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Review Article

Woody Species Conservation, Management, and Its Socioeconomic Importance of Agroforestry Practice in Ethiopia

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The preservation of biodiversity is not at all a luxury. In many developing countries, the reduction in biodiversity caused by the conversion of primary forest to unsustainable agricultural landscapes has increased. Agroforestry provided habitat for various species of wildlife and had significant social and environmental advantages. However, there is a lack of knowledge on the significance of agroforestry in the management and conservation of woody species. The review's main goal is to emphasize the socioeconomic significance of agroforestry in Ethiopia and the conservation and management of woody species. The most common agroforestry practices are typically carried out in different parts of the country on homegardens, crops, woodlots, and coffee farms. The most typical woody species utilized in agroforestry practices in southern Ethiopia are *Cordia africana*, *Millettia ferruginea, Erythrina brucei, and Olea capensis*. In Ethiopia's northern region, you can find *Croton macrostachyus*, *Vernonia amygdalina*, *Faidherbia albida*, *Acacia nilotica*, *Acacia seyal, and Grewia bicolor*. The central highlands of Ethiopia also have *Albizia gummifera*, *Cordia africana*, *Croton macrostachyus*, *Ficus vasta*, and *Vernonia amygdalina*. Agroforestry improves the environment and the socioeconomic system by producing tree products such as timber, firewood, food, and building materials (reduce soil erosion, increase soil moisture and fertility, coffee shade, and keep microclimate balance). Woody species in agroforestry are managed through pollarding, thinning, and pruning.

1. Introduction

The preservation of biodiversity is not at all a luxury. Throughout millennia, a variety of cereals, fruits, vegetables, fine firewood, fine lumber, delectable fodders, domesticated animals, etc., have been culled from biodiversity. There are still plenty more in the abundant wild that may be beneficial as food or medications. Furthermore, biodiversity is essential to the health of an ecosystem because it drives the balance necessary for an ecosystem to function properly. The natural order is a resilient phenomenon that tends to withstand stress and shield nature (humanity) from disturbances, even our own careless deeds [1]. In many developing countries today, the loss of biodiversity as a result of turning primary forests into unsustainable agricultural landscapes has grown. For instance, one of the most noticeable characteristics of the Ethiopian highlands is environmental deterioration, which manifests itself as deforestation, loss of biodiversity, and decreased soil fertility. In the highlands of Ethiopia, some 27 million hectares of land have been considerably degraded, of which 2 million hectares have been so severely damaged that they cannot support cereal production in the future [2]. The well-known factors of forest clearing, exposing surface soil to erosion, and overgrazing, which typically results in a loss of biodiversity, are the fundamental causes of land degradation in Ethiopia.

It is vitally necessary to save the environment, or to plant the correct tree species in the right location for the right purpose [3], as well as to manage any remaining tree resources, such as trees on farms, other types of agroforestry trees in rangelands, and the like [4]. There is sufficient data to conclude that trees and shrubs, when properly maintained, can significantly contribute to preserving and enhancing soil fertility and overall productivity in agroecosystems [5]. There are countless instances of conventional land

management techniques that involve cogrowing trees and livestock on the same plot of land throughout the world. When using these traditional land-management techniques, trees are purposefully kept on or near farmlands to support agriculture and other livelihood systems [6].

Agroforestry is a type of sustainable land use that combines farming or animal husbandry with planting trees to start an agroecological succession [7]. Agroforestry is a tool for diversifying and boosting productivity and is heavily pushed globally due to its economic, social, and environmental benefits [8, 9]. Growing trees alongside annual crops also aids farmers in overcoming agricultural failure brought on by land degradation and climate change [10, 11]. Despite all these benefits and uses, many local communities are seeing a sharp decline in the number of woody species on agriculture. This is because farmers' needs have not received enough scientific attention. This research evaluates pertinent management approaches and focuses on the socioeconomic significance of Ethiopia's agroforestry practice for the protection of woody species.

2. Methods

For these reviews, systematic methods were used. Online search different published and local source of document that relate with the topic identified between September 2021 and April 2022 used as source of information. The author use web-based search for seeking of published research material from various regions of Ethiopia which was conducted on woody species management and its socioeconomics. By using the Google search engine, regional university websites, and international scientific databases, the author specifically included documents published 2000–present (primarily from 2015) from the southern, northern, eastern, southwestern, northwestern, mid-Rift Valley, and central highlands. A total of 89 published papers were chosen for this review based on the predetermined inclusion criteria; documents that lacked details regarding the study topics and aims were excluded. The Natural Database for Africa (NDA), version 2.0, was used to identify tree species native to Ethiopia and their scientific names [12]. The review is to fulfill the information gap on woody species diversity management and socioeconomic importance.

3. Literature Review

3.1. Global Agroforestry Cover. Agroforestry, a traditional land-use practice found throughout the world, focuses on maximizing the benefits of biological interaction by intentionally linking trees, crops, and animals under agroecological systems [13]. According to a World Agroforestry Centre (ICRAF) working paper [14], agroforestry covers around one billion hectares or 43% of agricultural lands globally and involves more than 900 million people. In Asia, agroforestry is also prevalent and has played a critical role in local livelihoods since ancient times [15]. If defined as being more than 10% tree cover on agricultural land [14], then agroforestry covers 77.8% of all agricultural land in Southeast Asia, 50.5% in East Asia, 27.0% in South Asia, and 23.6% in Northern and Central Asia. Thirty-five years ago, widespread concerns over land degradation and the lack of effective solutions in Africa led to the hope that international agroforestry research could contribute new solutions [16]. Despite local success stories [17], many parts of Africa have continued to experience food insecurity, declines in per capita farm income, and land and soil degradation, aggravated by biodiversity loss [18]. Throughout Africa, agroforestry systems come in a wide variety of shapes and forms. Many of these systems have little more in common than the coincidence of woody perennials with agricultural crops and/or livestock. Basic data collection by the FAO does not clearly stress the segregation between forests and agricultural landscapes with trees. This can be seen as an historical anomaly rather than a reflection of incompatibility between annual and perennial plants within a farming system [16].

3.2. Agroforestry Practice and Human Well-Being. AFS have the potential to serve in the restoration and rehabilitation of degraded ecosystems and could help to reinstate ecosystem services [19]. Food security, land tenure security, enhanced farm-based incomes, management of terrestrial and soil biodiversity, carbon sinks, hydrological functions, wildlife corridors, reduced soil erosion, biodiversity conservation, microclimate improvement, increased nutrient retention via root capture and cycling, etc., are some of the diverse benefits of AFS reported from the region [20]. There is considerable evidence that AFS support sustainable production, providing subsidiary household provisions with diversified products, conservation of natural resources, aquifer recharge, etc. [21]. Agroforestry support is a sustainable intensification within a land use archetype that are based more on ecology than on chemistry and climate science [22]. Article 2 of the Paris Agreement proposed to strengthen global efforts to reduce climate impacts with reference to sustainable development and poverty alleviation. Hence, it is vital to recognize and acknowledge the role of agroforestry and to mainstream it at country level to address global climate targets. Leveraging the mitigation potential of land use sectors is crucial, in meeting emission reduction targets [23].

3.3. Agroforestry Practice in Ethiopia. Parkland agroforestry (scattered trees on croplands), homegardens, hedge-row intercropping, riparian zone vegetation, enclosures, and natural regeneration of species in forests and pasture are the most prominent agroforestry practice activities in Ethiopia. Some examples of parklands agroforestry in Ethiopia include maize intercropping with *Cordia africana* in Bako and western Ethiopia, as well as *Faidherbia albida*-based agroforestry in the Hararghe Highlands and Bushoftu area [24, 25]. In several places of southern and southwestern Ethiopia, multistorey homegardens are also prevalent. The structural complexity of homegardens varies, ranging from complex and diversified forms comprising several species, such as those found in Sidama, to simpler forms with one or two crop/tree mixes, such as those seen in Gurage [26–30]. As living fences, a variety of multipurpose tree and shrub species

were utilized. The majority of farmers' crops are grown in both homegardens and fields. Traditional agroforestry practices are compared to the homegarden complex [31].

In several areas of Ethiopia, hedgerow intercropping is used. In the hararghe highlands of eastern Ethiopia, one such example is the intercropping of sorghum/maize and chat (*Catha edulis*) hedgerows. Riparian vegetation can be found around rivers, streams, and other bodies of water. There are several perennial and intermittent rivers in Ethiopia, and some of these rivers and streams support huge populations of species with lush vegetation. *Acacia tortilis, Acacia nilotica, Balanites aegyptiaca, Tamarindus indica, Tamarix* spp., and *Ziziphus* spp. are examples of riparian zone vegetation in Ethiopia, which can be found along the Awash and Eliwoha waterways. During the dry season, riparian vegetation provides valuable feed for animals, as well as food, medicine, fire wood, farm implements, and timber for construction for utensils for humans.

It is also home to many plants and animals. Another agroforestry practice is enclosures and natural regeneration of species [32]. The establishment of enclosures is a realistic and cheap approach to the improvement of pastoral and degraded woodlands. The successful enclosure practices in Ethiopia include the enclosures of large inhospitable parts of Tigray Terrains, and enclosures established by Self Help International (SHI), Ireland, in the dry lands of the rift valley of southern Showa [33]. The enclosures are managed for the advantage of local people, with cut-and-carry grass production, restricted harvesting of wood products and other minor forest products, and making them agroforestry practices in kinds of trees and shrubs [34]. Furthermore, household gardens in central, eastern, western, and southern Ethiopia have roughly 162 plant species, with 78 percent of them being food crops [35]. The homegarden is a site where many indigenous taxa's crops have evolved and diversified. Also seen in homegardens are crops introduced during the early stages of agricultural breakthroughs, as well as species planted at the experimental level. Homegarden has a lot of promise in Ethiopia, according to the findings [36].

In agricultural lands, live fences, windbreaks, and isolated trees all help to conserve biodiversity. Floristic variety can be high in these agroforestry practices, and a large number of animal species may use these environments for eating, sheltering, and breeding in some circumstances. Live fences, windbreaks, and lone trees form natural habitat networks that can improve landscape connectivity and help conserve biodiversity at different scales. They do not, however, constitute whole biological units and cannot supply the same range of habitats or services as the original ecosystem. As a result, species in them are likely to seek refuge on live fences, windbreaks, and lone trees present in neighboring remnant habitats, at least to some extent [37].

4. Agroforestry for Biodiversity Conservation

As an in situ conservation strategy, agroforestry activities boost biodiversity on farmland. The importance of agroforestry in conservation varies depending on the type and management of the crop (Table 1) [38].

5. Woody Species Conservation in Agroforestry

Managing multipurpose trees such as *Cordia africana, Millettia ferruginea, Albizia gummifera, Croton macrostachyus, and Erythrina brucei* as a major element of agricultural landscape are extensively accepted by Ethiopian farmers [39] (Table 2). *Cordia africana, Ekebergia capensis, Olea capensis, Erythrina brucei, Millettia ferruginea, Citrus medica, and Annona senegalensis* are also important in the south of the country, particularly in homegardens where they are managed using farmers' local knowledge [40]. *Croton macrostachyus, Cordia africana, Vernonia amygdalina, and Erythrina abyssinica* are other popular indigenous multipurpose tree species found in Ethiopia's west Hararge zone [41] (Table 2). In the southwestern areas of Ethiopia, *Millettia ferruginea and Cordia africana* are the most chosen woody plants for retention and planting in homegardens [42]. In contrast, in Tigray, the fruit tree *Cordia africana* is an indigenous fruit trees and fodder trees *Faidherbia albida, Acacia nilotica, Acacia seyal, and Grewia bicolour* are important in agroforestry practices [43] (Table 2). In addition to these, *Albizia gummifera, Cordia africana, Croton macrostachyus, and Vernonia amygdalina* are popular in smallholder coffee farms in Ethiopia for coffee shade [44].

Among the 670 species reported in the ICRAF agroforestry database (https://apps.worldagroforestry.org/), *Acacia abyssinica, Albizia schimperiana, Citrus medica, Celtis africana, Erythrina brucei, Ficus vasta, Millettia ferruginea, Schefflera abyssinica, Vernonia schimperi, and Oxytenant.* Only *Acacia nilotica, Acacia seyal, Acacia tortilis, Olea europaea, and Faidherbia albida* are among the "top-100" tree species prioritized for planting in the tropics and subtropics [12, 45]., *with Olea europaea and Faidherbia albida* being given high conservation priority [46]. In the international timber trade, trees including *Cordia africana, Acacia nilotica, and Albizia gummifera* are classified as commercial wood species [47].

6. Agroforestry Strata

Farmers intentionally maintained annual and perennial herbs, as well as woody species of several plant groups, to meet their subsistence and economic demands [48]. According to the findings, 159 species were found in the homegarden, with 70.44 percent of those deemed helpful to the community. In agricultural environments, agroforestry is also an essential sanctuary for native and threatened species. For example, 85 percent of the 50 woody species identified in traditional agroforestry in southeastern Ethiopia by [49] were sourced natively. As reported in various agroforestry practices in Ethiopia, agroforestry conserves endangered and national priority plant species such as *Cordia Africana, Vicus vast,* and *Olea African* (Figure 1). For example, coffee-based agroforestry in the southern region of Ethiopia [50] reported more than 59 percent native woody species, including 22 species of conservation significance out of 155 species. Currently 56 species are included in the 2004 IUCN Red List of Threatened Species [51], all of them woody plants, of which

Table 1: Biodiversity dimensions in agroforestry practices in the tropics [38].

Agroforestry practices	Biodiversity issues
Shifting cultivation	(i) Fallows consist of multiple species; and biological diversity, in both inter- and intraspecies, is intense (ii) Long decrepit periods of 15 to 20, a long time to protect wild species differences
Homegardens	(i) High associate- and intraspecies differing qualities including a number of natural product, feed and timber trees and bushes, nourishment crops, restorative, and other plants
Agroforests	(i) Maintain tall species differing qualities comparative to normal forests but ruled by a number of carefully overseen financially important tree species
Parkland agroforestry	(i) Naturally proliferated trees guarantee wide species differences

Table 2: Major woody species in agroforestry in Ethiopia [12].

Major trees species	Area in Ethiopia	Sources
Annona senegalensis, Citrus medica, Cordia africana, Ekebergia capensis, Erythrina brucei, Millettia ferruginea, Prunus africana, Ficus vasta, Syzygium guineense, Vernonia schimperi, Moringa stenopetala, and Olea capenssis	Southern part of Ethiopia	Zebene and Agren; Mesele; Mathewos et al.; Takele et al.; Teklu; Alemu et al.; Adane et al.
Cordia africana, Croton macrostachyus, Erythrina abyssinica, and Vernonia amygdalina	Eastern parts of Ethiopia	Gindaba et al.; Desalegn and Zebene
Acacia abyssinica, Albizia gummifera, Albizia schimperiana, Cordia africana, *Croton macrostachyus, Erythrina abyssinica, Ficus thonningii, Ficus vasta.,* *Schefflera abyssinica, Sesbania sesban, and Millettia ferruginea*	Southwestern parts of Ethiopia	Getahun et al.; Nigussie et al.; Tola et al.; Hundera et al.; Getahun et al.; Habte et al.
Acacia nilotica, Acacia seyal, Balanites aegyptiaca, Capparis tomentosa, Carissa edulis, Citrus medica, Cordia africana, Faidherbia albida (Acacia albida), Ficus sycomorus, Grewia bicolour, Oxytenanthera abyssinica, Dalbergia melanoxylon, and Moringa stenopetala	Northern parts of Ethiopia	Etefa et al.; Gebrewahid et al. Gebru et al.
Acacia abyssinica, Albizia gummifera, Cordia africana, Croton macrostachyus, *Erythrina brucei, Faidherbia albida (Acacia albida), Ficus vasta, Rhamnus prinoides, and Vernonia amygdalina*	Central highlands of Ethiopia	Yadessa et al.; Duguma and Hager; Ebisa and Abdela; Negese and Motuma
Acacia tortilis, Acacia mellifera, Celtis africana, Grewia bicolor, Olea europaea, *Dichrostachys cinerea, and Balanites aegyptiaca*	Mid Rift Valley of Ethiopia	Shenkute et al.
Acacia abyssinica, Albizia gummifera, Cordia africana, Croton macrostachyus, and Erythrina abyssinica	Northwestern parts of Ethiopia	Linger

20 are threatened. Rare/threatened species like *Boswellia pirottae, Hagenia abyssinica, and Taverniera abyssinica* were identified as fragile in the wild and in need of immediate conservation attention (Figure 1)

7. Socioeconomic Benefit of Wood Species

Agroforestry offers a significant potential for the protection of socioeconomically and environmentally important indigenous tree species utilized for a variety of services such as fodder, food, medicine, fuel wood, farm implements, and utensil wood [52]. The majority of the inhabitants in the country rely on rain-fed agriculture, which includes agroforestry practices. Nontimber forest products and timber forest products such as fruit, firewood, honey, spices, lumber, pole, and charcoal are used to determine tree product income [53, 54]. Even if the quantity of revenue obtained varies from place to place, that extra income is playing a significant role in improving farmers' livelihoods, particularly when crop production hazards arise as a result of climate change [55]. Furthermore, in Kaffa and Wolaita Zone 800 to 1500 ETB in [56], and 1683 ETB where annual average income comes from homegarden agroforestry practice in Jimma Zone, southwest Ethiopia [55], the farmer earns 47 percent of his income from nontimber forest products. Various factors, however, determine the amount of money produced from tree products. According to some research, the age of the farmer, household wealth status, land

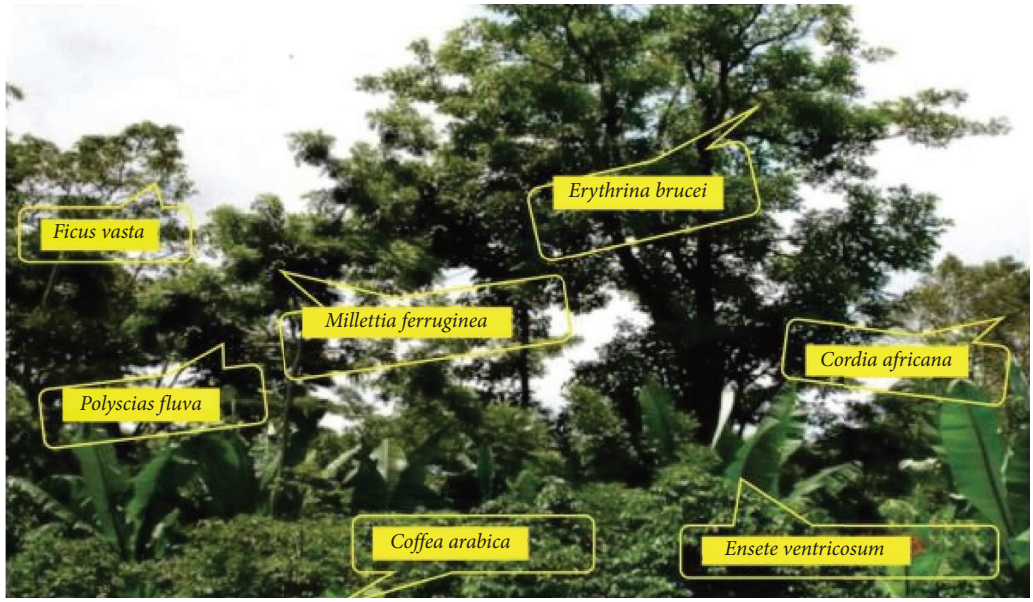

Figure 1: The upper- and middle-story species in a Gedeo agroforest. Photo credit: Negash 2013.

size, and education level all have a beneficial impact on household income [57, 58].

According to [59], the World Health Organization estimates that at least 80% of the inhabitants of most developing nations rely on traditional medicine for primary health care. Various works of literature [60–62] demonstrate the benefits of trees or shrubs for traditional medicine in various locations of Ethiopia. *Croton macrostachyus*, for example, is used to treat malaria, diarrhea, epilepsy, ringworm, and skin rush; *Cordia africana* is used to treat evil eyes; Euphorbia candelabrum is used to treat ringworm; *Millettia ferruginea* is used to treat fungal infection; and *Vernonia amygdalina* is used to treat diarrhea and stomach ache. Thus, in the Boosat district of central eastern Ethiopia [61], roughly 52 medicinal plant species were found; while in the Jimma zone of southwestern Ethiopia [62], 39 medicinal plants used to treat various diseases were identified. Tree-based agroforestry land use practice provides a shade service. People are assembled under a shade tree for social issues and religious purpose (e.g., playing) in southwestern Ethiopia [63].

8. Management of Woody Species Diversity in Agroforestry

It is commonly accepted that agricultural conditions have a significant impact on how trees integrated into agricultural fields are maintained [64]. Trees have a unique role in a variety of management systems, whether they are predominantly subsistence or free enterprise operations and are consequently integrated into agricultural fields to varying degrees. The main factor affecting the employment and management of trees is the management system [65]. Little or nothing is understood about current ground management practices, farmers' perceptions of the function of ground trees, and so the varied yields of ground trees in meeting their needs and their production, in contrast to what is celebrated regarding the plant and placental parts of agroforestry practices and practices unit celebrated goals and regarding the challenges farmers face that limit their capability to develop piece of ground tree resources in their farming systems.

The selection and management of the impacted species has an impact on the system's effectiveness as woody species management has the potential to be a tool for dominant agriculture competition in agricultural fields. Through the use of heading, topping, and pruning techniques that should be used in the early summer or at the height of the season, it is important to manage the trees to ensure the sustained production of mulch or leaf feed and mild shade [56]. In order to try to improve coverage in a certain area, understanding tree care methods in a given location (forest), (woodland), (jungle), (tree-plant), and on private farm fields is absolutely essential. To do this, it is crucial to know management practices within the context of social unit keep ways and farmers' views on the values of trees [66].

Agroforestry piece of ground management procedures have a number of options, but the most common ones are pruning, facet branch cutting [67], pruning [68], watering, plant protection and fertilization [69], and root cutting [70]. By pruning, the mother trees should be able to grow taller without unduly shadowing the plants below [71]. Pollarding aids in reducing excessive shading. Although it is not a typical procedure, thinning was done in woody species when the canopy of two or more adjoining trees started to close and produce obtrusive shadows. To lessen the impact on crops, increase animal feed, and gather wood for fencing and firewood, agroforestry species in parklands that are still on arable ground are pruned [72]. Overall, maximizing the system's benefits is the main justification for managing woody species. Otherwise, woody species might impair agricultural productivity by competing with plants for resources like light, water, and nutrients, especially in areas

with high tree density and size [73, 74]. Woody species must be managed in agroforestry in many regions of the nation for a variety of reasons, including home consumption and boosting household finances. The primary factor for choosing a tree and creating an effective management plan in agroforestry is the farmer's preference for particular tree species.

9. Summary

Ethiopia's oldest traditional practice is the agroforestry practice, which is currently viewed as a cutting-edge way to utilize land. Indigenous multipurpose agroforestry tree species are rapidly being incorporated into agroforestry practices in Ethiopia due to their significance in producing economic items for smallholder farmers while also serving crucial ecological roles. The most significant indigenous multifunctional tree species in Ethiopia are *Cordia africana, Millettia ferruginea, Ficus vasta, Albizia gummifera, Croton macrostachyus, Faidherbia albida, Vernonia amygdalina, Acacia nilotica, and Erythrina brucei*. Homegardens, farmland, coffee plantations, and woodlots are a few examples of agroforestry approaches that farmers are more informed about. It makes a substantial contribution to the variety of products grown on a single plot of land. Therefore, from the perspective of farmers, it is better than monoculture. In addition, it offers environmental services, socioeconomic advantages, and tree products (such as timber, firewood, food, and building materials) (reduce soil erosion, increase soil moisture and fertility, coffee shade, and keep microclimate balance). Once they are established as mature trees, numerous management techniques, including as pruning, pollarding, coppicing, thinning, and lopping, are employed to ensure the compatibility of trees with various crops in agroforestry practices.

Data Availability

The data used to support the study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Supplementary Materials

Figure 1: Enset-Coffee agroforestry homegarden with different configuration. Figure 2: typical agroforestry practices observed in semiarid and subhumid zones of Oromia. (a) *Faidherbia albida* amongst teff in semiarid. (b) *Ziziphus mauritania* and *Acacia abysinica* in maize fields in semiarid (Miyuki (I) et al. 2017). (c) *Cordia africana* in a maize field in subhumid (Ayele (Y) Ewnetu (Z) Asfaw Z 2014). Figure 3: coffee farmer agroforestry practice around Jimma town (Endale B 2017). Figure 4: *Eucalyptus camaldulensis* (a) and *Cupressus lusitanica* (b) woodlot tree-based agroforestry (Endale B 2017). (*Supplementary Materials*)

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