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The impacts of *Acacia decurrens* plantations on livelihoods in rural Ethiopia

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ABSTRACT

This study was undertaken to examine local perceptions of the impacts of small-scale tree plantations, notably of *Acacia decurrens* (J.C. Wendl.) Willd., in Ethiopia's Upper Blue Nile Basin. A particular focus of our study was on the different dimensions of livelihood sustainability centering on economic, social, human, physical, and natural capital. The unprecedented expansion of small-scale tree plantations in degraded agricultural land can be attributed to farmers' efforts to overcome the problems of limited income options and land degradation. However, these initiatives may have differential effects in terms of maintaining the sustainability of the natural environment and rural livelihoods. Interviews conducted with farmers revealed that the plantation system has yielded rich benefits by increasing their incomes, providing them with employment and improving their social lives. The plantations have also significantly improved degraded soils, thereby increasing natural capital. However, associated risks have also been found related to rising food prices, caused by a shift from annual to perennial crops and growing inequalities, with small farmers or those with limited financial resources having fewer options to invest in plantations. Moreover, in the face of such a positive overall impact of the plantation systems, the regulation of child labor, a potential issue, could become difficult. Apart from measures to address the issue of child labor, improved infrastructure and market access are required to help balance food security and plantation systems through functioning markets and financial systems that enable economically impoverished farmers to participate in this business. These findings offer important insights for research and policies seeking to sustain small-scale farmers' tree plantation systems, land use, and rural livelihoods.

1. Introduction

Agroforestry systems, particularly small-scale farmers' tree plantation systems, have been receiving positive coverage in discussions in recent decades. This holds on a global scale, where reducing deforestation is expected to yield environmental benefits (e.g., greenhouse gas emission reduction); however, it also implies potential economic losses for deforesters (Sathaye et al., 2006) on regional and/or national scales in both developing and developed economies. For example, reforestation of degraded landscape has been reported in Uganda (Fimbel and Fimbel, 1996). Although Garrity (2004) emphasizes the positive return on investments in agroforestry as well as the positive social and environmental effects of agroforestry on small-scale farming systems, he criticizes the lack of a broader perspective in terms of marketing and processing systems. Appiah et al. (2020) describe the wide range of economic, ecological, and social benefits of afforestation in Ghana, including the provision of non-timber forest products and environmental services; they particularly mention the positive effects of afforestation on the livelihoods of disadvantaged groups, especially women. Overall, tree plantation systems have been beneficial, particularly in terms of economic benefits, with only few critical voices claiming the need for a multi-dimensional assessment considering the social effects – mainly the distributional effects - of the above-mentioned systems.

Several authors claim that small-scale farming and subsistence-oriented societies depend not just on economic assets for their livelihood (Baffoe and Matsuda, 2018a); such societies need social and environmental assets as well. In other words, rural societies need to be based on a diverse structure of assets, not on economic assets alone, and hence they need to diversify their economic activities toward more environmental, long-term investments. Based on this argument, Quandt et al. (2017) claim that agroforestry systems are an environmental asset that

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can improve the resilience of small-scale systems toward environmental shocks. However, there are also voices that question the linkages among environmental and social assets, resilience, and livelihoods. For example, Baffoe and Matsuda (2017) argue that investments in social or environmental assets can be economically counterproductive, while Cochrane and Cafer (2018) argue that diversification does not automatically imply resilience, particularly if the respective technologies and systems are maladaptive or socially imbalanced.

Based on the above, we question whether the plantation system under investigation in this study contributes to improving not only economic wealth but also social and environmental assets and their respective benefits toward livelihoods. In examining this, we also aim to assess the potential for social and environmental resilience of such a plantation system. We hypothesize that plantation systems not only increase economic wealth but also contribute positively to environmental and social assets, and thus improve rural livelihoods. Through our investigation of local people's perceptions, we aim to offer some broad insights on the contributions (changes and tradeoffs) of rapidly expanding small-scale plantation forestry to sustainable rural livelihoods. Specifically, we analyze the effects of small-scale tree plantations on livelihood capitals and associated outcomes on rural households located in watershed areas in the highlands of north-western Ethiopia. Such insights may prove valuable for tracking the contributions of plantation forestry towards poverty alleviation and rural development and for designing local land use policies as well as market-centered and structural adjustment policies for rural areas.

2. Expansion, drivers and trade-offs in tree plantations

Over the past decades, due to rapid globalization, the world's agriculture has witnessed a significant shift from traditional to cash crops, threatening local diversity with its associated change in land use patterns (Lambin et al., 2001). The area of plantation forests has increased from 167.5 million ha in 1990 to 277.9 million ha in 2015, mainly distributed in East Asia, followed by Europe, North America, and Southern and Southeast Asia (FAO, 2020; Payn et al., 2015). Besides, in its latest report, FAO (2020) indicates that forest plantations cover about 131 million ha, and in the last decade (2010–2020), its area coverage has been annually growing at a rate of 3%. Tree plantations are managed by both small- and large-scale producers across the globe for a variety of reasons, including, among others, satisfying increasing demand for timber, fuelwood and pulp productions, restoration of degraded areas, and for its role in adapting and mitigating the effects of climate change (Gerber, 2011; Payn et al., 2015).

In the majority of cases, the expansion of tree plantations is often driven by public and private sectors' investments rather than initiatives by small-scale producers. In general, large-scale tree plantations have received little positive feedbacks globally, if not in all regions (Malkamäki et al., 2018); particularly in developing countries, they were often associated with concerns about land grabs, displacement of local populations, poor worker conditions, declining water availability and its quality, high chemical use, and low levels of biodiversity (Andersson et al., 2016; Gerber, 2011). On the other hand, small-scale tree plantations, particularly agroforestry systems, are argued by many authors to offer various economic and non-economic benefits, among them higher crop yields as economic benefits, but also ecological services like nitrogen fixation, and increases in the organic matter and availability of phosphorus, as well as a reduction in soil erosion, and other ecosystems services (Elagib and Al-Saidi, 2020; Garrity, 2004; Kuyah et al., 2019; Nigussie et al., 2017a; Ota et al., 2020). However, in some cases like in Southern Asia, the increase in tree plantation systems is not necessarily assigned to environmental services, but rather simply to increasing global commodity prices in the sector, along with relatively cheap land prices (Byerlee, 2014). As commented by Elagib and Al-Saidi (2020), in order to unfold the full benefits of small-scale tree plantation systems, there is a need for functioning institutional and socio-economic environment. Sikor and Baggio (2014) argue that tree plantation systems – in a relative smallholder setting in Vietnam – tend to benefit larger farmers more than smaller ones, which implies negative distributional effects. Similar socio-economic effects are also reported in Ghana, where Narh (2019) finds that landless and migrant farmers are disadvantaged by the establishment of teak plantations. Su et al. (2014) bring forth the argument that the success of plantation systems in China depends on households' resource endowment, in particular labor endowment, but also on local infrastructural, ecological and institutional conditions. Other authors state that there seem to be trade-offs between environmental services and economic benefits, for example, high carbon stocks and crop yields in West Africa (Tschora and Cherubini, 2020), between the expansion of timber plantations and lower pressure on natural forests (Pirard et al., 2016), as well as the deforestation effect of cash crop systems in China (Li et al., 2018) and Laos (Junquera et al., 2020). Su et al. (2014) highlight a trade-off between expansion of new cash crop plantations (e.g., tea, fruit, mulberry, nursery) and food crop (rice) production, on the one hand, and natural forests, on the other. In Europe, research results also imply trade-offs between ecosystem services and biomass production of tree plantation systems (Torralba et al., 2016).

The above literature shows that as much as there are overall benefits from tree plantation systems, there are also trade-offs and risks, which often feature rather on a local or regional scale, due to the fact that such risks are often globally- or government-policy induced (e.g. by the increasing global markets or specific support policies) but locally – and hence quite diversely – expressed due to specific institutional conditions (laws, resource endowment, social structures, etc.). This implies that local studies such as the present one have to be conducted, in order to identify the shortcomings of plantation systems and relate them to benefits which would serve as inputs to meta- (regional or global) scale analysis. Such case studies will eventually contribute to a bigger, holistic picture of tree plantations and agroforestry systems at a regional and global scales.

3. The sustainable livelihoods approach

The sustainable livelihoods approach (SLA) encompasses all the dimensions of sustainability, namely ecological, social, and economic sustainability. It entails a process of creating sustainable economic and social outcomes that promote well-being through allocations of resources, institutions, processes, and strategies for creating such outcomes within a given political framework (Solesbury, 2003). More specifically, an important insight emerging from the application of the SLA is that the poor rely on a wide range of capital assets, the absence of which can affect their livelihood. Hence, their opportunities to employ such assets productively to create and augment wealth hinge on their differential access to and returns from these assets. The commonly accepted categories of capital are natural, financial or economic, human, social, and physical. However, the specific dimensions of these different categories of capital vary across studies (e.g. Scoones (1998), Tacoli (1999), Campbell et al. (2001), Adato and Meizen-Dick (2002), Erenstein et al. (2010) as cited in Quandt (2018)).

Most of the above-mentioned authors restrict the definition of the economic capital dimension to actual capital assets, whereas Quandt et al. (2017) include access to jobs in the same category along with salaries earned from other work (Quandt et al., 2019). Accordingly, we have included income opportunities and jobs as well as livestock assets and market access in the category of financial and economic capital. Baffoe and Matsuda (2018a) define social assets as social resources based on the relationships between people, upon which individuals draw. Consequently, our definition of social capital covers factors that could potentially affect societal cohesion, such as prevalence of crime, as well as a wide range of other relevant factors. In the present study, these factors encompass individuals' contributions to community-initiated soil conservation measures, prevailing agreements regarding

resource distribution (especially land contracts), associations, co-operatives, and community activities, market access and performance (food price development), and women's household burdens. Human assets are skills, knowledge and abilities of individuals that are vital to engage in various livelihood strategies (Baffoe and Matsuda, 2018a). Hence, human capital in this study features itself as children's schooling opportunities and adults' non-formal knowledge. Natural capital is the stock of natural resources from which resource flows (e.g. land, water, soil) and services (e.g. erosion protection, biodiversity change) beneficial for livelihoods are derived (Baffoe and Matsuda, 2018a; Quandt et al., 2019), comprising here the dimensions of soil fertility and the degree of soil degradation and erosion. Physical capital, on the other hand, refers to the basic infrastructure and producer as well as consumer goods (e.g. transport, shelter, communications, machinery) enabling the pursuit of various livelihood strategies (Baffoe and Matsuda, 2018a). Here, physical capital is expressed as access to communication infrastructure through owning communication devices such as mobile phones as well as assets such as housing and their quality. While the definition of physical capital in other studies tends to be infrastructure oriented (see e.g. Baffoe and Matsuda, 2018a; Quandt et al., 2019), we consider assets that are physical but are not directly or solely attributed to productive activities. They may provide access to infrastructure (mobile phones), but do not refer to the infrastructure itself (e.g., streets and telecommunication networks), which comes under the political arena and is therefore outside the scope of farmers' decision making. The aforementioned assets can be employed both for productive and non-productive (consumptive) purposes. The same holds for housing, which is a consumptive rather than a productive asset.

4. Contextualizing the expansion of the tree plantation system

Several factors have contributed to the poor performance of Ethiopia's agricultural sector, the most significant being severe land degradation (e.g., Nigussie et al., 2017b, c; Schmidt and Tadesse, 2019). This is of particular concern in the highland areas that support highly concentrated human and livestock populations. Extensive clearing of natural forests (Duguma et al., 2019; Wondie and Mekuria, 2018; Zeleke and Hurni, 2001) has exacerbated deforestation in the Ethiopian highlands caused by the expansion of crop cultivation into fragile environments, such as degraded hillsides. Apart from causing soil degradation (Nigussie et al., 2017c), the high deforestation rate has diminished households' wood supplies required for cooking, heating, and construction purposes (Duguma et al., 2019; Guta, 2018).

From the 1970s onward, successive governments of Ethiopia have sought to address the dual problems of land degradation and firewood shortage through externally funded land rehabilitation and reforestation programs entailing the establishment of plantation forests on degraded hillsides (Nigussie et al., 2017a). In addition, small-scale agroforestry, entailing the dissemination of a number of fast-growing, exotic multi-purpose tree species, such as eucalyptus and acacia species, to farmers has been promoted in this region (Nigussie et al., 2017a; Wondie and Mekuria, 2018). Despite substantial investments in reforestation and afforestation programs and widespread adoption of the introduced tree species by small-scale farmers, these initiatives have had varying degrees of success across the drought-prone rural landscape of the Upper Blue Nile Basin (UBNB), as in the other regions for a number of reasons: the performance of individual tree species in a particular context, market incentives, risk and uncertainty, and political, biophysical, and socioeconomic conditions (Le et al., 2012; Nigussie et al., 2019, 2017a).

Historical shifts in land use, earlier from natural forest to field cropping systems and in recent decades to smallholder plantation systems, have shaped traditional land use practices and decisions in the UBNB (Ahmed et al., 2019; Sultan et al., 2017; Wondie and Mekuria, 2018; Yimanie et al., 2019), which in turn have implications for sustaining the livelihoods of small-scale farmers. For example, there was and is a rapid expansion of *Acacia decurrens* (J.C. Wendl.) Willd.[1] (hereinafter called acacia) plantations, comparable with the rapid expansion of Khat (Catha edulis) in the past decades (Cochrane and O'Regan, 2016; Feyisa and Aune, 2003; Wondie and Mekuria, 2018). In particular, the expansion of acacia plantations in this locality, given their potential for higher financial returns (Berihun et al., 2019; Teshager Abeje et al., 2019; Yibeltal et al., 2019), could have varying impacts on the livelihood capitals of small-scale farmers.

5. Study site

The Guder watershed is situated in Fagita Lekoma District (10°57′ to 11°11′ N and 36°40′ to 37°05′ E) in the Amhara region of UBNB in Ethiopia (Fig. 1). Acacia plantations constitute one of the dominant managed ecosystems in this region (Berihun et al., 2019; Nigussie et al., 2017a; Sultan et al., 2017). The Guder watershed has an elevation range of 1800 m – 2900 m, and its total area is 741 ha. The mean annual rainfall in this region is 2454 mm, which occurs during June–September, with a unimodal rainfall pattern, and the daily temperature ranges between 15 °C and 24 °C (Yibeltal et al., 2019). The Guder watershed represents a typical watershed in the Ethiopian highlands, which falls within the moist subtropical climatic condition (Berihun et al., 2019; Yibeltal et al., 2019). It is characterized by a mixed rainfed crop–livestock farming system, with crop cultivation, livestock husbandry, and charcoal production being the most important livelihood activities (Nigussie et al., 2017a; Teshager Abeje et al., 2019; Yibeltal et al., 2019). Major crops grown in the watershed include teff (*Eragrostis tef* Zucc.), barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L.) and potato (*Solanum tuberosum* L.). Horses, cattle, sheep, and donkeys are the most common livestock kept by farmers. Acrisols and Leptosols are the major soil types (Yibeltal et al., 2019).

Acacia is the principal fast-growing exotic tree species, followed by eucalyptus, extensively grown by small-scale farmers in the Guder watershed (Abebe et al., 2020; Alemu et al., 2020; Kassie, 2015; Nigussie et al., 2017a). Acacia has been introduced into state-owned plantations of the north-western highlands for land rehabilitation since the 1990s (Nigussie et al., 2017a). Since 2006, the area coverage of acacia plantation has progressively increased across the watershed (Kassie, 2015). In 2017, the main land use types found in the watershed are acacia plantation (35.4 %), cultivated land (32.7 %), grazing land (13.4 %), bushland (6.6 %), forest land (9.5 %), and settlement (2.4 %) (Berihun et al., 2019).

Cultivation of acacia starts with raising seedlings during the dry season (January–May). Seedlings are planted during the rainy season (June–August) so that there is sufficient moisture for the outplanted seedlings and they can be manage alongside the intercrop. Plantations are usually harvested at 4–5 years (Kassie, 2015). Charcoal is the key bioenergy product derived from acacia woodlots, and it is produced mainly to be sold at the farmgate to local traders. These local traders then pass the charcoal to wholesalers in nearby towns, who in turn sell it to wholesalers in major urban markets. Rising population and expanding urbanization are the driving factors for the growing demand for charcoal in the major urban areas of Ethiopia (Kebede et al., 2002; Mondal et al., 2018).

6. Methods

This study is aimed at acquiring a deeper understanding of how the spontaneously expanding acacia plantations are generally perceived by local stakeholders and, specifically, how these may influence rural livelihoods. To address the latter question, we applied the SLA, which

[1] *Acacia decurrens*, a fast-growing multipurpose tree species native to Australia, has been cultivated outside its native environment. It grows to a height of 6–12 m or more (Kassie, 2015).

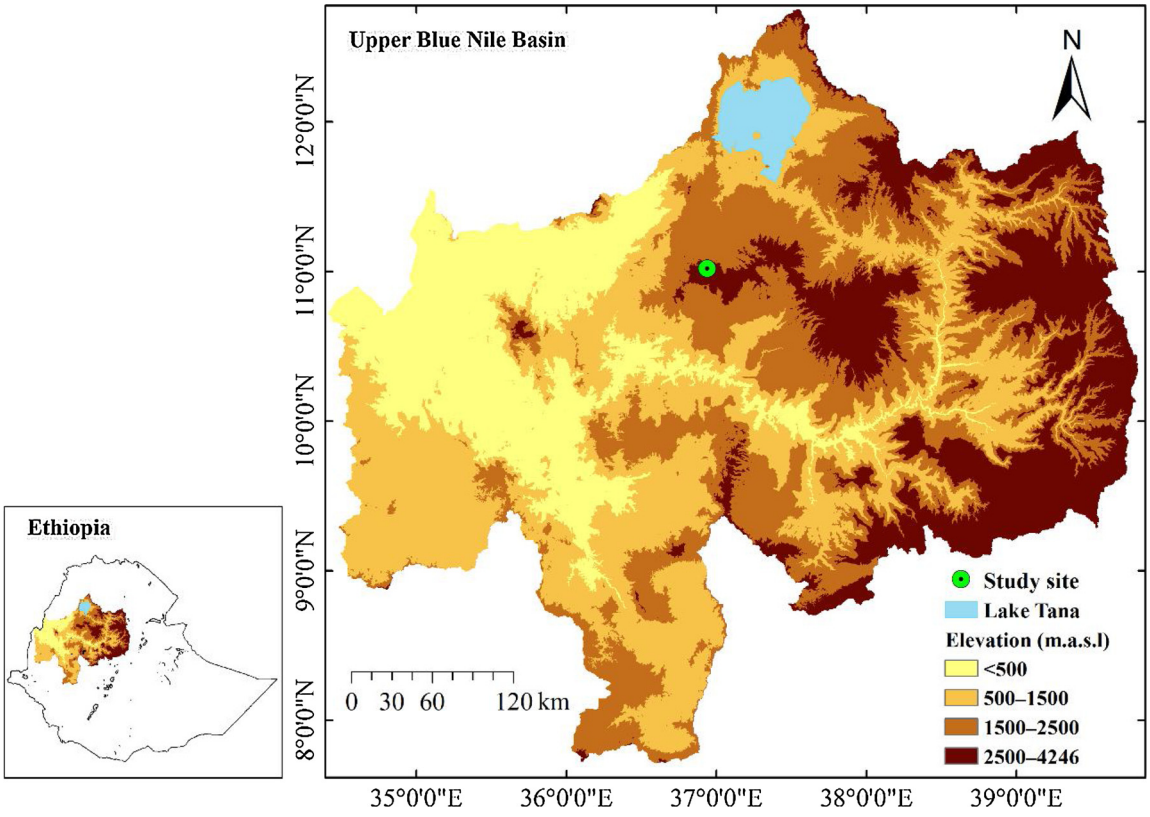

Fig. 1. Map of the study area.

allows for a conceptual integration of environmental issues within a holistic rural development framework (Solesbury, 2003). Accordingly, a qualitative design was selected for the study. Data, contextualized within the SLA framework, were collected during two periods of fieldwork: June to September 2018 and January to February 2019 through 42 in-depth interviews, 3 focus group discussions (FGDs), 8 key informant interviews, and multiple field observations. We conducted observations and key informant interviews to familiarize ourselves with the local context and to identify pertinent issues related to the acacia plantation system. We selected key informants based on their knowledge of the locality. They comprise the chairperson of a cooperative, four agricultural experts (two local-level and two district-level), two charcoal traders, and one NGO expert working on the site.

The researchers took photographs and field notes during field observations. Each of our in-depth interviews held with respondents provided a detailed portrayal of the plantation system and its effects on the environment and on rural livelihoods. The interviews were guided by a set of open-ended questions. The three FGDs, each with eight to ten participants, were conducted at different stages of the research. The first FGD was held at the start of the first round of fieldwork to enable the researchers to become familiar with the local context and to identify important aspects of the plantation system. Two further FGDs were held at the end of the first and second rounds of fieldwork, respectively, to triangulate the findings from the interviews and field observations and to elicit different perspectives. The FGDs were conducted by a moderator, with an assistant who took notes during the discussions. On average, each in-depth interview, key informant interview, and FGD lasted approximately 60 min, 45 min, and 90 min, respectively. The use of multiple qualitative data sources yielded rich contextual details. All the interviews were recorded and later transcribed for analysis. The themes, which were preselected, were related to livelihood capitals/assets. A thematic approach was adopted in the data analysis, as the theoretical SLA discussion enabled sorting and categorizing the data. Manual rather than computer-assisted techniques were applied for the analysis.

7. Results

7.1. Changes in land use

In some watersheds in the UBNB region, such as Guder, the expansion of plantation areas is indicative of local communities' interest in this land-use type. All the respondents indicated seeing significant changes in land use over the last decade. They reported the steady expansion of acacia plantations across the watershed. In addition, they recognized that the plantations had expanded at the expense of other forms of land use, notably annual crops and pasture. The effects of this increase in plantation areas and land use change on the dimensions of livelihood assets in the region are discussed below.

7.2. The impact of the plantations on the social capital

In response to a question about post-plantation tenancy changes, all the respondents disclosed a shift in the tenure arrangement from a social to an economic foundation. This perception was affirmed by an elderly farmer in the following recollection:

> *Besides [wanting] equal shares at the end, land owners base their decisions these days on the sharing-out of land, comparing the initial payments offered by lessees. In the past, however, we preferred to lease out our land to people near us, and sometimes we would even go so far as to beg fellow farmers to take it through sharecropping or by paying a very small fixed amount. But now, thanks to girar*[2] *, land is as scarce as gold.*

A few respondents also revealed rising conflict among farmers over land informally transferred to lessees for long periods prior to the

[2] Vernacular name for *Acacia decurrens*

establishment of the plantations.

An advantage associated with the expansion of plantations mentioned in all the individual interviews and group discussions was the reduction in the mandatory annual free labor contribution by farmers within ongoing public work schemes for implementing soil conservation technologies.

A few respondents also mentioned that the establishment of farmers' associations and cooperatives (e.g., the Endewuha Bee and Natural Resource Product Development Cooperative) and of youth groups (e.g., groups engaged in the production of acacia and its by-products, the seedling business, market facilitation, and loading and unloading activities) was an important outcome of the plantation system.

All the interviewed women noted that after the plantations were established, their on-farm firewood supplies and usage of charcoal for cooking and heating purposes were significantly enhanced. Female respondents were also asked to assess how their labor requirements for firewood collection changed after the plantations were established. They responded that their work burden, in terms of the time they spend collecting firewood, has declined slightly. Furthermore, our own observations indicated limited charcoal consumption by rural households. In addition, an ancillary advantage mentioned by some of the interviewed farmers included a reduction in the silvicultural practices associated with plantations, which gave farmers more free time to engage in both productive and non-productive livelihood activities.

With the expansion of employment opportunities associated with the plantations, all the interviewees perceived a significant decline in crimes, notably theft, in their locality. The interviewees further opined that past incidents of theft in the neighborhood were strongly correlated with unemployment of the rural youth. For example, one young respondent observed, "*nowadays, everybody in our area is very busy with girar and charcoal-related activities. [There is]no time for theft*." According to the discussants, there were associated increases in youths' incomes, leading to an apparent decline in crime.

7.3. The impact of the plantations on the economic capital

The most common economic benefit associated with the plantations was a rise in employment opportunities at the level of the watershed. In this context, a young respondent explained how the situation had changed:

> *Some years back, my colleagues and I had no option other than to migrate seasonally and become employed as daily laborers in areas where cash crops (e.g., sesame and coffee) are produced. However, we are currently considering this livelihood strategy as a last resort because of the job opportunities created by girar in our locality*.

All the respondents indicated that they had established plantations primarily to produce charcoal for the market. The interviewees clearly underscored the importance of charcoal sales as the principal source of monetary income for all farmers. The respondents also mentioned that firewood is an important tree product that is widely collected from plantations and consumed, but rarely sold. Other benefits associated with plantations and mentioned by respondents were crop and grass hay generated from intercropping practices at the time of establishment and in the second year of the plantation. While some farmers reported an increase in their livestock numbers, the majority of farmers indicated a reduction in livestock numbers and therefore a reduction in their capital assets, as livestock is a common source of savings. For instance, one interviewed farmer noted, "*I used to raise more than 20 animals, but now I am limited to only five (two horses for tilling, a cow and two sheep)*." They partly attributed their declining livestock holdings to reduced land availability for forage production, both grazed and hayed, because of the expansion of plantations.

An extension expert who was interviewed also raised the point that the spontaneous expansion of plantations has constrained the ability of poor farmers to meet their annual food supplies from their own production. We asked interviewed farmers to recall the ease with which they were able to meet their food needs from their own production. In congruent terms, the majority acknowledged that their community relies on staple crops (e.g., maize, finger millet, and teff) purchased from nearby areas and considered the plantations the main reason for the displacement of food crops. However, none of the interviewed farmers openly identified the above concern as a significant problem.

Another perceived benefit of the plantations, as indicated by several respondents, was the improved market access and the rapid commercialization of charcoal through trade to urban areas. As one farmer observed, "*I don't need to go physically to district marketplaces to sell charcoal as I do for other crops. Instead I inform commission agents or local assemblers; then, the traders come to my doorstep*." A related point noted by traders is that increasing demand for energy in major urban areas (e.g., Addis Ababa, Bahir Dar, Gonder, and Dessie) has been one of the critical factors contributing to the expansion of acacia plantations at the local scale.

7.4. The impact of the plantations on the human capital

In response to a question about observed changes in human capital after engaging in plantation work, the majority of the respondents reported a slight improvement in parental practices of sending children to schools and using healthcare services. One of the interviewed farmers made the following observation:

> *In the past, let alone sending children to school, poor farmers had no choice other than to send them (mainly sons) to wealthy farmers for tending livestock. Moreover, when it was essential to receive health services, we sold animals. But now this culture is changing because of girar*.

Thus, respondents directly attributed the observed changes to the plantations, which have augmented their incomes and provided more reliable earnings than traditional farming as well as more spending money.

According to most of the interviewed farmers, charcoaling is an important skill that they acquired after the plantations were introduced. Production techniques were most likely developed by seasonally migrating farmers based on their observations of charcoal production outside the area, and they subsequently introduced these techniques in their area on their return. This was confirmed by a respondent: "*We learned charcoal making from our previous migration areas when we were mobile.*"

All the respondents indicated that using the earth mound kiln is the prevailing method for producing charcoal throughout the community (Fig. 2). Some of the interviewed farmers reported the increasing popularity of a new technique of using leaves collected from the plantation instead of teff straw to cover the wood piles during the charcoaling process. We observed this practice during our fieldwork. During the discussions, all the farmers stated their preference for charcoaling their woodlots in the same plot of land where they farm. One farmer elaborated as follows:

> *I make charcoal from my woodlots in the same farmland and distribute leftovers during farming. When I plant teff afterward, seeds that were sown on kiln sites show superior growth, but mostly end up with the stems bent over. However, wheat and barley have better resistance and show improved yields at such sites*.

The majority of respondents sourced tree seedlings from their own nurseries. Farmers stated that their knowledge of plantation development and management has improved substantially. When asked to state one area of improvement, they noted that their skills in nursery practices, specifically in seed treatment, have improved. However, all the farmers reported planting tree seedlings without removing the polythene bags; none of them recognized this practice as a potential environmental problem.

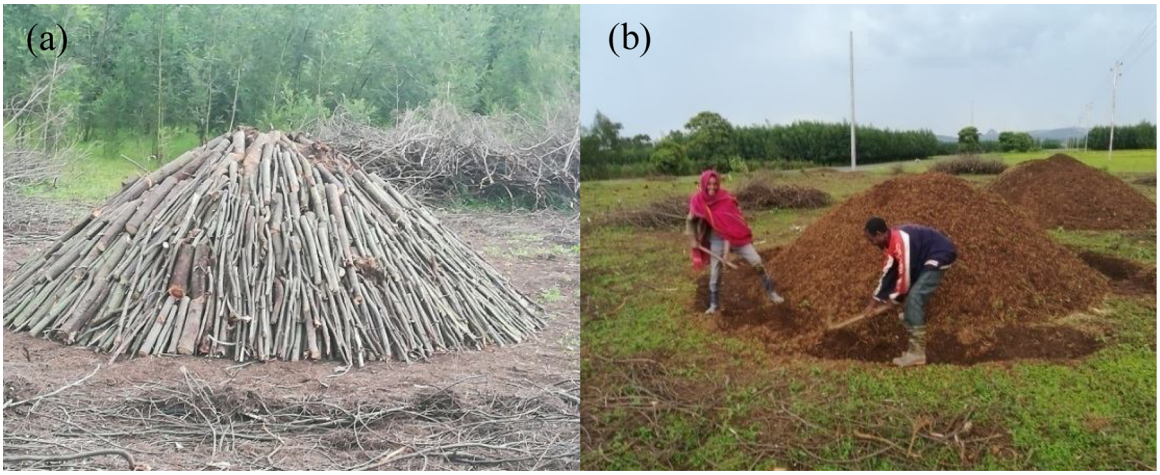

Fig. 2. Charcoal production (a) cut wood of acacia stacked for charcoaling (b) charcoal burners' preparing an earth mound kiln.

7.5. The impact of the plantations on the physical capital

According to the respondents, the plantations have played a positive role in improving the community's physical assets. Our in-depth interviews revealed that farmers perceived changes in these assets, notably their ownership of mobile phones and solar photovoltaic cells, and improved lifestyles, as important outcomes relating to the establishment of the plantations. The majority of the respondents felt that the plantations had positively influenced the availability of important communication assets, notably mobile phones. All male respondents, barring some of the older farmers, reported that they possessed at least one mobile phone in their homes. During an FGD, one farmer stated, "*every household in our village has at least one mobile phone. We use them mostly for communication and listening to music and radio programs*." However, only a few female respondents reported owning such assets. In addition, a few respondents mentioned that plantations have had a positive impact on their households in terms of their acquisition of solar photovoltaic cells.

When asked about post-plantation lifestyle changes, all the respondents reported an overall improvement in their housing conditions, mentioning how thatched roofs were now changed to roofs of corrugated iron as an important outcome. Most of the interviewees reported that they have been able to create separate spaces within their homesteads for their livestock, which was not possible earlier.

7.6. The impact of the plantations on the natural capital

An important goal underlying the introduction of plantations was to improve the ecological conditions of degraded areas in addition to improving farmers' livelihoods. When asked about the observable ecological benefits, all the respondents noted improved soil fertility as one of the important benefits associated with the plantations, indicated by productivity gains—by as much as two-fold—for successive crop production (Fig. 3(c) and (d)). As one farmer observed, "*some years ago, my farmland's teff productivity was limited to not more than 6 quintals per ha. However, because of girar, the current yield of this same farmland has more than doubled.*" The majority of the interviewed farmers and focus groups associated gains in terms of yields with the dual role of the plantations in enhancing land productivity: The addition of significant amounts of leaf residue, that is, plant organic matter, commencing from the second year of plantation, improves the fertility and the nitrogen-fixing ability (i.e., nutrient cycling role) of the acacia trees. One farmer described the latter role as follows: "*Girar is wetting the soil like beans do*."

Another important benefit attributed to plantations by all the respondents was the improved ecological condition of the farmlands and degraded hillsides. Respondents noted that since the introduction of plantations, soil loss resulting from erosion has considerably reduced. As noted by one farmer, "*in the past, the soil was easily washed away in the rain and flowed down in streams to rivers carrying with it lots of mud. But now, as we are planting girar densely, only pure water flows down.*" Farmers also felt that plantations have helped them stabilize gullies, although experts challenge this (Fig. 3(b)). Furthermore, interviewees perceived that the expansion of the plantations has resulted in a reduction in flooding events.

Our own observations indicated that farmers are adversely affecting hillsides by sourcing and extracting "forest" soil for their nursery production, leading to environmental degradation (Fig. 3(a)). Interviewed farmers justified this practice as follows: "*mixing forest soil, farmland soil, and manure when preparing potting media facilitates the growth of seedlings and their survival when they are outplanted.*"

An important negative effect perceived by a few respondents was a decline in dry season cropping, mainly of vegetables, because of the extension of plantations to irrigated fields and swampy or wetland areas.

8. Discussion

8.1. Land pressure borne by increased plantation areas

In Guder, rapid and successful expansion of plantations happened mainly at the expense of annual crop and grazing lands (Berihun et al., 2019; Wondie and Mekuria, 2018; Yibeltal et al., 2019), implying that its introduction represents the most prominent change in land use and that local farmers are more interested in cash crop production than in subsistence agriculture. In recent years, the area covered by plantations in the Guder watershed has exceeded areas under any other type of land use (Berihun et al., 2019; Yibeltal et al., 2019). The replacement of agricultural and grazing lands by plantations (Berihun et al., 2019; Yibeltal et al., 2019) directly affects farmers' livelihoods by increasing the costs of their food and feed, which may also increase their production costs and the prices of agricultural products in local markets.

A decline in livestock numbers, particularly cattle, as reported by the majority of the respondents, could also reduce farmers' risk-bearing capacities. In Ethiopia, livestock usually serve as "saving accounts" and safety nets as they can be easily sold to meet farmers' urgent livelihood needs in addition to providing traction power and organic manure (Teshager Abeje et al., 2019; Tschopp et al., 2010). Moreover, farmers with livestock can participate in the practice of overnight cattle kraaling, which traditionally entails reciprocal relations within networks of individuals, aimed at recycling nutrients and sustaining soil fertility (Ikpe and Powell, 2002). Thus, livestock are critical for soil

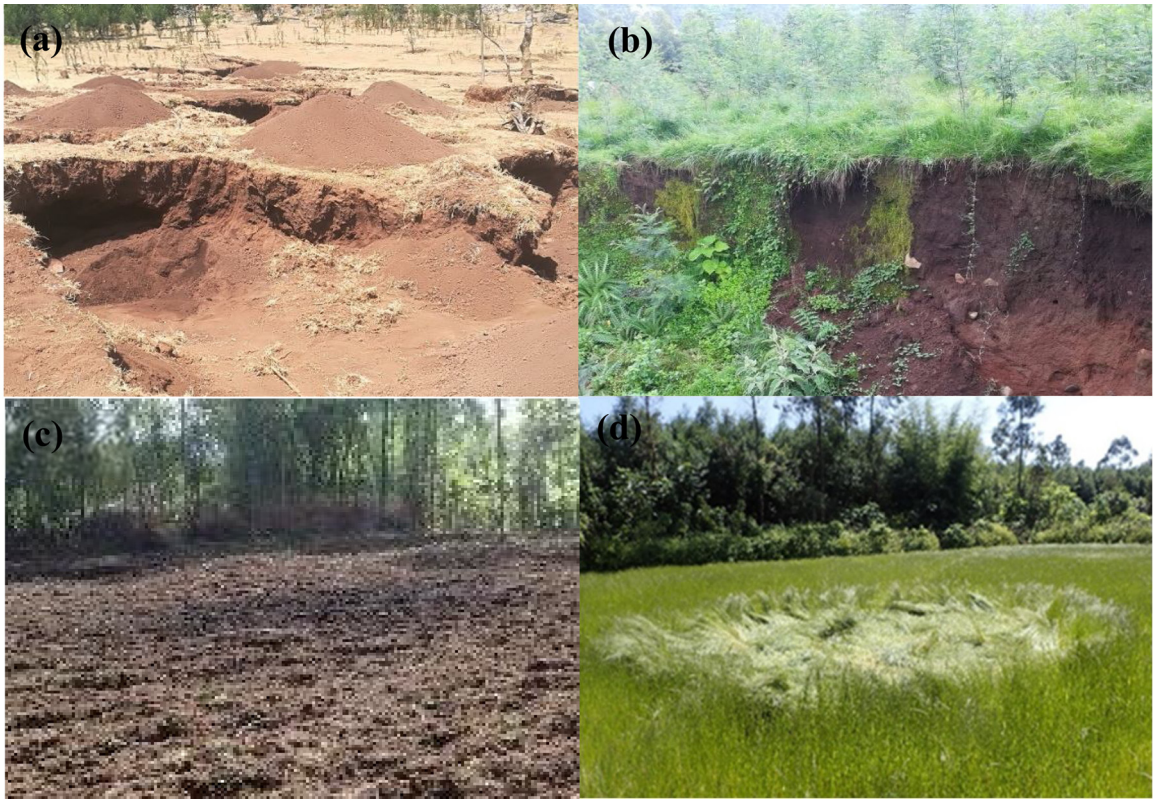

Fig. 3. Degraded land (a) extracted "forest" soil for seedling production (b) planted with acacia for rehabilitation (c) ploughed site after charcoal making (d) teff lodging in a kiln site.

replenishment within a low-input production system such as the system in the Guder watershed. Hence, the declining trend in livestock will inevitably limit the farming system's ability to maintain the fertility of crop fields. However, our own observations suggest that apart from the lack of grazing land resulting from the expansion of plantations, another factor that may contribute to the depletion of cattle stocks in the Guder watershed could be the shift in the farming system to an alternative plowing method entailing horse traction (Asmare and Yayeh, 2017).

8.2. Access to land and plantations

Studies have highlighted the significant influence of land access via social relations on economic performance and agricultural productivity in Ethiopia and more widely in Sub-Saharan Africa (Lawry et al., 2017). In the case of the Guder watershed, this is exemplified in the contracting of land through exchanges transacted among different social networks. For example, some years back, it was customary for those lacking financial as well as labor resources to make further investments in crop farming on their land by agreeing to sharecropping contracts. In such cases, farmers would lease their land through contracts made with kin and with close friends and neighbors to reduce the costs entailed in monitoring lessees. However, over the past decade, such customary land agreements based on social bonds have declined because of the expansion of commercial crop production (Nigussie et al., 2017b), which could be associated with the lessors' interest in producing cash crops on their land on their own, or their desire to find lessees who will pay them more than those to whom they previously leased land. In addition, as confirmed by respondents, the willingness of well-to-do farmers to pay more to increase their land acreage by leasing more land is driving the rise in rental prices. Consequently, land transactions now hold true so long as the sharecropper agrees to acceptable rental fees (e.g., 8000–16,000 ETB[3] per ha) at the commencement of the lease in addition to providing the landowner with half the net gains at the end of the plantation cycle (Nigussie et al., 2020). This shift in tenancy could also be related, *inter alia*, to the capacity of the innovation (a short rotation tree-based system) to solve the problem of loss of efficiency resulting from under-investment (limited use of inputs such as labor, fertilizer, and manure, thereby minimizing crop yields) in the case of customary land tenure. Other reasons for changes in tenancy could be the lack of or minimal requirements for external inputs in the plantation system or the system's better financial performance compared to annual crops (Nigussie et al., 2017a, 2020). Furthermore, respondents noted that farmers no longer engage in cash-based land rentals as they are realizing higher financial benefits from acacia plantations. A few farmers also reported that previous land transfers through informal rental contracts are engendering conflict between farmers because the lessors' awareness of new economic opportunities could incentivize them to default on agreements. It is also noteworthy that extensive soil conservation programs are underway throughout the country in a concerted effort to rehabilitate degraded environments (Nigussie et al., 2017b). Because of the wide plantation coverage in the Guder watershed, the expectation from farmers to contribute free labor has significantly reduced. They are, therefore, able to allocate time that would otherwise have been spent working in public work schemes to other productive activities.

At the country level, market demands for charcoal in major urban areas remain high (Kebede et al., 2002). This has contributed significantly to the expansion of plantations. Farmers in the Guder watershed are benefiting from their access to the Addis Ababa–Bahir Dar Highway. Those who are situated closer to the highway indicated that they now have greater access to additional market outlets for charcoal (e.g., passersby) unlike those in remote communities. This increased accessibility of markets for charcoal has occurred in parallel with the

[3] ETB denotes the Ethiopian Birr (currency), 1 USD ≈ 28 ETB.

increased availability of traders, who link farmers with distant marketplaces and information. Consequently better market opportunities have emerged enabling farmers to expand their plantations further.

Additionally, increased incomes from plantations enable farmers, but not poor and women-headed households, to purchase mobile phones. Owning mobile phones can also help farmers organize themselves into groups, enabling them to sell their charcoal in bulk, build new market connections with local and external actors in the charcoal value chain, and overcome constraints in accessing market information about charcoal price developments (Haile et al., 2019). This organizational process could further promote the integration of rural producers into local, regional, and central charcoal markets. In addition, the possession of photovoltaic solar cells, even if this was reported by only a few respondents, could help improve the welfare of rural households through enhanced access to energy for lighting purposes (Guta, 2018). Instead of relying on kerosene, dry cell batteries, dung cake, and firewood, farmers can use solar appliances to light their homes and charge their mobile phones. For small-scale farmers, using solar photovoltaic cells to generate energy could save household energy expenditure. These savings can then be used for other productive and non-productive purposes. Moreover, children could study for long hours into the night, and households could reduce indoor air pollution from using traditional fuels (Guta, 2018).

8.3. The impact of the plantations on land rehabilitation

The Guder watershed receives a higher rainfall distribution and has a greater population density than the other watersheds in the UBNB (Nigussie et al., 2017a, c). It has been subjected to centuries of continuous cultivation, entailing unsustainable agricultural practices (Nigussie et al., 2017b; Yibeltal et al., 2019). These factors along with extensive deforestation could have resulted in acidic soils of low fertility (Kassie, 2015), which in turn can directly impact agricultural productivity and ultimately local livelihood systems. Therefore, acacia has been promoted within the watershed by the government as a species well-suited for rehabilitating degraded environments and consequently improving the livelihoods of farmers who depend on them (Kassie, 2015). This plantation system has helped farmers stem the problem of soil erosion in their fragile land. The control of soil erosion through plantations of acacia trees can be attributed to (a) the dense and fibrous root system of these trees in stabilizing of soil (Zegeye et al., 2018) and (b) the high-density stands (Nigussie et al., 2017a). Other factors include slowing the surface runoff from heavy rains and the associated soil loss (Baziari et al., 2019; Sultan et al., 2017; van Dijk and Keenan, 2007). A further factor could be the less intensive interactions of farmers with the land during the plantation cycle, which could also promote better conservation (Baffoe and Matsuda, 2018b).

In their interviews, farmers revealed that they were aware of the poor growth of understory plant species after the second year of planting acacia, which might be due to the planting of higher-density stands for maximizing profits (Nigussie et al., 2017a). In turn, this situation may have contributed to a reduction in the system's ability to withstand biotic (e.g., insect pests, and fungal pathogens) or abiotic stressors (e.g., frost) and to recover quickly from disturbances (Jactel et al., 2009; Wondie and Mekuria, 2018). The low undergrowth coupled with the sealed soil crust surface may also have contributed to reduced water infiltration and increased runoff (Sultan et al., 2017).

Respondents also recognized the role of plantations in rehabilitating degraded soils, comparing this to the nutrient cycling potential of leguminous crops (e.g., faba beans). They reported enhanced soil fertility of previously less productive cropping lands after adding leaf mulch to the soil. In addition, farmers attributed improved soil productivity to the kiln sites used for charcoal production, which are located in same land used for crop cultivation (Nigussie et al., 2017a). This finding is in tandem with that of Dubiez et al. (2019), who reported that the spread of charcoal fines from earlier carbonization sites has positive effects on soil properties and, thereby, on crop production. Farmers also reported that teff planted on kiln sites was vulnerable to stem lodging. The problem of lodging in these sites could be closely related to the presence of a higher amount of nitrogen in the soil (Jactel et al., 2009). A further consideration is that even if farmers wish to produce teff that fetches higher prices in the market (Nigussie et al., 2017a), they often plant other crops that are resistant to lodging, such as wheat and barley to reduce the risk of lodging. This soil management strategy could improve farmers' livelihoods by reducing their use of external inputs for the following crops that are planted and increasing their productivity (Nigussie et al., 2017a; Oguntunde et al., 2004), which, in turn, could have positive implications for the economic returns of small-scale farmers. However, responses obtained from some of the interviewees as well as our own observations revealed that farmers appear to be resorting to substituting teff straw with acacia leaf litter as a covering material during the charcoaling process, which could diminish the amount of leaf residue available as mulch for restoring nutrients to the soil (Abebe et al., 2020; Harmand et al., 2004). The new type of residue management associated with the charcoaling process may entail a considerable ecological trade-off with the disruption of nutrient cycling and the accumulation of soil organic matter (Abebe et al., 2020; van Dijk and Keenan, 2007), which, in turn, could influence the availability of plant nutrients in the soil and, hence, crop yields.

The perception of interviewed farmers that plantations promote the stabilization of gullies has been rejected by agricultural experts, who argue that these trees have shallow roots. Consequently, their effectiveness in anchoring gully walls and preventing their collapse is limited. However, this view of the experts is questionable; Gyssels et al. (2005) have argued that tree species with a shallow but dense laterally spreading root system could be more effective for stabilizing shallow gullies, a fact that may apply here. Another observed ecological trade-off relates to farmers' nursery practices. To stimulate the growth of seedlings in the nursery and to ensure their survival after being transplanted to the farmland, farmers inoculate nursery soil with soil from communal land. This traditional nursery inoculation practice is known to introduce mycorrhizal fungi that facilitate the uptake of soil nutrients in sites with low fertility (Benites, 1990; Michelsen, 1992), which further contributes to the need for fewer inputs, such as a reduced need for fertilizer, that would otherwise have been applied to maintain soil productivity. However, considering the ongoing expansion of plantations, this soil extraction activity of farmers in procuring inoculating soil from communal lands is very likely to exacerbate the deteriorating conditions of the surrounding degraded environments unless timely action is taken to counter this trend. Furthermore, all farmers reported planting tree seedlings without removing the polythene bags around them, to save labor, thereby minimizing production costs in addition to minimizing lateral roots and encouraging long taproots. Even if none of the farmers currently alluded to any problems arising from this practice, a previous study (e.g., Jalil et al. (2013)) found that burying polythene bags with seedlings has long-term detrimental effects on the environment and agriculture, such as reduced water percolation and inadequate soil aeration.

8.4. The impact of the plantations on food production

Some of the respondents expressed frustration, attributing a decline in the staple food supply and irregular crop yields to expanding plantations. These impacts may result from the displacement of food crops by plantations (Wondie and Mekuria, 2018; Yimanie et al., 2019), which may undermine a household's ability to produce sufficient food to sustain its members during the entire plantation cycle. Additionally, an important concern raised by a few respondents was the expansion of plantations into cropping land that has access to irrigation and into swampy areas. In the past, farms with access to irrigation produced vegetables (e.g., cabbage, carrot, and beetroot). However, because of the financial stability associated with acacia cultivation, farmers have

been establishing plantations on irrigated land as well as encroaching into wetlands to acquire more land for such woodlots. It is widely held that increased incomes from plantations raise the total incomes of households, which may offset the decline in food crop production. However, as most rural households rely on subsistence agriculture to meet a large portion of their food needs (Teshager Abeje et al., 2019), the reduced production of staple food crops can increase farmers' reliance on crops produced in other areas. Moreover, it can increase the vulnerability of local livelihoods to fluctuating yields as well to the volatility of prices of food crops produced outside the watershed area. This situation may lead to a major imbalance in staple food production, with the majority of farmers converting their land use from food crops to plantations. It could also limit the availability of land-based options for farmers to respond to market signals. As investments in woodlots do not, in general, generate immediate yields, in the case of acacia plantations, farmers have addressed this issue by developing a *tanguay* system, entailing the intercropping of acacia with annual crops (e.g., teff, wheat, and barley) during the initial woodlot cycle (Kassie, 2015; Nigussie et al., 2017a). Intercropping is a well-accepted practice among farmers, enabling them to obtain early returns and optimize total returns per unit of land (Nigussie et al., 2017a; Wondie and Mekuria, 2018). Deploying this strategy minimally guarantees them the yield that would have been obtained had they planted cereals; besides, it requires no more labor than if the two crops were cultivated in separate plots, thus contributing directly to households' food availability. Apart from the crop produced during the establishment phase of the plantation, farmers obtain grass hay valued at about 3300 ETB ha^{-1} for their livestock during the second year of plantation (Nigussie et al., 2020), which contributes to their livelihood systems. This intercropping practice not only provides additional food and a livestock feed source for farmers, but also ensures that tree seedlings receive better care during the early phase of their growth. This finding suggests the plausibility of farmers changing their land management when they are sure of getting quick returns on their investments, usually within the time span of a growing season (Nigussie et al., 2017a; Thomas et al., 2018).

8.5. The impact of the plantations on the human and social capital

Environmental constraints have had an impact on human capital in the Guder watershed for a long time, given that the livelihoods of the majority of households in this region have centered on the exploitation of degraded cultivated lands and agriculture, characterized by low returns and low productivity (Wondie and Mekuria, 2018). All the respondents reported that their human capital has improved significantly as a result of the acacia plantations. In the past, poor households suffered from a lack of livelihood alternatives and were often compelled to send their children (mainly boys) to well-to-do families to engage in paid work as one of their strategies for diversifying their household income bases (Admassie, 2003). However, the interviewed farmers reported a decline in this practice and a corresponding upward trend in sending children to school. The latter trend is presumably the outcome of farmers' increased income from the plantations or their perception that farm-based livelihoods would not be feasible for their children. This observation could have some validity in that farming households may respond to limited resources relating to livelihood options in part by investing in the education of their children. However, local experts and our periodic observations of children transporting charcoal have sparked concern regarding the plantations' negative effect on children's school attendance. Plantations have opened up opportunities in the labor market for children (e.g., filling polythene seedling bags, and packing and transporting charcoal), which could affect children's academic achievements and raise the opportunity cost of schooling (Alfaro and Jones, 2018; Teopista et al., 2020). Consequently, children could drop out of school, with implications for the future educational achievements of youth in the community.

Our findings also confirmed that plantations offer possibilities for pursuing alternative livelihood strategies by providing employment opportunities for the community in general and for youth and women, in particular. An improvement in employment conditions has been one of the main factors contributing to a decrease in crime levels. Respondents noted that planting and harvesting (e.g., clearfelling, stripping branches, and sawing trunks) were the main labor-demanding activities in which large numbers of individuals, particularly youth, are engaged. When respondents were asked for further details on the labor required for such activities, they replied that a woodlot with an area of one hectare would require as much as 240 person-days casual labor in total. In most cases, farmers are compelled to hire casual labor. Respondents also noted that previously women were not commonly hired to provide labor (e.g., sawing trunks) and for the seedling business. However, in the post-plantation period, the hiring of women for these activities has increased, further illustrating the shifting social norms that have occurred alongside the economic opportunities created by cash crops. In addition, communities in the watershed area were earlier used to traveling to remote areas (e.g., in the Jawi, Metema, and Benishangul Gumuz) and in other nearby areas, seeking additional income opportunities. Charcoaling practices were prevalent in these areas, which were the destinations of migrants (Betru et al., 2019). Consequently, seasonal migrants acquired such knowledge while working in these areas and brought it back to their home areas. Nonetheless, as all farmers have not yet acquired sufficient experience, skilled charcoal burners, mostly landless, are engaged to perform charcoaling chores. Charcoal burners receive 8–10 ETB per sack for their services (Nigussie et al., 2020). In addition, some of the farmers mentioned an increased tendency to send children to school and their ability to pay for healthcare services because increased incomes from acacia plantations enable them to spend part of their earnings. It is thus likely that the improved incomes of rural households have encouraged them to invest more in human capital (e.g., education and health).

8.6. The economic impact of the plantations on rural livelihoods

The pursuit of autonomy and economic growth led small-scale farmers to practice plantation farming because this practice generated higher incomes compared with incomes derived from traditional farming. All the respondents reported an improvement in their post-plantation economic situation. Moreover, they all stated that charcoal sales were a critical cash income source compared with other possible income sources. One study found that a farmer generates higher returns from producing charcoal; the mean annual net cash flow amounts to about 35,000 ETB ha^{-1} from charcoal sales from a five-year old plantation, which is considerably higher than the cash that can be earned annually from teff monocropping (about 13,600 ETB ha^{-1}) (Nigussie et al., 2020). Farmers earning these higher incomes may be able to accumulate savings and thus become more resilient to shocks than farmers who lack such income (Kassie, 2015; Nigussie et al., 2020; Teshager Abeje et al., 2019). The higher incomes may also enhance farmers' access to food through improved spending ability or allow them to enjoy the benefits of increased purchasing power. Farmers were asked to quantify firewood benefits, producing an estimate of about 10,000 ETB ha^{-1}, which is comparable to the value reported in an earlier study (Nigussie et al., 2020) of approximately 8500 ETB ha^{-1} from a five-year old plantation. Farmers noted that given the limited supplies of firewood in the local market, they often consume their own supplies, which contributes to their firewood self-sufficiency. As firewood collection is one of the tasks performed by women, the existence of readily available on-farm supplies has implications for promoting gender equity. Consequently, women are able to reallocate their time for other productive and non-productive activities. Additionally, by supplying rural households with firewood that would otherwise have been harvested from natural forests in their vicinity, the plantations potentially contribute to a reduction in deforestation.

A final consideration relates to the fact that there is a ready market

for plantation stands that can be sold at any stage of the woodlot cycle. This adds to the appeal of making such investments, as reported by the respondents. The incomes obtained from distress sales of plantation stands at any stage of the woodlot cycle enable poor farmers to leverage their vulnerability to food shortages and also tackle rising food prices. This factor has contributed considerably to the increase in the popularity of this species among poor farmers and women who have few resources (Nigussie et al., 2017a, 2020), who cannot produce or cultivate enough crops to be self-sufficient during the growing periods. This pattern of early selling of plantations could be related to the frustrations of poor farmers connected to their lack of income or to food shocks that could prevent them from perceiving the potential gains from such long-term investments (Di Falco et al., 2019). At the same time, it should be pointed out that it is usually individuals with more financial resources and a comparative advantage over other social groups (such as women, the landless, and the poor) who avail the market opportunities associated with plantations, at least in the context of the study area. This is a further factor contributing to growing inequality in relation to rural livelihoods (Nigussie et al., 2020), necessitating an exploration of suitable options for embedding equity within the plantation system, particularly to enable socially disadvantaged farmers to participate in the plantation markets.

8.7. Summary of findings

The above findings lead us to reject the hypothesis that economically beneficial systems – in this case small-scale plantation systems – are also socially and ecologically beneficial, as they give rise to questions about social and even natural impacts, which are or could be potentially negative. Findings from other studies also imply that while there are benefits for small-scale farmers from plantations, these benefits could be limited because of economic and social constraints, such as risks, lack of capital, knowledge, or access to land (Ota et al., 2020). This is in line with the arguments of the authors cited in the introduction section, particularly Cochrane and Cafer (2018). In case the restrictions mentioned in the literature and the ones revealed in this study cannot be eased, small-scale plantation systems would soon face the same problems that persist in large-scale timber plantations, such as inequality and other social issues, in turn leading to social conflicts like protests and lawsuits (Gerber, 2011).

9. Conclusions

The above findings and discussion have shown that the acacia plantation system, promoted through national and international projects, has had a number of positive effects on all dimensions of sustainable livelihoods in the region where they have been implemented. It has produced economic benefits like higher incomes and increased labor opportunities, enabling farmers and rural households to purchase assets like housing and communication equipment. Its introduction has lightened women's labor burden, enhanced social capital and social cohesion within communities, increased schooling opportunities for children, and decreased the need for seasonal labor migration. These plantations have also enhanced natural capital by reducing soil erosion and improving soil fertility.

The extent of these positive benefits could serve to impede a consideration of the potential social and economic risks that have also accompanied the introduction of the plantation system. The spread of wood plantations reduces the area of food crop production, potentially increasing food prices. Further, it decreases crop diversity, which however, in the literature, is seen as an important means of risk management in vulnerable rural societies, wherein such societies or individuals forego specialization benefits for the sake of risk reduction (Abele and Twine, 2006). Moreover, some authors argue that diversification of income sources (particularly farm and off-farm) increases household income and thus resilience against risks (Baffoe and Matsuda, 2017). However, it can also be argued that diversification is a sign of vulnerability and that specialization techniques orientating toward crops that are specifically adapted to a risky environment will yield higher household income and food security (Cochrane and Cafer, 2018). In the case of acacia plantations, the above discussion could either lead to the interpretation that acacia plantations represent a diversification from a lower to a higher income source (annual cropping vs. plantation) or a specialization on adapted and thus high-income technology, which yields more benefits than the traditional diversification practice and enhances the environment, thus reducing risks and opening opportunities for further specialization.

Expansion of acacia plantation has also induced changes in land leasing and tenure practices, reflecting a shift from a socially and economically balanced land lease-based system toward a sharecropping system that is solely profit oriented. This shift is disadvantageous for small or landless farmers, who depend on rental or sharecropping systems. The situation could worsen if investments in acacia plantations are profitable (and feasible) only for farmers who are well-endowed with land or financial resources, or both. Another concern is that saving systems in the form of livestock appear to be declining. While this has some positive effects, like reduction in overgrazing, it has negative impacts as well on economic security and on the availability of manure. The exploitation of forest soils, used as fertile growing substrate for nurseries, undermines the positive effects of the plantations themselves. Charcoal making is another aspect, which is considered a positive aspect for income generation, but could have a negative impact on the environment through biomass burning, or on health, affecting the respiratory system (Alfaro and Jones, 2018). Last, but not the least, the establishment of these plantations could involve the risk of encouraging child labor, thus offsetting the positive social effects of schooling or availing health services.

Notwithstanding these issues, the predominant perception of positive effects will likely make it difficult to regulate the newly established plantation and charcoal production systems, as such regulation could negatively affect the overall system and its entailed economic benefits. Usually, the main considerations underlying the formulation of rural development policies center on questions of how to derive maximum gains from a positive situation; experiences from cases where a positive phenomenon has escalated beyond the planned outcome, necessitating its regulation, are rare. From the above findings and the issues mentioned in the literature (e.g., Gerber, 2011; Ota et al., 2020), political measures should aim at social balance, equity and access to resources, and opening the markets – both for production factors (land, labor, capital), as well as for outputs to create and secure value chains, employment, and income at a broad societal scale.

In any event, it is essential to ensure the prevention or immediate handling of serious issues that could arise. The first concern is to prevent child labor. Case studies of West African cocoa plantations have shown that child labor can be reduced through sensitization as well as by allaying or preventing pressure associated with costs. This is because rising costs and declining yields or revenues entice farmers to employ cheap child labor. In addition, provisions must be made for (free) schooling (Abenyega and Gockowski, 2003; Bøås and Huser, 2006). Another point would be to prevent land grabbing and thus avoid the problems of plantations growing larger on account of smallholder systems.

Regulating acacia plantations to offset increases in food prices or potential inequality among farmers may, however, prove difficult to justify, given the plantation system's overall positive effects. An alternative approach to pursue could be fast-paced improvement of infrastructure and its extension from main roads deeper into the hinterlands, thereby enabling more farmers to participate in the charcoal business or supply markets with food items as their prices increase. Raising taxes to finance such investments in infrastructure may be a feasible option. However, there is a risk that this strategy could lead to lower profitability and therefore reduce the spread of the plantation system. In

turn, the appeal of cultivating annual crops may increase. However, it is difficult to determine an "optimal tax" because taxation could reduce profitability for farmers and encourage them to exploit child labor to reduce labor costs.

Credit schemes could alleviate the financial pressure on the landless, enabling them to participate in the plantation system. To counter the decline in livestock-based savings, rural banks—or rural saving and credit systems—should be promoted to prompt a shift in the system from in-kind savings toward a monetary system. This would benefit the entire rural economy, as cash is more easily available for investments compared with in-kind savings.

Otherwise, one can be hope that market forces will regulate the system, so long as markets function. Given the increasing food prices, farmers may be inclined to plant annual crops. Consequently, the two competing systems could be brought into balance. However, as suggested above, the effective operation of market forces, free of transaction costs, would require functioning markets and infrastructure.

In conclusion, the scope of our study was limited to evaluating local people's insights on benefits and concerns regarding the rapid expansion of small-scale acacia plantation systems on livelihood capitals and their consequent impacts on rural livelihoods. An evaluation of the ecosystem goods and services would complement these findings on local people's perceptions by providing empirical insights into the effects of plantations on ecosystems, for example, the water demands of plantations and their effects on the groundwater table. Such a study would shed light on the plantations' impacts on the diversity of species and their long-term ecological effects. In addition, there is a need for a close monitoring of equity and social outcomes to counter the possible negative issues from the early stages of plantation development. This falls within the scope of regularly assessing the economic and social impacts and development of the plantations and could be achieved by making it a part of the country's annual agriculture surveys. Another point of research would be to examine closely the incentives to invest in plantations, particularly land tenure and land rights, and its potential effects on household labor.

Author statement

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