows the occurrence of different functions and drawbacks for *F. Albida*. Every function was recorded only once per household, and not per occurrence in the interview (N=38).

Fodder (total)	35
Land improvement (total)	33
Construction (total)	22
Fuel	17
Beneficial Shade (total)	6
Fencing	5
Misc	2
Sale (total)	1
Detrimental shade	4
Hindrance to cultivation	3
Housing Ghosts	1

Faidherbia Albida

Quantitative

F. Albida was present in 38 households. The number of trees ranged from 1 to 150 trees. The average number of trees was 22.09.

All households in Abreha we Atsbah, but only 10 households in Mayberazio (N=27) mentioned *F. Albida* as one of their main trees in or next to their farmland.

Quantitatively, the main functions elicited for *F. Albida* were fodder (n=35), land improvement (n=33), various kinds of construction (n=22), and fuel (n=17) (see Table 4). Households mentioned on an average 3.18 different functions for *F. Albida.*

The main drawbacks where detrimental shade (n=4), hindrance to cultivation (n=3) and housing for ghosts (n=1). Households mentioned on an average 0.21 different drawbacks for *F. Albida.*

F. Albida is most commonly found scattered on agricultural plots (n=35), and rarely in the edge (n=2).

Qualitative

> *"I plant it mainly for my children. I'm not sure whether I am going to see its products. But its products, I know they are valuable and I expect my children will thank me for having these trees in the farm, will remember me for planting the trees in the farm."* (Female, 67y, Site 2)

Picture 5 The pictures shows a pod of *F. Albida*. Source: Author.

Picture 4 The pictures shows a view into a *F. Albida* tree. Ripe pods (yellow-orange) and unripe pods (green) are visible. Source: Author

F. Albida provides three different products: pods, foliage, and wood (see the hierarchical value map in Appendix 4: HVM of .

Pods

Each spring, the *F. Albida* produces a large amount of seed pods (see Picture 5 & Picture 4). The timing is critical as it's a time period where little alternative fodder sources are available. The amount of pods produced can vary due to weather conditions or treatment of the tree in the previous year. The pods are described as very valuable, largely due to their perceived nutritional characteristics. "*It's fattening.*

It produces more milk. It's like cereals" (Male, 45y, Site 1). "*It's like the food for humans"* (Male, 43y, Site 1). All livestock are perceived to find it comfortable to eat them.

When used as fodder, participants explained the pods improve the performance of the livestock. They're healthier, and get fat more quickly. Furthermore, cattle produce more milk. There have been differing opinions on the milk though. Whereas most participants mentioned that the milk gets generally better after being fed with *F. Albida* pods, one participant noted an odd smell of the milk. Therefore, the milk shouldn't be sold on the market and instead pods were only fed to cows with suckling calves.

Being able to use *F. Albida* pods as fodder relates directly to two instrumental values: First, it allows for the household to keep more livestock year round, because a critical food shortage period can be avoided. Secondly, it can generate cash. A number of participant households associated the pod with selling more livestock. Some even created a fattening business around the *F. Albida* pod, in which they would buy either oxen or sheep in the winter, feed them with the pod, and sell them again a couple of months later.

Cash income from livestock sales could be used for different purposes. On one hand, cash is useful in difficult times. It could be used to substitute basic needs or to solve upcoming problems, such as crop failure. On the other hand, one common reply was to invest the money into the education of the household's children, this way providing for them into the future. Participants argued that education is the way to a better life for children. Other participants even saw a connection of having more livestock with a higher living standard in the household, such as being able to afford new furniture or television.

Even the fact of having more livestock was directly connected to providing for the children:

> "*It's mainly for my children. The children will be benefitted from that.* (…) *If I have a better number of livestock, better productive land* (…) *it will be good for the children.* (…) *At least they have got something to start doing things. They will depend on this to start things, to do their own, to scale it up or do something on those."* (Female, 50y, Site 2)

Some participants mentioned that having more livestock means having more independence: "*Freedom of choice:* (…) *It means I can have what I need.* (…) *I don't want to look from others, from others to share or to beg at a time of shortage or the like"* (Female, 36y, Site 1).

Foliage

The foliage of *F. Albida* is perceived largely beneficial. Many participants explained that crops under the canopy of the tree are automatically fertilized or perform better compared to outside the canopy: "*The crop under the canopy: Near the f.albida and* *outside – totally different! In colour, in performance, in vigour and the like"* (Male, 34y, Site 1). Explanations differ slightly, but most respondents mentioned that the leaves are nutrient rich. Furthermore, they have been observed to decompose quickly. Other participants argued more generally that *F. Albida* is a friendly tree and improves crop performance as part of that friendliness. An important aspect of *F. Albida* as mentioned by participants is that it sheds its leaves in summer. This way, it does not shade crops. Furthermore, some participants associated this shedding with an increase moisture in the soil surrounding the tree.

All three, the nutrients from the leaves, the absence of summer shade, and increased moisture have been associated to improved crop performance, which in turn allows for more harvest. The effect of F. Albida is assumed to be long-term: "*If you compare F. Albida and fertilizers, F. Albida is there for years and fertilizer you use for this year only"* (Male, 34y, Site 1). In few cases participants saw that crops underneath a *F. Albida* could grow too large and produce relatively few seeds. This effect would particularly occur if additional fertilizer or manure was applied to the crops under the canopy.

Depending on the household, sometimes the additional harvest was associated with cash generation. This was the case especially if households were producing cash crops such as irrigation products. For others, the additional harvest was intended to be consumed within the household.

Picture 6 The picture shows an agroforestry system with scattered *F. Albida*. In this system, litterfall from the trees ends up right in the agricultural plot. Source: Author.

Furthermore, *F. Albida* was described to provide relief for the household. One respondent explained that since the tree provides fertilizer by itself, the household has to work less with fertilizing or preparing compost. More commonly mentioned was the shade from *F. Albida*, which was seen as relieving for both farmers and livestock: "*In the dry season, when I plough, I use to have shade under the trees. And I enjoy the shade. Not only me but also the oxen. So it* (…) *gives you a resting time as you have suffered."* (Male, 53y, Site1). Shade provisioning for livestock was described to be important for two reasons: It improves health and performance of the animals, and animals enjoy being in the shade. The latter point was frequently compared to the way humans get relief from the sun.

The leaves of *F. Albida* can also be fed to livestock directly. In Abreha we Atsbah, where *F. Albida* was most common, this only happened when there was an acute shortage of fodder. It was mentioned that pruning the *F. Albida* for fodder would result in a reduced amount of pods the following year:

> "*We know that the leaves are good feed for the sheep, but they have competing uses. The litter fall is very important for the land, and also, if you cut the leaf, next year you might not find sufficient pods. So it's better to use the pods for the livestock and to leave the leaves for the litter fall to produce more pods next year"* (Male, 34y, Site 1).

In Mayberazio, feeding the leaves and branches was more common.

Branches

The branches of *F. Albida* serve three different functions: They can be used as firewood, are used to construct farm equipment, and can be used to create fences. All of the uses relate to household consumption.

As a firewood, the *F. Albida* is not described as particular suitable since it burns with a lot of smoke, which is unpleasant for people close to the fire. It hurts the eyes and can pose a health hazard. Furthermore, the branches of *F. Albida* recover slowly, so frequent harvesting is not possible. Participants explain that they use *F. Albida* branches mainly when they are dry or when more preferable fuel sources are not available or accessible.

For certain parts of farm equipment *F. Albida* is the preferred wood. It is described as strong and light. Furthermore, *F. Albida* trees do not take much damage from being pruned, and they regenerate naturally, which means that they are somehow easily available within the household.

As the branches are thorny, they are sometimes used for fencing. This way they serve to protect staple and cash crops, and straw.

Stems

The stems can be used in different kinds of construction. They are usually only used for household needs. The stem was described as being of a light yet durable wood. Stems usually don't grow straight, but can grow very thick. Traditionally, it was commonly used to serve as certain parts in house construction, such as beams, frames or doors. Many of these doors are still in use. However, it is not allowed to fell *F. Albida* anymore, so the stem has become less available. It can only be felled with the permission of local authorities, e.g. in cases where the tree has died.

Miscellaneous

Participants highlighted that *F. Albida* has very long vertical roots. Because of this, the tree does not pose any direct hindrance for cultivation unless it is occurring very densely. With high density (distance between stems smaller than 10m) cultivation becomes difficult as the oxen cannot move in a straight line while ploughing.

F. Albida was frequently described as a versatile tree.

Even within the same sub-district *F. Albida* was observed to not grow everywhere. Participants explained that on some farms, it just did not establish, even if encouraged or planted. Commonly participants mentioned they did not even try to plant it, because if it was not naturally establishing, that meant that *F. Albida* did not prefer the location anyways.

One participant mentioned that due to its size, *F. Albida* could host evil spirits (similar to C. Africana). However, this participant was careful to highlight that there had been no signs of this in the own household ever.

Acacia Lahay

Quantitative

Acacia Lahay was present in 26 households with numbers that ranged from 2 to 250 trees[3]. The average number of trees was 37.76[4]. The number of *A. lahay* was recorded for each household.

No household in Abreha we Atsbah, but almost all households in Mayberazio (N=27) mentioned *A. lahay* as one of their main trees in or next to their farmland.

Quantitatively, the main functions elicited for *A.lahay* were fuel (n=22), various kinds of construction (n=19), fencing (n=17), and fodder (n=11) (see Table 4). Households mentioned on an average 3 different functions for *A. lahay.*

The main drawbacks where detrimental shade (n=14) and hindrance to cultivation (n=6). Households mentioned on an average 0.58 different drawbacks for *A. lahay.*

A. lahay is most commonly found in the boundaries of agricultural plots (n=23) or in a block (n=11). Only once (n=1), it was found in a scattered way.

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[3] One household with 5000 *A. lahay* trees was excluded. The household in question was an outlier containing 20 times as many *A. Lahay* as the second ranking household. Including this household, the average number of trees would have been 228.62.

[4] See above.

Qualitative

A. lahay provides three different products: foliage, wood, and pods (see the hierarchical value map in Appendix 5: HVM of *A. lahay*).

Table 6: The table shows the occurrence of different functions and drawbacks for *A. lahay*. Every function was recorded only once per household, and not per occurrence in the interview. The total number of households was 26. (N=26)

Fuel	22
Construction (total)	19
Fencing	17
Fodder (total)	11
Misc	1
Sale (total)	2
Land improvement (total)	2
Beautification	1
Bee forage	1
Detrimental shade	14
Hindrance to cultivation	6

Foliage

The foliage of *A. lahay* can be used as fodder, especially for goats. The tree allows pruning and leaves recover once a year.

A. lahay was also described to have a quite intact canopy, especially during the summer. Because of that, it can shade crops and lead to a loss of crop productivity. This can partly be resolved by the location of *A. lahay* outside of agricultural plots. Furthermore, shading effect can be reduced by pruning.

Branches & Stems

The wood of *A. lahay* is described as very versatile. It is used for different kinds of construction, most notably farm equipment and soil roofing, can be sold, used as fuel, or used for fencing.

As firewood, it has been described as the most preferred source by many respondents. It is free of smoke, provides fire for a long time, and produces big amounts of high-quality charcoal: "*Lahay is very good for everything, flammability and charcoal. Its charcoal is very nice for melting iron, to make the plough* (…), *for coffee and the like.* (…) *It's number one*" (Male, 57y, Site 2). However, *A. lahay* woods are rarely available on a level where a household could rely on them solely. As a result, they are used occasionally, or at special events, such as ceremonies when there is a need for a lot of cooking. Mostly, the firewood from *A. lahay* is consumed within the household, but there has also been a household that sold excessive branches or stems to towns. According to this household, there is a good market for *A. lahay* firewood.

In construction the most common use of *A. lahay* is for soil roofing, either for housing or for storage cellars. Participants argued that it is particularly suitable for this purpose because it is resistant to termites. Furthermore, the branches and stems of *A. lahay* are not straight or long enough for other construction. *A. lahay* is used for farm equipment as well, but is not preferred because it wears out.

The branches of *A. lahay* are very thorny and are thus used as fencing material to protect cash and staple crops (see Picture 7). However, it has been mentioned that the rudimentary fences made with *A. lahay* usually only last for maximum one year, as the branches decay quickly.

According to a number of respondents *A. lahay* sheds its thorns. This poses as a problem if the trees are within or in close proximity to agricultural fields, as it can be a hindrance for different farm work and can lead to injuries for adults and children: "*Since its thorns fall, when you weed, it might bite* [sting – Ed.] *you. When you harvest even, it might bite you"* (Male, 52y, Site 2). "*Sometimes you need to visit the hospital or clinic. For all activities, it is not good"* (Male, 65y, Site 2).

Picture 7 The picture shows a close-up of branches of *A. lahay*. The long thorns and the pods are well visible. Source: Author.

Pods

A. lahay produces a pod that can be fed to livestock (see Picture 7). Both sheep and goat can consume it. For sheep, the *A. lahay* pod was described as ok, which means that it sustains them. For goats, the pod was described as good fodder, meaning that they grow faster: "*It's fattening. Their* [the goats' – Ed.] *meat is very nice, for our consumption as well as for the market.* (…) *So that's why we feed these pods"* (Male, 58y, Site 2). Using the *A. lahay* pod as fodder allows for keeping more livestock. Participants associated the improvement in livestock with selling more animals. This helped them to solve household problems or to provide education for their children. With education, respondents argued, the children would be able to have a better life in the city: "*Nothing is here to share. It is just sufficient for me and my wife"* (Male, 58y, Site 2).

Miscellaneous

A. lahay regenerates naturally by itself.

Its roots were described as shallow and lateral, which meant that they could pose as a cultivation barrier if the trees were located to close to agricultural fields. However, one respondent pointed out that in areas further away from the plots, these roots can contribute to an increased soil stability.

Some respondents mentioned that *A. lahay* provided a sort of beautification for their household. Working in a beautiful environment like this, they explained, could make them more productive. Furthermore, some perceived that they gained a sort of satisfaction from this beauty itself.

Cordia Africana

Quantitative

28 Households had got *Cordia Africana*. Numbers ranged from 1 t o15 trees per household. The average number of trees was 4.77.

Only 5 households in Abreha we Atsbah, but 23 households in Mayberazio mentioned *C. Africana* as one of their main trees in and next to their farmland.

Quantitatively, the main functions elicited for *C. Africana* were food consumption (n=14), various kinds of construction (n=11), sale (n=10), and fodder (n=9) (see Table 4). Households mentioned on an average 2.7 different functions for *C. Africana*.

The main drawbacks where detrimental shade (n=10) and housing ghosts (n=2). Households mentioned on an average 0.65 different drawbacks for *C. Africana.*

C. Africana is most commonly found in the boundaries of agricultural plots (n=9). Systems with alleys (n=7) or scattered occurrence (n=5) of trees are common too.

Table 7: The table shows the occurrence of different functions for C. Africana. Every function was recorded only once per household, and not per occurrence in the interview. Although there were a total of 28 households with C. Africana, functions were only mentioned by 20 households (N=20).

Food consumption	14
Construction (total)	11
Sale (total)	10
Fodder (total)	9
Fuel	5
Bee forage	2
Beneficial Shade (total)	2
Land improvement (total)	1
Detrimental shade	11
Housing Ghosts	2

Qualitative

C. Africana provides five different products: foliage, branches, stems, flowers, and fruits (see the hierarchical value map in Appendix 6: HVM of

Foliage

The foliage is associated with two different functions: Since it is decomposable, it contributes to land improvement. Furthermore, it is fresh and can be pruned and thus is used as a supplement fodder. As a fodder the C. Africana foliage improves the general performance and health of livestock. This livestock can then be sold e.g. during drought times.

One drawback of the C. Africana foliage is shade: Because it has shade in the summer season, it can negatively affect the land. However, since the cordia can be pruned, this effect can be reduced.

Branches

The branches of the C. Africana can be used as fuelwood if they are dry or if no other fuel sources are available. "*We mainly use some dry woods from the cordia* (…) *but we don't want to cut it intentionally for fuelwood because we use it intentionally for other purposes*" (Male, 57y, Site 1). Furthermore, they are used in general construction. Both of these functions only are relevant for household consumption.

Stems

Construction is also one of the main functions of the stems. They are suitable for such purposes because they are strong. For households, the common usage of C. Africana stems includes certain parts within house construction, as well as making furniture such as beds. Beds made of C. Africana are considered to be more comfortable and are used to replace clay beds.

Stems can also be sold on the market (see Picture 8). They are valuable because of the quality wood that doesn't decay, and there is a market demand for them. C. Africana can be harvested in times when the household faces problems and the money gained can be used to solve these problems.

Even when there is no specific plan to harvest and sell cordia, the trees are sometimes retained because of the possibility of harvesting them some time in the future. They have been described as investments for the household's children. "*It's a capital good – like you have saving in the bank."* (Male, 47y, Site 2).

According to a participant, a cordia stem can be sold for approximately 6000 Birr (~270 USD), but takes around 50 years to grow to harvestable size. That makes a return rate of 120 Birr (~5.4 USD) per year.

One important aspect of C. Africana is that it's a protected species which is not allowed to be cut without permission. Households indicated that permission can be granted if the household is in existential need.

> "*Now, the problem is there is a restriction by the government* (…). *Now, if you did it, it's illegal. Otherwise, the cordia* [C. Africana, Ed.] *is a very precious resource* (…). *Once upon a time, if I'm challenged, I can sell it having permission*" (Male, 47y, Site 2).

> "*If the people know that you have a problem at home, a shortage, you can ask permission and they allow you to sell"* (Male, 40y, Site 2).

Flower

The flower of the C. Africana was mentioned as bee forage.

Picture 8 The picture shows harvested stems of *C. Africana* in the town of Axum, close to Mayberazio. A local carpenter processes them into furniture. Source: Author.

Fruit

Seasonally, C. Africana produces a fruit which is consumed within the households (see Picture 9). The fruit is sweet and produces a sticky liquid when chewed. As a result of that, it is consumed recreationally: *"It's not something that you consider as a breakfast or as a lunch or as a snack, no. Just simply like you chew chewing gum. It's like that"* (Female, 50y, Site 2). This consumption is associated with a state of relaxation and personal satisfaction. The cordia fruits are most popular with children, but are also consumed by adults. "*When it's ripe, it is sweet. It tastes like honey. So we eat it to get relaxed or to play with it"* (Female, 48y, Site 2).

The fruits are not used as staple food but rather as a nutritional addition, especially benefitting children. One respondent even mentioned that the kernel of the fruit, when swallowed, has medicinal benefits preventing stomach diseases, and thus contributes to the household's health.

Picture 9 The picture is a close-up of the canopy of *C. Africana.* The round yellow fruits, about the size of a hazelnut are well visible. Source: Author.

Miscellaneous

C. Africana is described as slow-growing, but regenerates by itself and does not require planting.

Furthermore, it has been mentioned that C. Africana trees could be possible hosts for evil spirits. According to two respondents, these spirits like to rest in large trees such as C. africama: *"The devils prefer large cordia* [C. Africana, Ed.]*, large Ficus. It's because it is comfortable for them. Otherwise, Eucalyptus spp. and the like is not preferably by them."* (Female, 60y, Site 2). However, this drawback can be prevented by placing metal objects or containers of holy water in the tree.

Croton Macrostachyus

Quantitative

18 Households mentioned that they had *Croton Macrostachyus* on their farm. Numbers ranged from 1 to 20 trees per household. The average number of trees was 5.12.

Only one household in Abreha we Atsbah, but 17 households in Mayberazio mentioned *C. Macrostachyus* as one of their main trees in or next to their farmland.

Quantitatively, the main functions elicited for *C. Macrostachyus* were various kinds of construction (n=7), land improvement (n=3), fodder (n=2) and fuel (n=2) (see Table 4). Households mentioned on an average 2.43 different functions for *C. Macrostachyus.*

The only drawback was detrimental shade (n=6). Households mentioned on an average 0.86 different drawbacks for *C. Macrostachyus.*

C. Macrostachyus is most commonly found in the boundaries of agricultural plots (n=7) or around homesteads (n=3), but even within plots, either in an alley system (n=4) or scattered (n=2).

Table 8: The table shows the occurrence of different functions and drawbacks for *C. Macrostachyus*. Each function was recorded only once per household, and not per occurrence in the interview. Although there were a total of 18 households with *C. Macrostachyus*, functions were only mentioned by 7 households (N=7).

Construction (total)	7
Land improvement (total)	3
Fuel	2
Fodder (total)	2
Sale (total)	1
Beautification	1
Misc	1
Detrimental shade	6

Qualitative

C. Macrostachyus provides three different products: Foliage, branches, and stems (see the hierarchical value map in Appendix 7: HVM of)Appendix 3: HVM of *Eucalyptus spp.*.

Foliage

The foliage is associated with two different functions: Since it decomposes quickly, it contributes to fertilization and land improvement: "*C. Macrostachyus is a kind tree* (…)*. Its litterfall is very decomposable and very good for the land. And then we use to mulch compost by the litter"* (Male, 52y, Site 2). Furthermore, it can be used as fodder. Goats feed on it, but for other livestock it's not very palatable. *C. Macrostachyus* can be pruned and sheds its leaves in March.

Branches & Stems

The branches of *C. Macrostachyus* can be used for farm equipment which is attributed to the fact that they are durable and do not crack. Furthermore, they can be used as firewood. The stems can be harvested as timber and sold on the market.

Miscellaneous

C. Macrostachyus is described to regenerate by itself. Furthermore, it was mentioned that it provides some sort of beautification, partly because it was considered a "kind" tree, and contributes to land improvement.

Acacia Etbaica

Quantitative

10 households had *Acacia Etbaica* on their farms. Numbers of trees ranged from 11 to 100 per household. The average number of trees was 37.57.

A. Etbaica was only found in Abreha we Atsbah and not in Mayberazio.

Quantitatively, the main functions elicited for *A. Etbaica* were fuel (n=7), fodder (n=4), different types of construction (n=3), land improvement (n=3), beautification efforts (n=3) and different shading functions (n=3) (see Table 4). Households mentioned on an average 3.43 different functions for *A. Etbaica.* No drawbacks were mentioned for *A. Etbaica.*

Table 9: The table shows the occurrence of different functions and drawbacks for *A. Etbaica*. Every function was recorded only once per household, and not per occurrence in the interview (N=7)

Fuel	7
Fodder (total)	4
Construction (total)	3
Land improvement (total)	3
Beautification	3
Beneficial Shade (total)	3
Misc	1

A. Etbaica is most commonly found in the boundaries of agricultural plots (n=6). Sometimes the trees are scattered on the fields (n=3).

Qualitative

A. Etbaica provides four different products: foliage, branches, stems, and pods (see the hierarchical value map in Appendix 8: HVM of).

Stems & branches

The stem of *A. Etbaica* can be used as fuel. However, it is protected and not allowed to cut it without permission. Thus, it is not very accessible.

The branches can be used as fuel wood as well. They are popular because they are flammable and caloric, and because they produce a good charcoal which then is used for cooking coffee. Due to the fire wood quality of the A. Etbaica, it is used at ceremonies where oftentimes a lot of cooking and thus a lot of firewood is required. The branches can though also be used for making farm equipment which then is used within the household.

Foliage

The foliage of the A. Etbaica provides two different functions: Firstly, the litterfall is seen as a fertilizer that improves the land. On the other hand, the leaves can also be eaten by animals but they do not contribute a lot to overall animal fodder.

Pods

The pods can be used as animal fodder as well. They improve the performance of goats and can act as fodder for sheep in times of shortage. The pods are not seen as particularly fat or nutritious. They are small and thus difficult to collect.

Miscellaneous

A. Etbaica is known to provide shade which by some is associated to land improvement. Other respondents told that the shade gives livestock relief and improves their performance.

One respondent described that A. Etbaica in general and on a larger scale leads to more rain: "*It's good for having more rain. The more you have these trees, the more you have rain* (…). *We believe that"* (Male, 41y, Site 1).

The tree was also described as providing a beautiful environment, which was associated with happiness. One respondent explained that the beauty of the tree is related to the fact that it grows and regenerates naturally.

It was also mentioned that, although *A. Etbaica* regenerates naturally, it does not do so wherever but has preferences.

Ziziphus Mucronata

Quantitative

Ziziphus Mucronata was present in 9 Households. The amount of trees ranged from 2 to 15 trees per household. The average number of trees was 2.47.

No household in Abreha we Atsbah, but 9 households in Mayberazio mentioned *Z. Mucronata* as one of their main trees in or next to their farmland.

Quantitatively, the main functions elicited for *Z. Mucronata* were fencing (n=14), various kinds of construction (n=4), food consumption (n=3), and fodder (n=2) (see Table 4). Households mentioned on an average 1.86 different functions for *Z. Mucronata.*

No drawbacks were mentioned.

Z. Mucronata is most commonly found in the boundaries of agricultural plots (n=5) or scattered in the plots (n=3).

Table 11: The table shows the occurrence of different functions for *Z. Mucronata*. Every function was recorded only once per household, and not per occurrence in the interview (N=14).

Fencing	14
Construction (total)	4
Food consumption	3
Fodder (total)	2
Fuel	1
Sale (total)	1
Land improvement (total)	1

Qualitative

Z. Mucronata provides four different products: stems, branches, foliage, and fruits (see the hierarchical value map in Appendix 9: HVM of).

Foliage

Respondents explained that one of the advantages of *Z. Mucronata* lies in the fact that it sheds its leaves in the summer season. This leads to an increased litterfall, thus land improvement, and to a minimized shade effect during cropping season.

Furthermore, *Z. Mucronata* has to be pruned for proper growth and the cuttings can be used as livestock feed, which by respondents has been associated with being able to keep more livestock.

Stems & branches

The stem of *Z. Mucronata* can be processed to timber and is then used to produce furniture.

The main function of the branches is their use as fencing material. *Z. Mucronata* is described as a very good fencing material because it has crooked thorns and because it decays slowly and can serve as a fence for up to two years.

Fencing in relation to *Z. Mucronata* was associated with protecting cash crops and livestock fodder both from the own livestock and from 'escaped livestock' that roams freely. Protection of these resources was associated with a higher amount of cash available for the household.

However, the branches of the tree can also be used or sold as firewood. Both of this was attributed to the fact that the tree has to be pruned. Furthermore, it was mentioned that there is a good market demand for *Z. Mucronata* branches.

Fruit

Z. Mucronata produces a fruit which according to respondents is good for children. It is consumed mainly within the household but can even be sold for gaining cash for minor expenses. Consumption of the fruit was associated with providing relaxation and personal satisfaction. One respondent mentioned even that the fruit at times can substitute for smaller meals:

> "*They don't always ask you for* injera [local bread – Ed.]*. Especially as a snack. So they reduce consumption of* injera *as well.* (…) *You see: As a mother I should save, I should be economical. So if they don't ask me again and again especially for a snack, it saves somehow. Which means it's playing a very important role. And the children are not hungry but they are feeding on this."* (Female, 55y, Site 2)

Several participants mentioned that they want to expand on or add *Z. Mucronata* to their farm. Sometimes this was motivated by the need for fencing material, and at other times by the multiple uses of the tree.

Ficus thoninngii

Quantitative

6 Households had got *Ficus thonningii* on their farms. The number of trees ranged from 1 to 20 trees with an average number of 3.40 per household.

No household in Abreha we Atsbah, but 6 households in Mayberazio mentioned *F. thonningii* as one of their main trees in or next to their farmland.

Quantitatively, the main functions elicited for *F. thonningii* were fodder (n=4), and different kinds of construction (n=1) (see Table 4). Households mentioned on an average 1.5 different functions for *F. thonningii.*

Table 12: The table shows the occurrence of different functions and drawbacks for *F. thoninngii*. Every function was recorded only once per household, and not per occurrence in the interview. (N=6)

Fodder (total)	4
Construction (total)	1
Misc	1
Detrimental shade	2

The main drawback was detrimental shade (n=2). Households mentioned on an average 0.50 different drawbacks for *F. thonningii.*

F. thonningii is most commonly found in the boundaries of agricultural plots (n=3) or in the homestead (n=1).

Qualitative

Foliage

The foliage is mainly providing fodder (see the hierarchical value map in Appendix 10: HVM of *F. thoninngii*). Especially cattle can feed on the foliage. The tree produces leaves in large quantities. Leaves contain a sap, which is understood to "soften livestock": "*It is good for their digestive system.* (…) *When they eat F. thoninngii*, *they eat others well.* (…) *They become smooth, with good skin, and also improved body performance"* (Male, 50y, Site 2). As a fodder, foliage of *F. thoninngii* improves the performance of livestock and enables households to have more livestock. "*If we have more F. thoninngii*, *that could feed more. It's obvious we will have more* [livestock – Ed.]" (Male, 50y, Site 2). This additional livestock has been associated with solving problems and challenges when occurring.

One drawback of the foliage is that it can lead to an excess of shade which is detrimental to nearby crops. However, since *F. thoninngii* can be pruned, this effect can be reduced.

Miscellaneous

It has also been mentioned that *F. thoninngii* can be used for making doors.

Saspania & Lucinia (Sesbania Sesban & Leucena leucocephala)

Quantitative

3 Households had got *Sesbania Sesban & Leucena leucocephala*. The number of trees ranged from 50 to 200 trees per household. The average number of trees was 102.33. The number of *S. Sesban & L. Leucocephala* was recorded for each household.

No household in Abreha we Atsbah, but 3 households in Mayberazio (N=27) mentioned *S. Sesban & L. Leucocephala* as one of their main trees in or next to their farmland.

Table 13: The table shows the occurrence of different functions and drawbacks for *S. Sesban & L. Leucocephala*. Every function was recorded only once per household, and not per occurrence in the interview. (N=3)

Fodder (total)	3
Fuel	1
Sale (total)	1
Land improvement (total)	1
Detrimental shade	1

Quantitatively, the main functions elicited for *S. Sesban & L. Leucocephala* were fodder (n=3), fuel (n=1), sale (n=1), and land improvement (n=1) (see Table 4). Households mentioned on an average 2 different functions for *S. Sesban & L. Leucocephala.*

The main drawback was detrimental shade (n=1). Households mentioned on an average 0.33 different drawbacks for *S. Sesban & L. Leucocephala.*

S. Sesban & L. Leucocephala is found in the boundaries of agricultural plots (n=1) and in alleys (n=1).

Qualitative

Foliage

The foliage of the two trees is described to be of high quality (see the hierarchical value map in Appendix 11: HVM of *S. Sesban* & *L. leucophala*)Appendix 3: HVM of *Eucalyptus spp.*.. It can be eaten by all livestock and is used as a moist supplement: "*We use other sources of feed like hay (…) but we need to have the trees, especially the S. Sesban & L. Leucocephala because they improve the quality, the colour, skin"* (Male, 33, Site 2). The foliage needs to be pruned and recovers quickly after pruning. The fodder gained from the two trees improves livestock, saves costs of alternative fodder inputs, and enables the household to be self-sufficient:

> "*This year, since we have the plants we are not buying much* [fodder – Ed.]. *Just we are relying on ourselves. (…) Since we get self-sufficient in livestock feed we don't spend money for livestock feed and we can have surplus, extra money"* (Male, 49y, Site 2).

The foliage can at some point even contribute to land fertility.

The trees can have some shading effect on nearby crops. This shade effect can be reduced through pruning. Due to the need to prune the two trees, they can also occasionally be used as firewood.

5. Discussion

5.1 Tree functions

Explanatory notes on some functions

Physical or social fencing?

Fencing was one of the most mentioned functions in Mayberazio whereas almost nobody mentioned it as a function in Abreha we Atsbah. The reason for this lies partly within the legal preconditions. In Mayberazio, the zero-grazing policy came into action very recently, whereas zero-grazing has been practiced and enforced in Abreha we Atsbah for a long time. As a result, there is almost no need for fencing in Abreha we Atsbah: Letting livestock roam freely is punished. Thus, property is protected through policy enforcement.

This, I reckon is an important step. Effectively, households in Mayberazio spend resources on maintaining their crops. These resources could be used for creating benefits instead. As of now, households choose trees for their farm according to which are the best for fencing. Instead, they could have trees that are good at providing other functions, e.g. land improvement. The zero-grazing policy, once fully established and enforced, is expected to ease this situation. A critical aspect will be that households trust the enforcement of the policy. If a household is not absolutely certain that they will have their fields protected from others livestock, building a fence seems like a better use of resources than improving soils. Building this trust and implementing the policy will take time and might mean fundamental changes to the farming system.

Picture 10 The picture shows *A. lahay* branches used for fencing fruit tree seedlings. A 'fence' of branches is erected around the area in need of protection. Source: Author.

One related aspect that has to be looked at further is the role of goats. In Abreha we Atsbah, there were very few goats. Respondents argued that it was almost impossible to keep goats under the zero-grazing laws, as they are difficult to keep under control. They would wander off, do damage to enclosures or other people's crops, and then the livestock owner would be punished. In Mayberazio goats were the most common mammalian livestock. It is likely that goat owners are going to face problems with their goats escaping, and fines resulting from that. A natural reaction would be to reduce the number of goats for other livestock, as happened in Abreha we Atsbah. The difficulty comes with the fodder. Whereas Abreha we Atsbah has *F. Albida* trees which provide feed for goats, sheep and cattle, Mayberazio relies largely on *A. lahay*, and this tree's pods are mainly good for goats. As a result, the transition from goats to other livestock might be more difficult for Mayberazio. It's a difficult situation which has to be looked into further, as it affects the future success of the newly created zero-grazing policy.

Wood functions: Fuel & construction

Wood functions are the most mentioned functions quantitatively, and even qualitatively they receive a lot of attention. In both sites, wood was mentioned as critical. Rural households in Tigray depend on wood as a fuel source for cooking and there are limited alternatives. Electricity and electric cooking is not available yet. Seen contextually, firewood is a scarce resource. Historically, firewood was collected in community lands, either through gathering of fallen branches or through cutting. But this common resource is decimated and legally off-limits. It seems as if these laws are respected very well in the two study sites.

With common wood sources being off-limits, producing fuel on the farm has become a necessity for households. To the understanding of the author, it is the main priority of having trees on a farm. Basically every household of the study had at least some tree dedicated for fuelwood.

However, this might change. With a trend of increasing infrastructure on the countryside and soon abundant electrical power (due to large national investments on hydropower), there might be possibilities for at least some households to change to electric cooking. This might reduce the demand for fuel wood. The interesting question is how this would influence agroforestry systems. It might change the relative importance of the wood function. It's possible to imagine then that farmers would slowly move to systems that provide other, then relatively more important functions, probably income generating functions. On the other hand, maybe households would have less need for trees in general, which might make them reduce trees on their farms. For other wood functions, such as farm equipment or construction, there will probably be a demand in the future as well.

Shade: Friend or foe?

Shade in the study sites could be perceived very differently. Some trees give good shade, shade that improves the land, supports crops, and gives relief to humans and livestock (see Picture 11). At other occasions shade could be associated with not only hindering crop growth, but degrading the land, and absorbing nutrients. This is interpreted as being the way respondents perceive their surroundings: The radius of shade is likely to coincide with either beneficial or detrimental below ground effects of trees. Thus trees with beneficial below ground effects, nutrient rich litter, or fixed nitrogen might be perceived to have a beneficial shade, whereas trees with detrimental below ground effects were perceived to have detrimental shade.

Picture 11 The picture shows a herd of cattle seeking protection from the sun during midday. They are shaded by a *F. Albida* tree. Source: Author.

Explanatory notes on some values

Provision for children & better life

Providing for the household's children seems to be a main goal for most participants. This provision can take different forms, but education is one of the most common ways. It's expected that education will grant children a better life. This value of a 'better life' has been mentioned most commonly together with the prospects of the children. Mainly, interviewees wanted a better life for their children, not for themselves. This might be influenced by the age of the respondents though: Since many of them were elderly, their efforts might be more focused towards the younger generation.

A better life could mean many different things, and participants were generally reluctant to go into specificities of how better lives look like. A general idea was that children could have more comfort in urban areas and that a good life means that they are self-sustained in what they are doing. Thus, they can lead lives independently from the parental farm.

Generally, security seemed to play a big role for participants. This shows in the idea of a 'better life' being a self-sustained one, but even in other aspects: The generalist farming system, in which underperformances in some sub-systems are weighed up with other sub-systems; a focus on perceived secure investments, such as housing; the popularity of tree species which serve as capital reserve for the future (e.g. *C. Africana*, despite its small return rate).

This is an interesting aspect. There has been a general discussion in development work that smallholder farmers can be risk-averse and reluctant to introduce changes (see Grigsby, 2002). In this study, similar trends have been observed. However, participants of this study have proven to do introduce change as long as it is a change that offers more security.

Basic needs

This study has used the concept of personal values rather loosely. Due to this, basic needs are discussed as values as well. Generally, many functions of trees were connected to basic need provisioning, such as housing, food provision, or clothing. Although most households seem to be self-sufficient, small incomes are oftentimes used for buying clothing or subsidizing food consumption. Housing is largely built with material that can be obtained around the farm. Here wood sources have shown to play a major role.

In a context of subsistence farming, it is not surprising that a large part of household activities is directed to fulfilling the basic needs of the family. This has been confirmed in this study. However, it was also shown that livelihood provision itself is not the only thing valued by respondents.

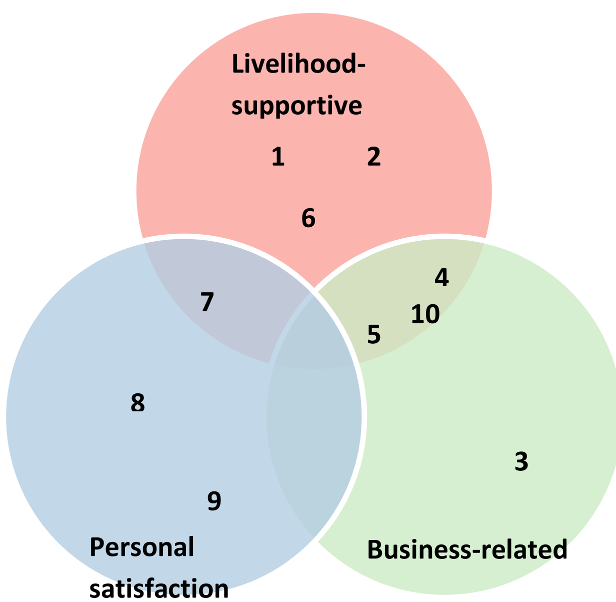
Comparison with earlier research

In the same or similar study area there have been earlier studies on functions of agroforestry trees and particularly on *F. Albida*. Whereas this study has highlighted similar functions as Guyassa and Raj (2013), the results differ largely from what Hadgu *et al.* (2011) has produced. The most likely reason for the difference is the choice of methodology. This current study employed an open interview, thus interviewees were able to express functions with their own words. No suggestions were given. It is assumed that Hadgu *et al.* (2011) used more of a structured approach which allowed respondents to choose among a range of predefined answers. However, the specific methodology is not mentioned.

Generally, in accordance with other research (Mekonnen *et al.*, 2009), this study has found that farming households have an extensive knowledge on trees in their surroundings. This is particular evident in the preferences of specific trees for specific purposes. Farmers design their agroforestry systems with trees that fit their purposes best.

Function groups

There are interesting trends to be seen in connection to the functions. Based on the results from the HVM, the functions can be divided in three different function groups: (1) Livelihood-supportive functions, (2) business-related functions, and (3) Personal satisfaction functions. The livelihood-supportive group are those benefits gained from trees that are connected to the basic household functioning. The business-related group are those functions that are generally used to introduce a substantial change to the households farming system. Personal satisfaction functions are a third group of functions, which aim primarily at the happiness of the household. Some functions are clearly one or the other, whereas other functions can be in the intersection of groups



1. Construction (total)
2. Fuel
3. Sale (total)
4. Fodder (total)
5. Land improvement (total)
6. Fencing
7. Food consumption
8. Beneficial shade (total)
9. Beautification
10. Bee forage

Figure 9 The figure shows the different functions trees provide in the study cases. The functions are classified into three different function groups: Livelihood-supportive; business-related; and personal satisfaction. Source: Author.

(see Figure 9). These hybrids are often household dependent: For some household a specific function might be related to business, whereas it is related to livelihood for another household.

Generally, livelihood-supportive functions seem to be perceived as the most important. Almost equally important were possibilities of making business from the trees. However, it should be considered that it's well possible to have a business without trees, but very difficult to have a livelihood without trees. Personal satisfaction functions received rather little attention from farmers, but were present.

Livelihood or business or both?

For most households of this study it seemed that securing the livelihood was the main goal. This was more or less expected in a context where farming is on a subsistence level. Having trees on or next to farmlands enabled households to better cope with a harsh situation, through e.g. fuel provision, yield increases, or shade provision. Trees made the task of being a farmer in the sites just a little bit easier.

On the other hand, there are some trees that are deliberately used by households to make a difference to their lives. An example of this is *F. Albida*, especially in Abreha we Atsbah: Due to the fodder created by this tree, several households have been able to create considerable cash inflows. This money could then be reinvested in whatever the household was interested in, e.g. housing sector, irrigation, or education.

Trees that could provide these initial boosts to household economy were present in both sites, however patterns were different. *Eucalyptus spp.* was a popular tree for business-related activities in both sites. *F. Albida* was popular in Abreha we Atsbah, and *C. Africana* in Mayberazio.

Those three trees were all found to be very relevant in their own way. The main reason for this is that all three provide both livelihood-supportive and business-related functions. This is assumed to be critical for households. There are limits to livelihood support, as the example of *A. lahay* has shown. This species is seen beneficial and all households in Mayberazio possessed and used this tree. However, for many households, *A. lahay* serves mainly as provider of wood and once these households have sufficient trees to cover their wood needs, they seemed not particularly interested to expand on it. On the other hand, there are limits to business-related trees as well: *Eucalyptus spp.* is not expanded upon beyond the point where it negatively affects farming activities, although it could generate a good profit. Similar reason might lie behind the fact that *S. Sesban & L. Leucocephala,* a fodder business-related species mix, was not very popular among respondents although it had been specifically promoted in one of the sites for decades. It only does one thing, produce fodder, and that seemed not sufficiently interesting for respondents. Studies in other parts of Ethiopia have earlier indicated the importance farmers attribute to using trees for multiple purposes (Mekoya *et al.*, 2008a; Mekoya *et al.*, 2008b).

Hybrids: Fodder & land improvement

Both fodder and land improvement are interesting to look at in relation to livelihood and business, because they are hybrids in this classification.

Depending on the type of fodder and household's management system, tree fodder can either contribute to the basic livelihood or to business related activities. Some trees (e.g. *A. Etbaica*) produce fodder that due to its quantity or quality enables a better sustainment or minor improvement of livestock. Other trees produce fodder that allows for improvement of livestock or enlargement of herds. Here too, it depends on quality, but even on the quantity of produced fodder. Generally, both aspects of tree fodder are important. Which one is more preferable depends entirely on the management strategy of the household.

Land improvement is mainly a livelihood-supportive function because of two reasons: First, most crops are only intended for household consumption. Second, even if a considerable increase in yields could be generated, on farms with average acreages of between 0.5 - 0.6 ha, this surplus could impossibly be enough to introduce a substantial change to the household. The only exception for the livelihood-supportive function is irrigated fields. On fields that have access to irrigation in winter, cash crops such as vegetables are common. These irrigation products are one of the most profitable income sources for households in the study sites. Here, yield increases can make a considerable difference. Thus, in combination with irrigation, land improvement is a business-related function.

Personal satisfaction functions

The role of personal satisfaction functions is not quite clear from the study. As can be seen from the ranking in Figure 6, they were some of the quantitatively least mentioned functions. Furthermore, it seemed as if their importance varied a lot from farmer to farmer. More qualitative research is needed to understand the role of these functions.

Specialisation

Interestingly, agroforestry systems in Abreha we Atsbah are much more specialised than in Mayberazio. The reasons for that are not quite clear and would have to be researched in more detail. One possible explanation is that together, *Eucalyptus spp.* and *F. Albida* provide a portfolio of functions that is sufficient to cover the core interests of farmers. There were other, minor important species present in most farms. As discussed further up, this study focused on the main species and thus, minor species are possibly overlooked.

Concluding the discussion on function grouping

This paper argues that making a distinction between livelihood-supportive, business-related, and personal satisfaction functions is critical for promoting agroforestry in the region. It can serve as a basic communication tool for extension services, and as a strategic method of choosing relevant tree species for agroforestry.

Communication starts with understanding each other. Knowing not only the functions but even the overall goal or outcome of the functions can prove to be very helpful for development workers in the area. Bringing the example of the fruits of *C. Africana*: The function is food consumption, but it mainly serves for personal satisfaction. This detail can easily be overlooked but plays an important role for farmers' management. Another example is land improvement: Promoting trees that are good for the land, e.g. N2 fixing trees, can make sense, but such promotion has to be matched with the goals of the farming household. On small-size subsistence plots, land improvement might not be the most favoured investment for farming households because investing time and effort in the growth of trees might not be worth the return in crop yields.

Furthermore, this study indicates that agroforestry trees are expected to contribute to several farming system goals. If a tree species has to be interesting for farmers, it should contribute to the basic livelihood and create business opportunities. For extension services, as well as for researchers or development programmes, this is an important point to consider. Further research can be applied here to more specifically establish possible trees that fit this particular socio-cultural prerequisite together with contextual ecological prerequisites.

5.2 Multifunctionality

… in agricultural systems

One question that has come up in the process of this study is on the conceptual differences of multifunctionality. What is multifunctional and when can something be considered multifunctional?

The first step is to understand what a function is. There are two for this study relevant views on that. The first one sticks to the OECD definition of multifunctionality and looks at what agriculture contributes to. This approach shall be called function-approach in this study. Within this approach of multifunctional agriculture some authors assimilate functions with ecosystem services. A system that provides more than one service is multifunctional. This is kind of an addition to the regularly cited OECD definition on multifunctionality: The OECD for some reason only refer to the provisioning of food and fibre, and not provisioning in general. This itself is problematic in a time when fuel has become one of the most important outputs of agriculture, when fuel production and food production are inherently competitive agriculture land use systems. Thus, the ecosystem approach – looking at all provisioning functions – seems plausible. There are valid points for using this approach. In this study, e.g. it was found that trees contribute mainly with their provisioning functions, e.g. of fuel and fodder. This is an important finding since different provisioning functions are oftentimes competitive uses. One cannot use the branches of trees for farm equipment and at the same time have them produce a lot of foliage.

Other scholars argue that the functions are defined through the purpose or outcome of the agricultural system. This is called purpose-approach in this study. According to these authors, it’s not the functions itself that make a particular agricultural system multifunctional, but it’s the purpose of the system. They weigh the relative importance of producing food with other functions provided by the system. This can be supported with information from this study: As an example, *C. Africana* fruits should, according to a function-approach, be considered as food provisioning. However, they are valued not for their contribution to food consumption, but rather for the personal satisfaction and tradition of eating the fruits. Thus, from a purpose-approach they should not be considered as part of a provisioning function.

Another critical example is the farming lifestyle that was mentioned a couple of times. This lifestyle is at its core concerned with growing crops and having livestock in a sedentary way. It’s about producing the basic food that the household requires. All participants of this study follow this lifestyle. Even if they have considerable off-farm incomes, they always tend their land for household consumption. Thus, the results of this study are very comparable to the work of Rasmussen and Reenberg (2015) who found that agriculture was an important aspect for households in Burkina Faso even if their main livelihood was built around other businesses. The lifestyle is centred around food production, which according to the function-approach would see it fall under a provisioning category. However, using a purpose-approach producing crops and rearing livestock is primarily part of keeping the lifestyle, thus motivated by cultural considerations.

Both approaches are plausible. But generally, from this study it is the second, the purpose-approach that is the most convincing. The reason for this is that it is helpful for understanding the farming system on a deeper level. Furthermore, the idea of multifunctional agriculture, if viewed through a functions-approach, faces some difficulties. On a most basic level every agriculture is multifunctional, be it industrial pig farming in Denmark, subsistence-agriculture in Ethiopia, or bio-dynamic farming in Germany. Even where it’s most simplified, agriculture provides at its least employment to people, oftentimes rural people. Already this would mean that the OECD definition acknowledges every agricultural system to be multifunctional. Here, the purpose-approach, especially Wilson’s multifunctional spectrum (Wilson, 2009; Wilson, 2007) offers a method of weighing, or differentiating between different levels of multifunctionality.

... on other scales

Apart from multifunctionality on the scale of the agricultural system, there are other scholars that look at the multifunctionality within specific species or the combination of specific species.

Applied on the study case, the question would be: To which extent are agroforestry trees part of a multifunctional agriculture? Accounting for the purpose-approach the question would concern the motives of farmers to include trees. For the function-approach, the question should be whether agroforestry trees contribute to a system that produces more than just food and fibre.

The function-approach can be answered easily by looking at Figure 6. From the perspective of farmers, trees fulfilled provisioning functions for all participants. Furthermore, for a considerable amount of farmers, trees fulfilled supporting services such as beneficial shade, or land improvement. Thus, trees can to a large extent be seen as multifunctional according to the function-approach.

The purpose-approach is more difficult to use in this case. The first question to answer is what are the main purposes of having agroforestry trees in the fields. For almost all trees, the main purposes are connected to provisioning of building material, fuel, or fodder. The only notable exemption is *F. Albida* but even this tree species is primarily planted for fodder and only secondarily for its land improvement features. Thus, agroforestry trees in the study site could be considered as limitedly multifunctional according to the purpose-approach. However, as Wilson has pointed out, the species, or plot scale is not a reasonable scale for looking at multifunctionality within this approach. As discussed in the example of the farming lifestyle, this provisioning can be connected to a multitude of different purposes or outcomes on a household level. If related to the earlier discussion on function groups, it can be argued that trees do very well serve several purposes, namely livelihood support, business, and personal satisfaction. From this perspective, multiple outcomes are aimed for and thus, trees should be considered as part of a multifunctionality in the households' agriculture.

Concluding this section, trees are multifunctional in a function- and in a purpose-approach. Yet they are multifunctional for entirely different reasons. In a function-approach it is largely the land improvement aspect that qualifies for multifunctionality. This land improvement aspect has fairly little contribution in the purpose-approach. It falls under livelihood support, just as e.g. the production of fuel and building material. Instead, functions such as fodder production and sale contribute to multifunctionality within the purpose-approach.

… and functional traits

Functional traits are often used as the ecological link from a species to its multifunctionality potential. This study has not outspokenly used the concept, but can be connected to it. What was identified as attributes in the results section is more or less the participants' perspective on the functional traits of the respective tree species. According to research within MEC (Costa *et al.*, 2004) and studies on functional traits (Wood *et al.*, 2015; Moonen & Bàrberi, 2008) these attributes or traits can be used when looking for improvements of the current system. If for example one looks for alternatives for *Eucalyptus spp.*, one would have to consider which attributes connect *Eucalyptus spp.* to its functions in the perspective of farmers. Furthermore, one might want to add an ecological analysis of functional traits of *Eucalyptus spp.*, similar to the way Diaz *et al.* (2011) have proposed in their framework. A possible alternative to *Eucalyptus spp.* should then match the associated attributes, e.g. fast growth and availability, and ecological prerequisites, e.g. what can grow in the study site.

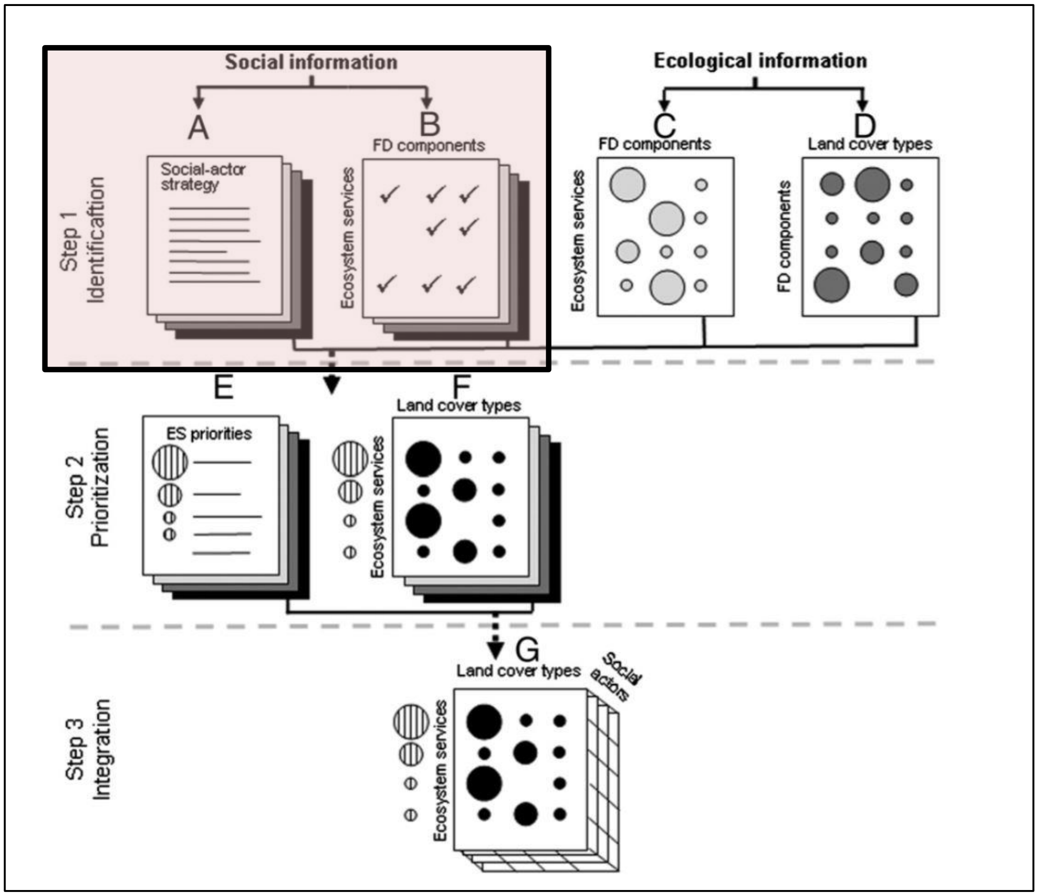


Figure 10 The framework proposed by Diaz *et al.* (2011). In relation, the current study has contributed with social information in Step 1, by both highlighting FD (Functional Diversity) components as seen by social actors' trough attributes and consequences, and giving insights into social-actor strategy through personal value aspects. Adapted from Diaz *et al.* (2011).

Although this study does not undertake such an analysis, the author wants to highlight that the use of MEC, as done in this study, can be a possible methodology to be employed in the first step of Diaz *et al.* (2011) framework (see Figure 10). Here, this study has contributed to providing a possible methodology.

5.3 Outlook and recommendations

Agroforestry is advocated for as a sustainable development practice, with possibly large benefits in Sub-Saharan Africa. This study has argued that an incremental success factor of agroforestry lies in the local knowledge system of farmers. If they perceive agroforestry as beneficial, they are likely to adopt it. Here, careful considerations have to be applied to what is perceived beneficial. First of all, benefits are very context dependent. In the case study, fuel was appreciated even if it meant a certain trade-off from food production (through *Eucalyptus spp.* plantation). Second, benefits should be viewed in the wider perspective of goals and purposes of farming households: Encouraging fertilizer trees ideally benefits farmers through improved yields. However, if the farming household is interested in introducing larger changes and transforming its livelihood, fertilizer might not be sufficient. This is particularly critical for agroforestry systems: Due to the long growing time of trees, households will think extra carefully whether it is worth the effort. So if the encouraged tree species does not exactly fit the purpose of the farmer, adoption is unlikely.

On another note, the study has shown that expected farming outcomes might be very complex. In this case, it was preferred that trees contribute to a business activity, as well as to the basic livelihood system. This complexity seems to lack in some agroforestry programmes. To achieve complexity and relevance of benefits, agroforestry promotion should at least partly employ bottom-up perspectives.

This study finds that agroforestry can have positive effects for farming households in Northern Ethiopia and recommends the development of bottom-up design for agroforestry.

5.4 Methodological approach

Means-End Chain theory has been used in researching farmers' decision-making before and the concept of multifunctionality has previously been used in explaining the multiple outcomes of agriculture. Yet by using Means-End Chain theory in combination with multifunctionality this study was built upon a novel methodological approach. There are interesting conceptual links between MEC and multifunctionality. The benefit of MEC is that it promises to provide a participant's perspective on each of the aspects: What does the participant perceive as being the functional trait or function, and what is his/her purpose for having this function? This social actor involvement has been described as highly important for the development of multifunctional agriculture (Diaz *et al.*, 2011; O'Farrell & Anderson, 2010). Here MEC offers a conceptual methodological way of not just including participants but even understanding their motives. However, it should be noted that as a singular example this study is not sufficient for proving the applicability of the approach. Instead, further research and possibly comparative studies targeting different methodologies should be conducted. Furthermore, there are some remaining question marks.

First of all, the author took a lot of freedom with the MEC theory, especially in terms of data analysis. Results would likely be very different if a quantitative analysis was conducted.

Second, subsistence agriculture has proven to be a system that was not particularly suitable for a MEC approach. Personal values, which are the fundamental behavioural drivers according to MEC theory, are not commonly mentioned as behavioural drivers in subsistence agriculture. Rather, certain decisions are taken based on. This has appeared as a flaw to the MEC approach. Personal values are thought to be a set of guidelines that allow for an individual to achieve its basic needs. In subsistence agriculture basic needs have to be targeted directly in a large amount of everyday activities. For solving this problem, the study has considered basic need fulfilment as a personal value, which strictly speaking is a misinterpretation. However, it was found to enable a comparison of what actions and decisions are directed towards. Furthermore, it was difficult to draw a line of what is basic need and what is not.

Taking housing as an example: To which extent is a new roof basic need and to which extent might it even be a question of status?

Third, laddering was found to be difficult and not always as rewarding as expected. One of the reasons is that at a level of basic need fulfilment further laddering could be offending for participants. This had to be avoided in any case. By using different laddering methods, it was possible to gain insights into higher cognitive levels on most aspects. Still, it is possible that laddering responses were skewed to those answers that participants found easiest to talk about. Children e.g. occurred as a common topic in relation to personal values. It’s very likely that the well-being of children is one of the most important things for participants. But it’s also possible that children happen to be a rather easy topic to talk about. Probably, there’s a little bit of both to it. This can be considered as a cultural aspect that influenced the way communication and thus interviews are guided. Another issue with laddering was that of language and interpretation.

Forth, this study has been largely dependent on the quality of translations. For all communications in the field an interpreter was used. The interpreter was a professional researcher from Mekelle university, having his core expertise in forestry and agricultural land use. This meant, that he was not a professionally trained interpreter. Of course this might have led to an increased margin of error in accurately translating formulations of participants. However, the hired interpreter had worked as such before, was familiar with the method of semi-structured interviews, and had the right expertise for translating terms and issues related to agroforestry. Thus, overall, the author is confident that the quality of the interpretation was high especially for those parts of the interviews that were concerned with the farming system, the trees’ attributes, and the trees’ functions. In terms of personal values associated with the trees, there might have been benefits of being able to access formulations of respondents more accurately or directly. This would though only have been possible if the interview was conducted in the local language. Most importantly the author was aware of this possible lack of communication. Thoroughness and carefulness were applied within the analysis, and especially in terms of personal values, the author has been reluctant to interpret formulations or answers that weren’t entirely clear. Furthermore, direct quotes were intensively used throughout the results section to allow for transparency.

Despite the drawbacks of the approach, the use of MEC theory in this study has proven to be a methodology for highlighting an interesting link between multifunctionality and local knowledge. On a level of personal reflection, the author would like to remark that in the beginning he was not working theoretically deep enough. To the author, it almost seems like sheer luck that everything fell into place much more than expected, especially in terms of the applicability of MEC theory in multifunctionality research. In hindsight, it could have been an advantage to draft a clearer framework between MEC theory and multifunctionality before embarking on the field trip. On the other hand, openness in terms of scientific theory enabled the author to be very flexible and reflexive, in the field and analysis.

6. Conclusion

This study set out to research household perceptions on tree functions in Northern Ethiopia. It was found that *Eucalyptus spp., Faidherbia Albida, Acacia Lahay, Cordia Africana, Croton Macrostachyus, Acacia Etbaica, Ziziphus Mucronata, Ficus Thoningii, Sesbania Sesban* and *Leucaena Leucocephala* were the most prevalent agroforestry tree species in the study sites. Through the application of a MEC-theory influenced framework, it was shown that trees in the study cases are perceived to serve a function as construction material, fuel, wood for sale, fodder, land improvement, fencing material, food consumption, beneficial shade, beautification, and bee forage. They can have drawbacks as they might shade in a detrimental way, deplete resources, hinder cultivation practices or house ghosts. On a level of personal values, trees contribute both to an improved basic livelihood system, to possible livelihood transformation through business creation, and to personal satisfaction. It was shown that the context plays a large role in determining which functions are preferred. The prevalent agroforestry system was argued to be multifunctional due to its multiple contributions to farming outcomes. MEC-theory has shown to have interesting links to the concept of multifunctional agriculture, and is identified as a possible methodology for researching farming decisions in the light of multiple outcomes. Overall, the study has argued that a bottom-up perspective focused on the intentions and purposes of farming households is required to design better agroforestry systems.

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Appendix

Appendix 1: Interview guide

Date of survey: _______________ Number of survey: _______

<u>Interview guide: Personal values of multifunctional leguminous trees</u>

Johannes Ernstberger

<u>Prior to interview:</u>

1. Introduction of myself, my interpreter, any gatekeeper if involved.
2. Introduction of the study: Interested in understanding motivations for integrating trees into agriculture.
3. Informed consent & ethics: This interview is on a voluntary basis. As an interviewee, you do not have to participate, or answer any question you do not want to answer. If at any point during the interview, you would like to stop or finish, just let me know. All information provided in the interview will be handled anonymously.
4. Recording: I would like to voice record the interview. The audio recording will only be used by me and be saved anonymously.

<u>Part 1: Structured checklist</u>

1.	Name of the village	
2.	Name of the head of household? /Level	
	a) Sex	M | W
	b) Age	years
3.	How many household members are there?	No.
4.	How many hectares of land do the household farm?	No.
	a) In how many plots?	
	b) Describe the plots, how do they differ?	

<table>
<tr><td>5.</td><td>What are the main crops farmed per season?</td><td>Current season</td><td>Previous</td><td>Year before</td></tr>
<tr><td>6.</td><td>Livestock/Poultry
a) Which animals are part of the household?
b) How many?</td><td colspan="3"></td></tr>
<tr><td>7.</td><td>What are the main income sources of the household?
a) How much annual?</td><td colspan="3"></td></tr>
<tr><td rowspan="4">8.</td><td>On which plots does the household integrate trees on their farmland?</td><td colspan="3"></td></tr>
<tr><td>a) In which system?</td><td>Scattered</td><td>Alley</td><td>Edges</td><td>Other</td></tr>
<tr><td>b) How many trees all in all? (Approximate)</td><td colspan="3"></td></tr>
<tr><td>c) Which species? (Rank: 1 to ..., 1 for most common)</td><td colspan="3"></td></tr>
</table>

Part 2a: Semi-structured interview, theme 1: Functions of the trees

1. Can you name me some functions / benefits that these trees fulfil?

   If not understand: a) What are these trees good for?
   b) In which ways do you use the trees?
   c) Why do you have those trees here?
   d) What would happen if the trees were not here?
   e) Any more functions of the trees?
2. Which trees fulfil which functions?
   a. What about the tree is fulfilling the function?

In the following, we go through all functions / benefits mentioned by the participant:

3. Why is this function important to you?

   If not understand: a) What would happen if this tree would not provide the function?
   b) In which way does this function help you?

Part 2b: Semi-structured interview, theme 2: Negative effects of the trees

4. Can you name me some negative effects of the trees?

   If not understand: a) What is problematic with these trees?
   b) Are there any conflicts with other farming activities?
5. Which trees have these negative effects?
   a. What about the tree is having he negative effect?

In the following, we go through all effects mentioned by the participant:

6. Why is this effect challenging for you?

   If not understand: a) What could you do if this effect was not there?
   b) In which way does this effect hinder you?

Concluding the interview

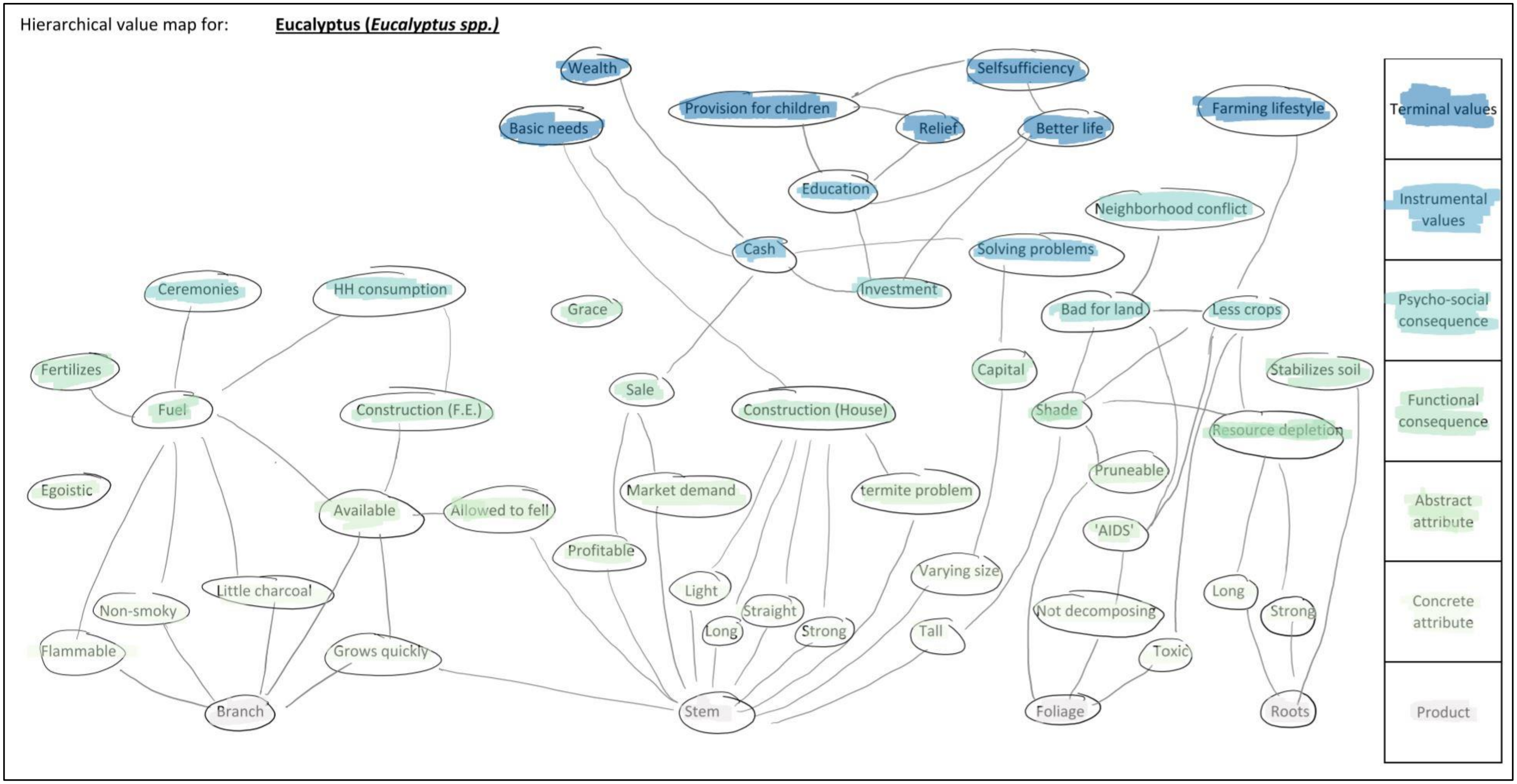
1. Overall, what do you think about using trees within fields?
2. Would you like to add anything to our conversation?
3. Do you have any questions for me?
4. Thank you very much for your contribution!

Appendix 2: List of attributes, consequences and values elicited in the study

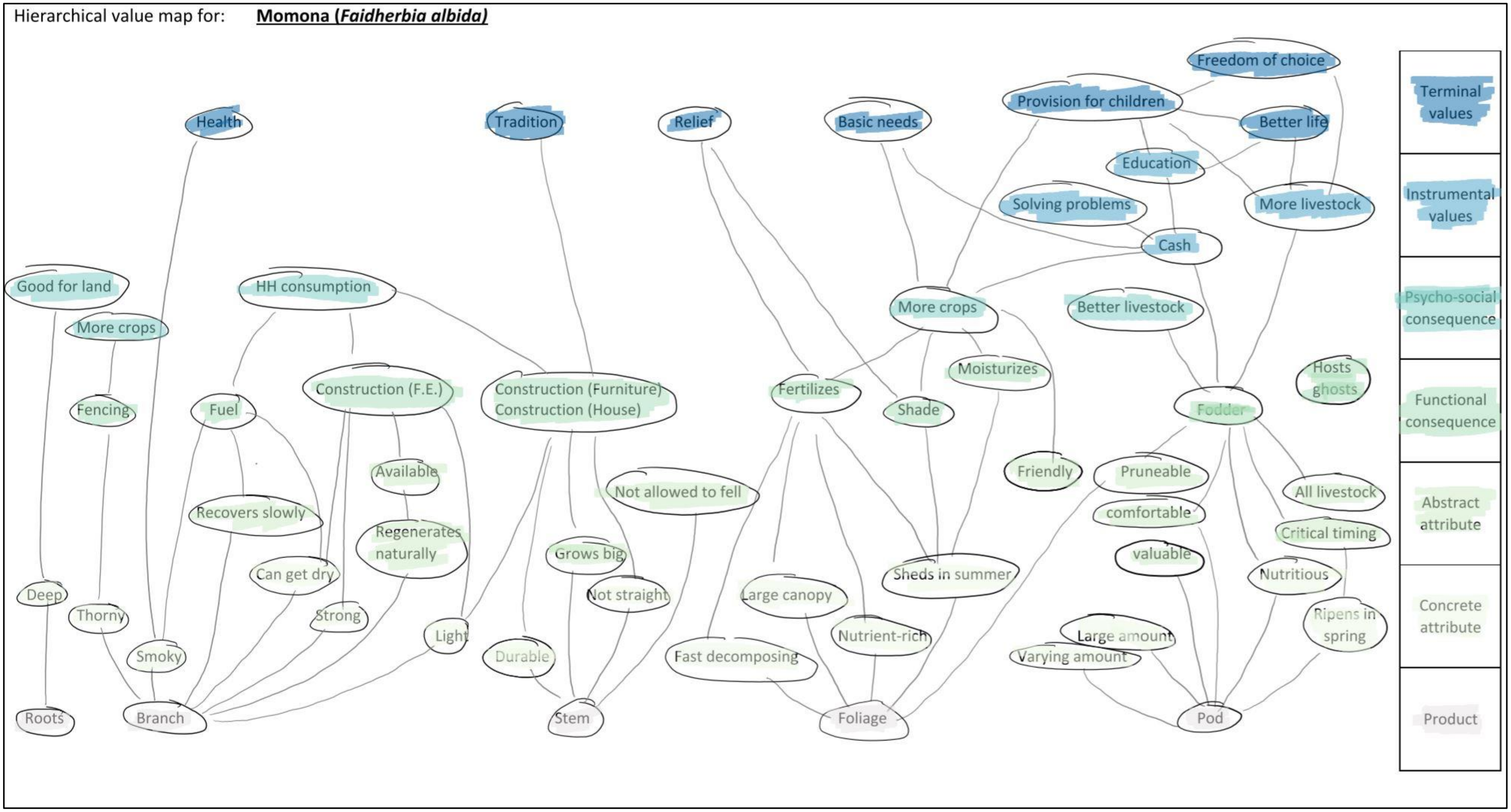
Concrete attribute	**Abstract attribute**	**Functional consequence**	**Psycho-social consequence**	**Instrumental value**	**Terminal value**
Caloric	Termites attack	Bee forage	Better livestock	Cash	Better life
Can get dry	'AIDS'	Capital	Investment	Education	Farming lifestyle
Decays	All livestock	Construction (F.E.)	More crops	More livestock	Freedom of choice
Deep	Allowed to fell	Construction (Furniture)	Neighbourhood conflict	More rain	Health
Doesn't crack	Available	Construction (House)	Good for land	Solving problems	Satisfaction
Doesn't decay	Cattle eat it	Food consumption	Bad for land		Provision for children
Durable	comfortable	Resource depletion	HH consumption		Self-sufficiency
Fast decomposing	Critical timing	Hindrance to cultivation	Less crops		Tradition
Flammable	Difficult to collect	Fencing	Ceremonies		Basic needs
Foliage in summer	Egoistic	Fertilizes	More productive		Relief
Fresh (wet)	Friendly	Fodder	Coffee		Wealth
Grows big	Goats eat it	Fuel			Livestock relief
Grows quickly	Good for children	Beautification			
Tall	High quality	Moisturizes			
Hooky thorn	Limited available	Sale			
Intact canopy	Market demand	Shade			
Large amount	Not accessible	Stabilizes soil			
Large canopy	Not allowed to fell	Hosts ghosts			
Lateral	Not much palatable				
Light	Not staple				
Long	Produces good charcoal				
Non-smoky	Profitable				
Not as fat	Pruneable				
Not decomposing	Recovers quickly				
Not straight	Recovers slowly				

Concrete attribute	Abstract attribute	Functional consequence	Psycho-social consequence	Instrumental value	Terminal value
Nutrient-rich	Regenerates naturally				
Nutritious	Requires pruning				
Little charcoal	Resistant to termites				
Ripens in spring	Serves for longer				
Sap	Sheep eat it				
Seasonal	Supplement				
Shallow	valuable				
Sheds in summer	versatile				
Sheds in spring					
Sheds thorns					
Short					
Slow-growing					
Small					
Smoky					
Sticky					
Straight					
Strong					
Sweet					
Thorny					
Toxic					
Varying amount					
Varying size					
Wears out					

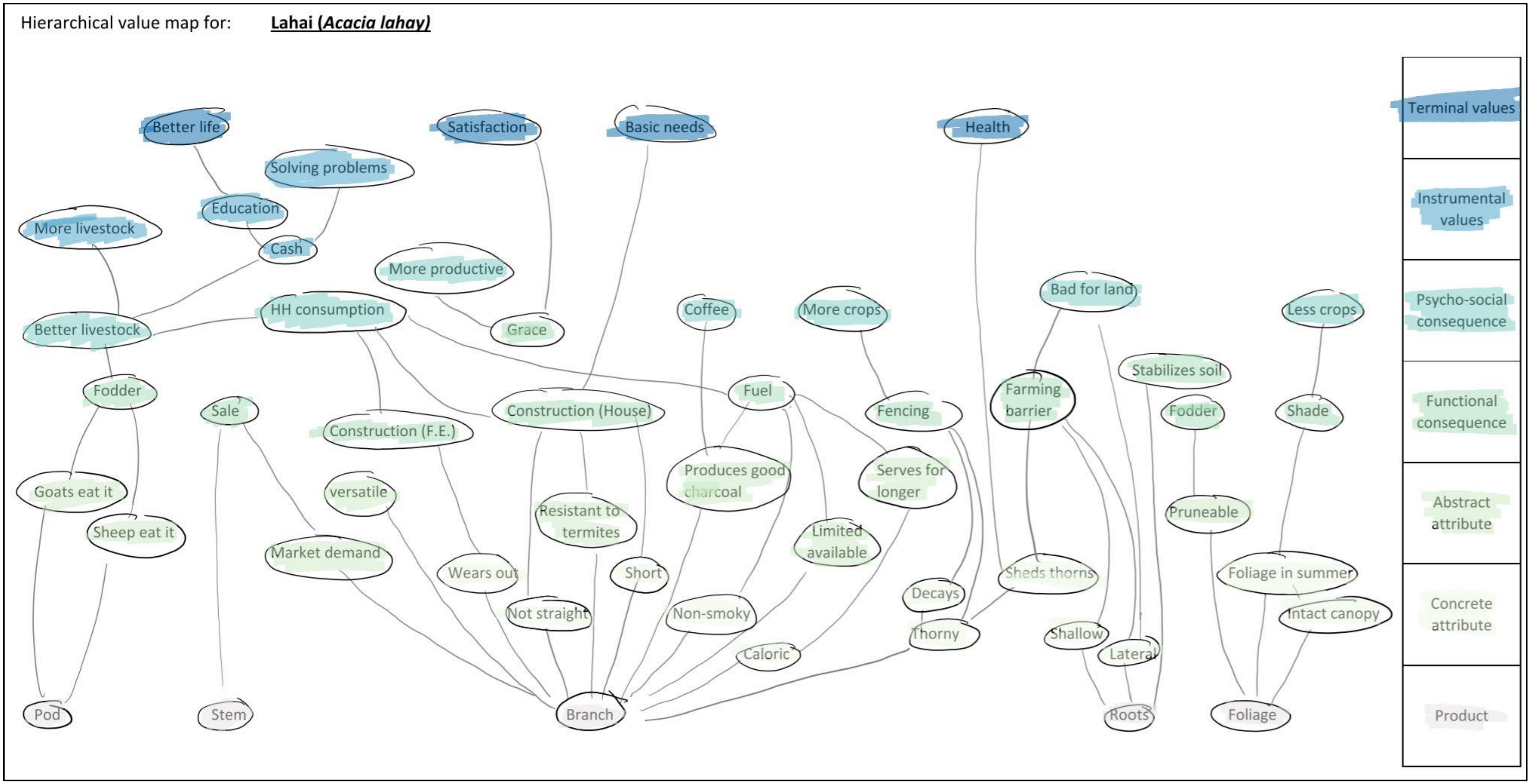
Appendix 3: HVM of *Eucalyptus spp.*



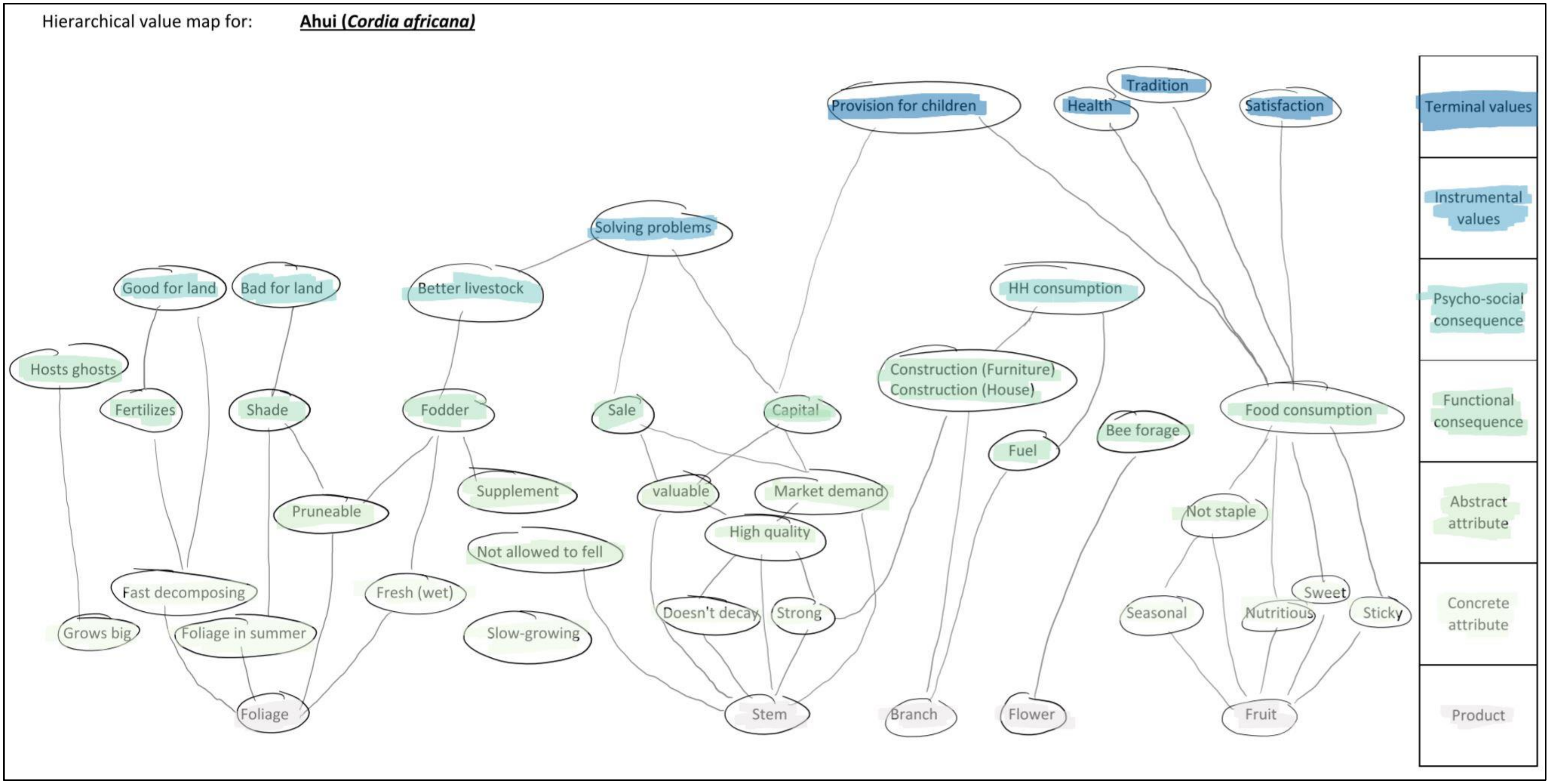
Appendix 4: HVM of *F. Albida*



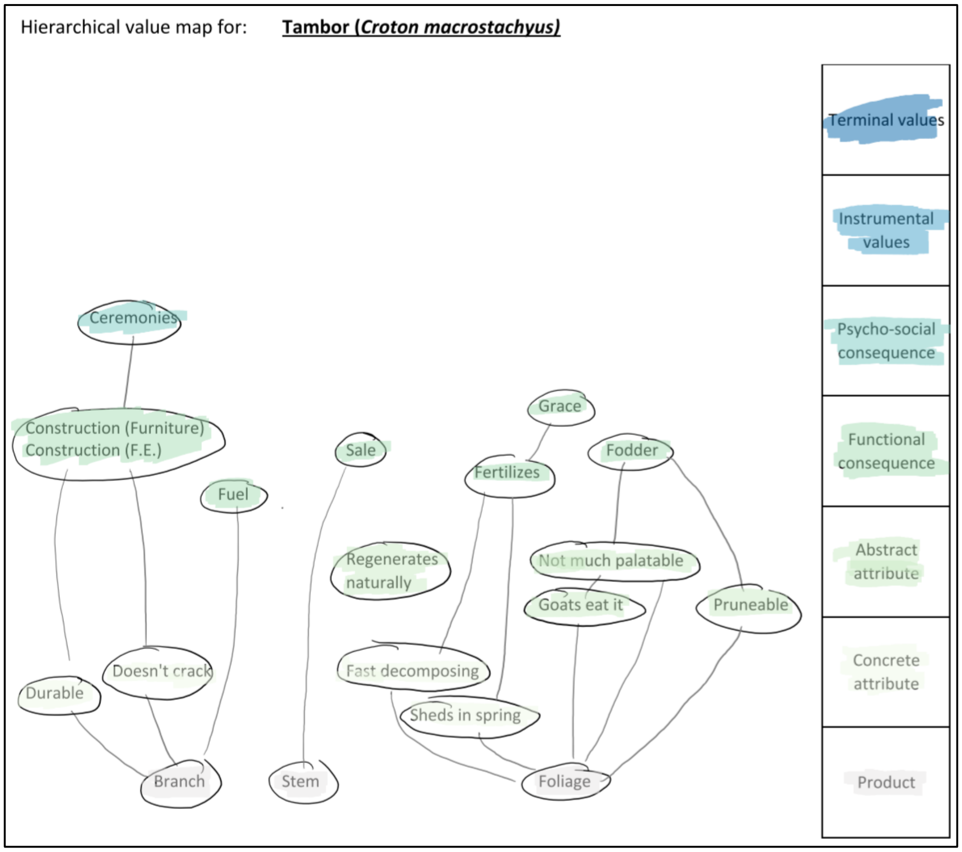
Appendix 5: HVM of *A. lahay*



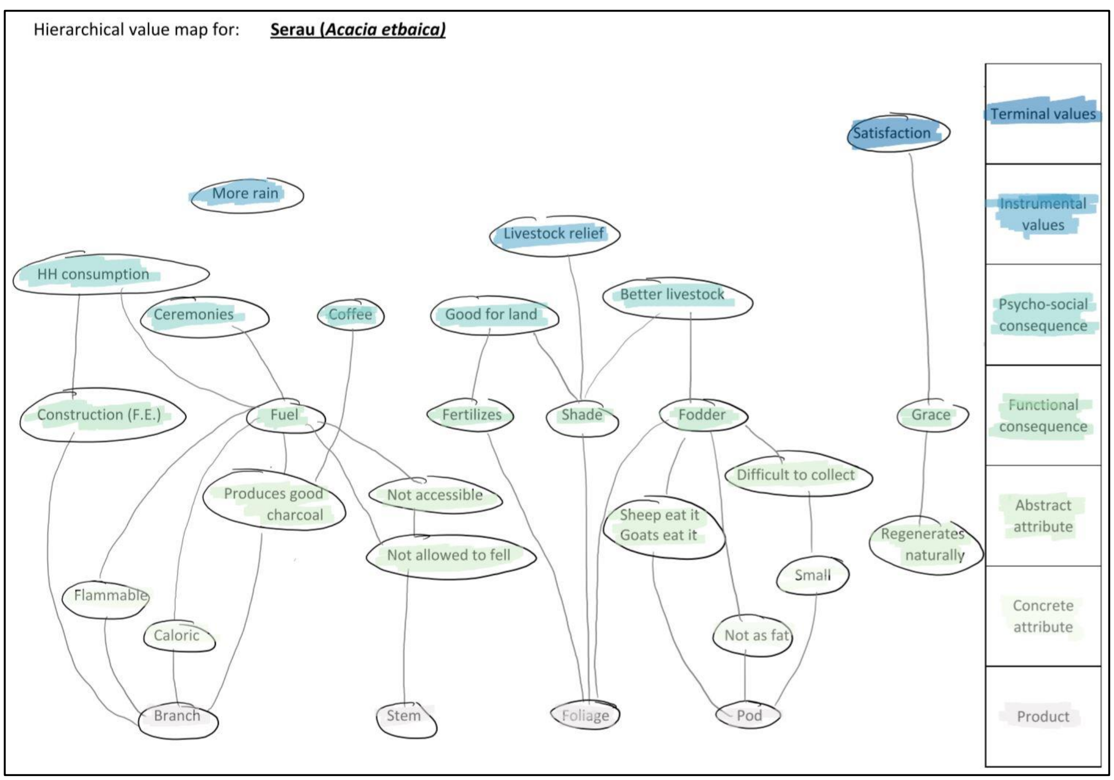
Appendix 6: HVM of *C. Africana*



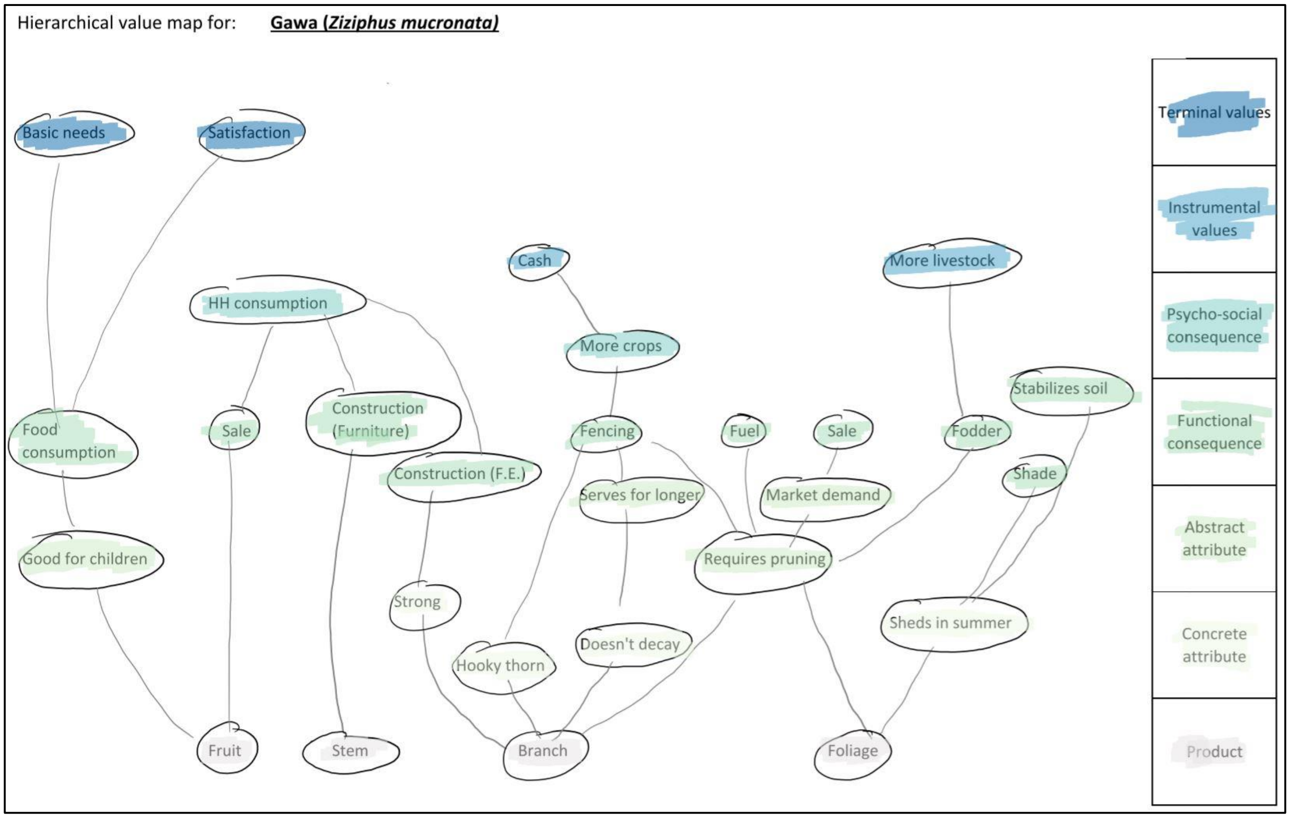
Appendix 7: HVM of *C. Macrostachyus*



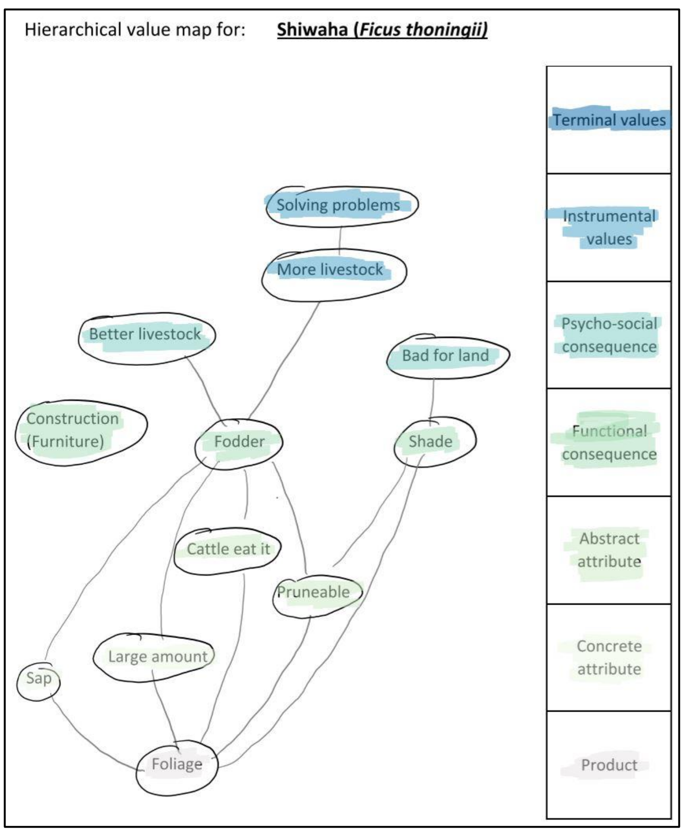
Appendix 8: HVM of *A. Etbaica*



Appendix 9: HVM of *Z. Mucronata*



Appendix 10: HVM of *F. thoninngii*



Appendix 11: HVM of *S. Sesban* & *L. leucophala*