

Research Application Summary

**Impacts of agricultural land expansion on deforestation and biodiversity loss in Ethiopia:
A review**

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Abstract

Future food demand worldwide can be achieved by increasing production. The increase in agricultural production can in turn be achieved by agricultural intensification and/or extensification. However, agricultural extensification has been a major contributor to deforestation and biodiversity loss. The objective of this review was to understand agricultural land expansion, the driving forces and its impact on deforestation and biodiversity loss in Ethiopia. In Ethiopia, the current traditional farming system has been practiced since the third and fourth millennium BC. Due to low productivity of this farming system coupled with the increase in demand for farmland attributed to increase in population size, there has been extensive farmland expansion. The agricultural extensification has substantially contributed to deforestation and biodiversity loss in the country. Similarly, the rapid expansion of farmlands has contributed to the economy of the country through increase in gross agricultural production. In addition, suitability for agricultural investment and the interest for foreign direct investment stimulated the government efforts towards agricultural land expansion recently. As studies show, 80 percent of new agricultural land expansion is at the cost of reduction in forest, woodland, and shrub land. In this review, studies show that expansion of agricultural land influenced forests and biodiversity negatively. Therefore, the Government of Ethiopia should promote agricultural intensification to increase agricultural productivity and tackle extensification. This approach would minimize deforestation and biodiversity loss.

Key words: Agricultural extensification, agricultural intensification, biodiversity loss, deforestation, Ethiopia, population growth, traditional farming system

Resume

La demande alimentaire mondiale future peut être satisfaite en augmentant la production. L'augmentation de la production agricole peut à son tour être obtenue par l'intensification et/ou l'extensification de l'agriculture. Cependant, l'extensification de l'agriculture a largement contribué à la déforestation et à la perte de biodiversité. L'objectif de cette revue est de

comprendre l'expansion des terres agricoles, ses forces motrices et son impact sur la déforestation et la perte de biodiversité en Éthiopie. En Éthiopie, le système agricole traditionnel actuel est pratiqué depuis le troisième et le quatrième millénaire avant Jésus-Christ. En raison de la faible productivité de ce système agricole et de l'augmentation de la demande de terres agricoles attribuée à l'accroissement de la population, il y a eu une vaste expansion des terres agricoles. L'extensification agricole a largement contribué à la déforestation et à la perte de biodiversité dans le pays. De même, l'expansion rapide des terres agricoles a contribué à l'économie du pays par l'augmentation de la production agricole brute. En outre, l'aptitude à l'investissement agricole et l'intérêt pour l'investissement direct étranger ont récemment stimulé les efforts du gouvernement en faveur de l'expansion des terres agricoles. Comme le montrent les études, 80 % de l'expansion des nouvelles terres agricoles se fait au prix d'une réduction des terres forestières, boisées et arbustives. Dans cette revue, les études montrent que l'expansion des terres agricoles a eu une influence négative sur les forêts et la biodiversité. Par conséquent, le gouvernement éthiopien devrait promouvoir l'intensification de l'agriculture pour augmenter la productivité agricole et lutter contre l'extensification. Cette approche permettrait de minimiser la déforestation et la perte de biodiversité.

Mots clés : Extensification agricole, intensification agricole, perte de biodiversité, déforestation, Éthiopie, croissance démographique, système agricole traditionnel.

Introduction

Food demand worldwide can be achieved by increasing agricultural production (FAO, 2016a). Agricultural production can be increased by either agricultural intensification and/or agricultural extensification (Tilman *et al.*, 2011; Byerlee *et al.*, 2014; IFPRI, 2015). Agricultural extensification is the expansion in area of agricultural land while agricultural intensification is the increase in yield by increasing agricultural inputs (Demeke *et al.*, 2004). Approximately 80% of global deforestation is caused by the expansion of agricultural land (Kissinger *et al.*, 2012). Demand for agricultural products, among other things, is becoming the major driving force of agricultural land expansion by clearing forests especially in the developing world (Gibbs *et al.*, 2010). This deforestation contributes to biodiversity loss, desertification, carbon dioxide emission, flooding and other environmental costs (Wolfersberger *et al.*, 2015). Agricultural expansion at the expense of forests cannot ensure food security rather food self-sufficiency can be met by the intensification of agriculture (FAO, 2016a). One of the major challenges in the world is to find ways on how to achieve food security through enhancing agricultural production without affecting the coverage of forest areas (FAO, 2018).

Global environmental changes are crucial pressures to African agriculture (Nyantakyi-Frimpong *et al.*, 2019). Deforestation in Sub-Saharan Africa (SSA) between 2000 and 2010 was strongly correlated with agricultural expansion (FAO, 2016a). In large part of Africa, persistent alteration and reduction of ecosystems happen at the expense of future generations' means of survivals (Kubiszewski *et al.*, 2017). Agricultural expansion in SSA countries such as Ethiopia is a problem to natural forests and ecosystem service deterioration as well as climate change challenges (Hadgu *et al.*, 2019). Countries of Sub-Saharan Africa have least diversified and poor rural economies, undeveloped agriculture, degraded environment and consequently are susceptible to changes in

climate, deforestation and biodiversity loss (Alagidede *et al.*, 2016). Ethiopia is a typical example in this regard (Echeverria and Terton, 2016).

With 26% of total land area, agriculture dominates the economy of many SSA countries including Ethiopia, and is key for creating job opportunity to about 83% of the population (Bioversity International, 2019). Ethiopian population is projected to grow by approximately 2.5% (World Bank, 2016), reaching an estimated population of 174 million by 2050 (Bekele and Lakew, 2014). Ethiopian undeveloped agriculture sector, which depends mainly on smallholder and rain-fed agriculture, provides most of the country's population with food (Harvey *et al.*, 2019). Agriculture has been the backbone of the country's economy (Mellor and Dorosh, 2010; FAO, 2016b) and has been contributing about 45% of the Gross Domestic Product (Bioversity International, 2019). Agriculture is one of the major sectors that contributed to the 11% of annual GDP growth between 2005 and 2010 with its more than 8% growth (FDRE, 2011a). Importantly the agriculture sector contributes to over 80% employment for the country's population (MoFED, 2010; Narasimham and Subbarao, 2017), but is still undeveloped (Woldie and Birhane, 2019). The agricultural growth was achieved through an estimated 15% cultivated land expansion and 40% yield increase (FDRE, 2011a).

Increasingly, the conversion of habitats, improper management of natural resources, pollution and change in climate are becoming important risks to the sustainable management and use of biodiversity for food and agriculture (Bioversity International, 2019). The driving forces for climate change in the country are mainly agricultural expansion to high mountains to narrow agricultural land shortage and paucity as well as new human settlement expansions in the afroalpine and sub-afroalpine ecosystems (EPCC, 2015). The expansion in agricultural land resulting from rapid population growth has led to environmental deterioration (ATA, 2017). Ethiopian agriculture has been suffering from ecological degradation of potential arable lands among other factors (Welteji, 2018). Like in the rest of the world, improving agricultural production while ensuring environmental sustainability is the major challenge of the country. Understanding agricultural land expansion based on proper analysis of the driving forces and the possible impacts is important for designing strategies that enable to see things out of the box and change the business-as-usual scenario in balancing agricultural growth and biodiversity and the environment in general in the country. The objective of the paper is to analyse agricultural land expansion, its driving forces, and its impact on deforestation and biodiversity loss in Ethiopia.

Agricultural land expansion and its drivers in Ethiopia

Agricultural land expansion. Agricultural expansion is not a new phenomenon in Ethiopia. Historically, in the northern highlands of Tigray and Wello, agricultural expansion was a prominent land related activity during the third and fourth millennium BC (Phillipson, 1990). Following an extensive review of historical accounts, Melaku (1992) concluded that most forest covered areas of the central and northern highlands had been cleared because of agricultural expansion before the sixteenth century. Intensification of agriculture has been taken as a strategy to reduce the effect of agricultural land expansion on forests (FDRE, 2011a). However, agricultural intensification has lagged behind extensification in contributing to agricultural growth in the country before the designing of the Climate Resilient Green Economy (CRGE) strategy in 2011. The economy of Ethiopia which is based on subsistence agriculture has depended on extensification rather than

intensification for millennia (Lemenih *et al.*, 2008).

Agricultural extensification especially farmland expansion has been one of the key factors that contributed to the agricultural growth in Ethiopia (Guush *et al.*, 2017). For instance, between 1980 and 2001, 78%, and 80% of production growth was from extensification of the cereal, and pulses as well as oil seed crops, respectively (Demeke *et al.*, 2004). According to a study conducted by Degife *et al.* (2018) in Gambella regional State of Ethiopia between 1987 and 2017, agricultural land expansion especially large-scale farms increases by 544 km². This was mainly by clearing of forest lands while small-scale farmland was decreased by only 147 km² between 2000 and 2017 according the same case study. Nationwide cultivated land increased from 4.7 million to 8.8 million hectares from 1980 to 1996 (Kiros, 2005), while the Ethiopian Environmental Protection Authority (EPA, 1997) reported an estimate of 80,000 to 200,000 hectares of land expansion for rain-fed agriculture at the expense of forest area. Eighty percent of new agricultural land was converted from forests, woodlands or shrub lands (FDRE, 2011b).

There are several reasons for the conversion of natural habitats into managed systems in the nation. Part of this is due to agricultural expansion by smallholder farmers in response to increasing population. As part of this, farmers increase cultivated lands by incursion into forests to which they may have access (Kiros, 2005; Georgise *et al.*, 2019). Moreover, local authorities distribute areas covered with forests to individual farmers through settlements. On the other hand, the conversion of natural forests into agricultural lands is through large-scale agricultural investments because Ethiopia sees agricultural investment as crucial to its economy and an effective approach for overall development strategy (Degife and Mauser, 2017). The Government considers the strategy as a means to ensure economic growth, food security, and poverty reduction. According to Franks *et al.* (2017) there is a spatial difference in the occurrence of smallholder and large-scale agricultural land expansions. Large-scale agricultural land expansion happened in areas with lower population densities mainly in the lowlands while smallholder agricultural land expansion occurred in most parts of the country.

Driving forces for agricultural land expansion. In Ethiopia agricultural land expansion could be related to biophysical, socioeconomic, political or institutional forces (Tadesse *et al.*, 2008; Diress *et al.*, 2010; Getahun *et al.*, 2017; Aregai and Biedemariam, 2019; Georgise *et al.*, 2019; Woldie and Birhane, 2019). This is caused by subsistence needs (DeFries *et al.*, 2010; Fisher, 2010; Duguma *et al.*, 2019), and market driven by nature to produce high value crops (Watson, 2007). Specifically, agricultural land expansion is caused by forces such as population increase (Solomon *et al.*, 2018; Aregai and Biedemariam, 2019; Duguma *et al.*, 2019; Georgise *et al.*, 2019; Getahun *et al.*, 2019; Woldie and Birhane, 2019) and undeveloped farming system (Duguma *et al.*, 2019; Woldie and Birhane, 2019). Moreover, suitability for agricultural investment and foreign direct investment are some of the issues that drove the Government of Ethiopia thrust for agricultural expansion in some parts of the country (Yassin, 2014; Degife and Mauser, 2017; Olay *et al.*, 2017). The most enabling factors of agricultural land expansion especially in large-scale commercial farming are availability of unused land, crop suitability, water resources abundance, and agricultural development policy (Degife *et al.*, 2018).

Agricultural practices and land use intensities. Traditional farming practice and the increasing degradation of land made Ethiopia to be a food insecure country (Bewket, 2007; Deressa, 2007;

Mojo *et al.*, 2010; Matous *et al.*, 2013). To minimize food insecurity at household level farmers tried to expand farmland by cutting down adjacent forests (Kiros, 2005). In addition, to fill the gap in food demand raised by the increase in population smallholder farmers cultivate their land intensively through-reduced fallows (Georgise *et al.*, 2019). Fallowing is not promoted as a good land management system because of the land shortage in Ethiopia (Matous *et al.*, 2013). However, increasing cropping intensity by reducing fallows result in soil degradation (Georgise *et al.*, 2019).

The increase in crop production in the country has been achieved as a result of cultivated land expansion rather than increasing land productivity using agricultural inputs, such as fertilizer (Mekuria, 2018). This is mainly due to the traditional farming system being practiced in the country. Though Ethiopia started farming using the dominant oxen-powered agricultural technology some 7000 years ago (Bahru, 1992; cited in Kiros, 2005), still the country has relied heavily in unimproved traditional practices, rather than improved farming practices, resulting in a stagnant agricultural farming system and low productivity (Kiros, 2005). Evidences from different studies confirmed the change from forest coverage and grasslands to agricultural land especially cultivated land in many parts of the country (Ejigu, 2013; Kindu *et al.*, 2015).

Impact of agricultural land expansion in Ethiopia

The two major proximate drivers of deforestation in Ethiopia are agricultural land expansion and unsustainable fuel wood consumption (Senbeta and Denich, 2006; Lemenih *et al.*, 2008; Tadesse *et al.*, 2008). The existing forests are under pressure from these forces as described in the REDD+ strategy of the country (FDRE, 2018). As the focus of this paper is on the impact of agriculture land expansion, in this section, the major impacts on deforestation and biodiversity are reviewed.

Impact of agricultural land expansion on deforestation. In Ethiopia, agriculture has been more attractive than the forest sector (Tadesse *et al.*, 2008) and thus crop land expansion has been the most prominent deforestation driver (Phillipson, 1990; Tadesse *et al.*, 2008; CIFOR, 2015; Franks *et al.*, 2017). The effect of agricultural land expansion can be mainly described by the change in Land Use and Land Cover (LULC) (Kindu *et al.*, 2015). In this case, LULC change is considered as the consequence of deforestation (Solomon *et al.*, 2018). This is largely a result of increased farming intensity and its pressure on natural vegetation (Mekuria *et al.*, 2018). Agricultural land expansion has indeed been responsible for constant deforestation through time (Bishaw, 2001).

One way of assessing the impact of agricultural expansion on deforestation is to consider the mechanisms that farmers used to mitigate production factors constraints, especially shortage of cultivable land and poor land productivity. Empirical studies undertaken in different parts of the country have shown that clearing of forests is used as a means to mitigate cultivated land shortage especially in areas close to constraints forests. One of these studies concluded that clearing of forests adjacent to the periphery was the prime mitigation strategy that farmers adopted for the land shortage following the increase in number of household members (Duguma *et al.*, 2019). Another study undertaken in a different region concluded that the opening up of new agricultural land as a means to feed the increase in population has significantly contributed to the existing deforestation process (Solomon *et al.*, 2018). Similarly, Duguma *et al.* (2019) concluded that as a consequence of soil fertility decline, the poor productivity of agricultural lands push farmers to enter into the forests to start new farmlands as has been the case in Menagesha Suba Forest, in Ethiopia.

Impact of agricultural land expansion on biodiversity loss. Despite Ethiopia being among the top 25 countries of the World that are known for their rich biodiversity (Gashaw *et al.*, 2015), it has low-intensity biological diverse farming system (Di Falco *et al.*, 2010) and consequently there is low variability of crop yields (Di Falco *et al.*, 2012). To narrow the gap (low variability of crop yields) created by such challenge farmers opt for additional lands by augmenting their farmlands through clearing of forest areas (Kiros, 2005). Clearing of trees for cultivation is becoming the most important peril to the dryland ecosystems of Ethiopia. For instance, deforestation and forest degradation in the western lowlands of Amhara, Tigray and Benshagul-Gumuz acutely affected the sustainability of *Boswellia papayrifera* woodland species and its production (EPCC, 2015). Agricultural land expansion has resulted in decline of biodiversity and natural habitats due to clearance of vegetation (Dudley and Alexander, 2017). Reduction of forest ecosystem services occurred due to the change of forest land to cropland (Watson, 2007). As such agricultural expansion in Ethiopia has contributed to climate change through its resultant effect on deforestation and forest degradation (Woldie and Birhane, 2019) which in turn caused biodiversity loss (Dias Nunes *et al.*, 2019).

As seen from above, agricultural expansion through its effect on deforestation is a threat to biodiversity (Admasu *et al.*, 2013) as it is the major driving force of biodiversity loss in the country (Franks *et al.*, 2017). The observed agricultural extensification resulted in the reduction of flora and fauna, and in demolition of habitats in general as it has taken place at the expense of forests, woodlands and other wildlife resources (FDRE, 2007). The reduction in biodiversity and agricultural intensification sustainability challenges are caused by agricultural extensification among other factors (Mausser *et al.*, 2015). Agricultural land expansion resulted in deforestation and consequently in the loss of important species of trees and shrubs (Ejigu, 2013). Forest resources degradation and reduction in Ethiopia affected the protection of biodiversity (Kidane *et al.*, 2018), resulted in the loss of biodiversity (Muys *et al.*, 2006; Fekadu, 2015; Kidane *et al.*, 2018). Original species are in peril in the highlands of Ethiopia because of the activities of human beings (CPCC, 2015). Vivero *et al.* (2005) identified wild food tree species that are at risk due to agricultural land expansion in Ethiopia. These include *Acacia negrii*, *Acanthus sennii*, *Dombeya longibracteolata*, *Phyllanthus limmuensis*, and *Rubus aethiopicus*. Similarly, a study by Senbeta (2018) in Abay-Chomen district, Ethiopia confirmed a decrease by 22 percent of natural ecosystems such as forest, woodland and grassland within a 44 years period.

Conclusion

This review investigated agricultural land expansion and its drivers as well as its impact on deforestation and biodiversity loss in Ethiopia. Based on the findings from the review, the following main conclusions can be drawn. First, agricultural land expansion is a complex issue and has long history. It has been a prominent land related intervention starting in the third millennium BC. Since then agriculture continued to be the backbone of the Ethiopian economy. It is practiced mostly by smallholder farmers, but more recently through large-scale farming (agricultural investment). Agricultural extensification especially cultivated land expansion has been one of the factors contributing to the agricultural growth in the nation. Second, the driving mechanisms and forces are complex and related to biophysical, socioeconomic, political or institutional forces. The main drivers are population growth, undeveloped farming systems, suitability for agricultural investment and foreign direct investment. Third, the expansion of agricultural land influences natural habitats

to be changed into highly managed systems and is the major driver of deforestation and forest degradation. Clearing of forest for agricultural land expansion has resulted in the loss of trees and biodiversity. Finally, it can be concluded that demand for increased agricultural production can be obtained by agriculture intensification if agricultural intervention is based on land use plan. If this approach is not followed, there might be a challenge in increasing production while maintaining the biodiversity of the country. From this we recommend that empirical investigation be undertaken on the changes in ecosystem services following both smallholder and large-scale agricultural expansion, and to estimate the willingness to pay off individuals to reduce pressure on use of forest lands, and to foster sustainable management of natural habitats to improve the forest ecosystems of the country.

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