Review

https://doi.org/10.18619/2072-9146-2025-1-82-87
УДК: 630*182.2(048)(63)

Kasu Hailu Biru[1]*,
Urge Cheru[2]

[1] Ethiopian Forestry Development Hawassa center, Plantation Research program
Addis Ababa, Ethiopia

[2] Ethiopian Forestry Development Jimma Center
Addis Ababa, Ethiopia

Corresponding Author: kasuhailu128@gmail.com

Author's Contribution: Kasu Hailu Biru: conceptualization, writing – review & editing the manuscript, has significantly contributed to the development and writing of this review. Urge Cheru: formal analysis, writing the manuscript.

Funding. This review did not receive any specific grant from funding agencies in public, commercial or not for profit sector.

Conflict of Interest: The authors declare no conflict of interest.

For citation: Biru K.H., Cheru U. Management and Ecological Services of Multipurpose Agroforestry Tree Species in Ethiopia. Review. *Vegetable crops of Russia.* 2025;(1):82-87. https://doi.org/10.18619/2072-9146-2025-1-82-87

Received: 07.10.2024
Accepted for publication: 14.11.2024
Published: 28.12.2024

Management and Ecological Services of Multipurpose Agroforestry Tree Species in Ethiopia. Review

ABSTRACT

Relevance. Ethiopians have a long history of planting trees, and they have embraced the idea of keeping natural trees with many uses as a distinctive feature of their agricultural landscapes. Farmers use agroforestry practices to maintain a number of species of multipurpose trees. The selection of tree species, their intended benefits, and ecological services are inconsistent due to variability in agro-ecological conditions. The main problems with Ethiopia's multifunctional agroforestry tree species were also related to management approaches.

Therefore, the purpose of this article is to examine the multipurpose agroforestry tree species in Ethiopia, their management methods, and their ecological benefits. In southern Ethiopia, *Cordia africana, Millettia ferruginea, Erythrina brucei,* and *Olea capensis* are the main multifunctional tree species used. The northern part of Ethiopia hosts *Croton macrostachus, Vernonia amygdalina, Faidherbia albida, Acacia nilotica, Acacia seyal,* and *Grewia bicolor.* The central highlands of Ethiopia are also home to *Albizia gummifera, Cordia africana, Croton macrostachus, Ficus vasta,* and *Vernonia amygdalina.* Farmers use coppicing, pollarding, and pruning tree management techniques to balance their survival with integrated crops because trees regenerate naturally. Multipurpose trees offer a range of agro-ecological services, such as improving soil fertility, mitigating erosion, mitigating the impacts of climate change, and maintaining biological diversity.

KEYWORDS:

Agroecology, Agroforestry, Ecological service, Management, Multipurpose, Species

Управление и экологические преимущества использования многоцелевых агролесомелиоративных пород деревьев в Эфиопии. Обзор

РЕЗЮМЕ

Актуальность. Эфиопы имеют долгую историю возделывания деревьев, и они приняли идею сохранения естественных пород деревьев с многоцелевым использованием как отличительную черту своих сельскохозяйственных ландшафтов. Фермеры используют методы агролесоводства для поддержания ряда видов многоцелевых деревьев. Выбор видов деревьев, их предполагаемые экологические преимущества непостоянны из-за изменчивости агроэкологических условий. Основные проблемы использования многофункциональных пород деревьев в агролесоводстве Эфиопии также связаны с подходами к управлению. Поэтому цель этой статьи – изучить многоцелевые виды деревьев для агролесоводства в Эфиопии, методы их управления и их экологические преимущества.

Результаты. На юге Эфиопии основными многофункциональными видами деревьев, используемыми в Эфиопии, являются *Cordia africana, Millettia ferruginea, Erythrina brucei* и *Olea capensis.* В северной части Эфиопии произрастают *Croton macrostachus, Vernonia amygdalina, Faidherbia albida, Acacia nilotica, Acacia seyal* и *Grewia bicolor.* В Центральных нагорьях Эфиопии также выращивают *Albizia gummifera, Cordia africana, Croton macrostachus, Ficus vasta* и *Vernonia amygdalina.* Фермеры используют различные методы выращивания и обрезки деревьев, чтобы сбалансировать выживание интегрированных культур, поскольку деревья восстанавливаются естественным образом. Использование многоцелевых деревьев дает ряд агроэкологических преимуществ, таких как повышение плодородия почвы, смягчение эрозии, смягчение последствий изменения климата и поддержание биологического разнообразия.

КЛЮЧЕВЫЕ СЛОВА:

агроэкология, агролесоводство, экологическая служба, управление, многоцелевые виды деревьев

Хайлу Биру[1]*, Урге Черу[2]

[1] Эфиопский центр развития лесного хозяйства Хавасса, программа исследований плантаций
Аддис-Абеба, Эфиопия

[2] Эфиопский центр развития лесного хозяйства Джимма
Аддис-Абеба, Эфиопия

Автор для переписки: kasuhailu128@gmail.com

Вклад автора: Биру К.Х.: концептуализация, создание черновика рукописи и ее редактирование, значительный вклад в разработку и написание этого обзора. Урге Черу: формальный анализ, создание рукописи.

Финансирование. Этот обзор не получал никаких конкретных грантов от финансирующих агентств в государственном, коммерческом или некоммерческом секторе.

Конфликт интересов. Авторы заявляют об отсутствии конфликта интересов.

Для цитирования: Biru K.H., Cheru U. Management and Ecological Services of Multipurpose Agroforestry Tree Species in Ethiopia. Review. *Vegetable crops of Russia.* 2025;(1):82-87. https://doi.org/10.18619/2072-9146-2025-1-82-87

Поступила в редакцию: 07.10.2024
Принята к печати: 14.11.2024
Опубликована: 28.12.2024

Introduction

Agroforestry practices are widespread among small-scale farmers in southwest Ethiopia. Because of the close relationship between the many crops, trees, and animals that offer a range of ecological and economic advantages, agroforestry is thought to improve agricultural sustainability [1]. Due to its economic, social and environmental benefits [2]; agroforestry is widely promoted throughout the world and is an instrument for diversifying and enhancing production [3]. Farmers can also combat crop failure brought on by climate change and soil degradation by planting trees alongside annual crops [4, 5]. Depending on socioeconomic and biophysical circumstances, smallholder farmers in Ethiopia employ a variety of agroforestry techniques [6-8]. Asfaw and Egren [9], state that they include sporadic trees on farms, woodlots, home gardens, silvopastures, and coffee shade trees. The most significant and conventional method of using trees in agroforestry to ensure their continuous production of a variety of goods on croplands is probably intentional management of naturally renewing trees [10]. Agroforestry trees need to develop quickly under human control, propelled by farmers or the market, in order to be planted in larger areas. One may argue that farmers' intentional planting, removal, or selection of trees is the first step toward domesticating the species [11]. In agricultural fields, farmers frequently control the natural regrowth of trees by providing protection for seedlings and young trees, mostly native species that have sprung from soil seed banks. Agricultural landscapes in Ethiopia's sub-humid zones are dominated by multipurpose trees, which are managed by farmers on a large scale [12].

Due to their environmental adaptability and status as essential components of the ecosystem, multifunctional tree species are typically preferred by Ethiopian farmers [13, 14]. Additionally, because to their ability to lessen wind and water erosion, they provide the most important resource basis for smallholder production systems. By fixing nitrogen and adding and breaking down nutrient-rich litter, trees help increase the fertility of the soil [15, 16]. Furthermore, according to several studies [16-19], they are essential for maintaining biodiversity, sequestering carbon, and enhancing microclimates for cash crops like coffee. Despite all of these advantages, many local communities are seeing a sharp decline in the amount of native trees used in agriculture [19-21]. This is because Ethiopian policymakers lack sufficient expertise, and scientists have not paid enough attention to the requirements of farmers. Additionally, there is a propensity to encourage alien tree species for various purposes [22]. This review looks at pertinent management practices and highlights the function of multifunctional agroforestry tree species prevalent across Ethiopia. It also investigates their Ecological services.

Methodology

This study processed by the review of the last [19] years types of the research published in the field of multipurpose agroforestry tree species were analyzed and read carefully by the author's collected helpful information about the importance of multipurpose purpose agroforestry tree species on ecological services in Ethiopia. These studies added significantly to our understanding of the ecological services provided by multipurpose agroforestry tree species in Ethiopia as well as their management approach. To verify the validity of the study, a list of all the papers was included in the reference section. This review paper had been effective impact where managing multipurpose tree species that preferred was adopted by the communities, and also increased the awareness of the significance of the managing techniques. The favorable effects, significance, advantages, and roles of multipurpose agroforestry tree species management on ecological services in Ethiopia are outlined in this review paper.

Results and Discussions

According to Wood and Burley [23], multipurpose trees are any woody perennials that are intentionally planted to contribute significantly to several production and/or service roles within a land-use system. These trees are deliberately maintained for multiple outputs, and their classification is based on their functional role in the agroforestry technique that is being examined.

Because multipurpose trees meet at least one conventional or cultural human need such as providing a live fence or windbreak or may be used in an alley cropping system to restore soil fertility or provide fodder, they have a larger positive influence on farmers' well-being than invasive species. They usually fulfill one or more secondary functions, such as producing fuel, construction materials, and food (fruits, nuts, and leaves] for the family, as well as saving soil and water [14, 24, 25].

The main species of multipurpose trees used in agroforestry in Ethiopia

Enhancing soil fertility to increase the yield of food and tree crops on the same farm land is a typical motivation for agroforestry practices [26]. Ethiopian agricultural landscapes are dominated by farmers' management of multifunctional trees like *Cordia africana, Millettia ferruginea, Albizia gummifera, Croton macrostachyus,* and *Erythrina brucei* [12, 27-30]; *Annona senegalensis, Cordia africana, Ekebergia capensis, Olea capensis, Erythrina brucei, Millettia ferruginea, Citrus medica,* and *Annona senegalensis* are among the other important species in the southern part of the nation (Table 1].

Many multifunctional tree species, including *Croton macrostachus, Cordia africana, Vernonia amygdalina,* and *Erythrina abyssinica,* can be found in the west Hararge zone in eastern Ethiopia [31]. The most common woody species for planting and retention in household gardens in southwest Ethiopia are *Millettia ferruginea* and *Cordia africana* [13]. Conversely, in Tigray's agroforestry systems where the native fruit tree *Cordia africana* is found *Faidherbia albida (Acacia albida), Acacia nilotica, Acacia seyal,* and *Grewia bicolor* are important fodder trees [11]. In Ethiopia, smallholder coffee plantations also cultivate *Vernonia amygdalina, Croton macrostachyus, Albizia gummifera,* and *Cordia africana* as shade trees [15].

Table 1. Important species of multipurpose agroforestry trees in Ethiopia

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	Asfaw and Ågren [9]; Negash [28]; Agize, Demissew [35]; Gina, Nigatu [29]; Gebretsadik [36]; Anshiso, Woldeamanuel [30]; Adane, Legesse [27]
Cordia africana, Croton macrostachyus, Erythrina abyssinica and Vernonia amygdalina	Eastern part of Ethiopia	Gindaba, Rozanov [37]; Mamo and Asfaw [31]
Acacia abyssinica, Albizia gummifera, Albizia schimperiana, Cordia africana, Croton macrostachyus, Erythrina abyssinica, Ficus thonningii, Ficus vasta., Schefflera abyssinica, Sesbania sesban and Millettia ferruginea	South-western part of Ethiopia	Yakob, Asfaw [13];Ango, Börjeson [38]; Nigussie, Taye [39]; Hundera, Honnay [40]; Edo, Gebremedihn [41]; Gemechu, Lemessa [19]
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	Guyassa, Raj [11]; Gebrewahid, Teka [42] Eyasu, Tolera [43]
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, Itanna [12]; Duguma and Hager [44]; Likassa and Gure [15]; Negese and Motuma [45];
Acacia tortilis, Acacia mellifera, Celtis africana, Grewia bicolor, Olea europaea, Dichrostachys cinerea and Balanites aegyptiaca	Mid Rift Valley of Ethiopia	Shenkute, Hassen [46]
Acacia abyssinica, Albizia gummifera, Cordia africana, Croton macrostachyus and Erythrina abyssinica	North-western parts of Ethiopia	Linger [4]

Acacia abyssinica, Albizia schimperiana, Citrus medica, Celtis africana, Erythrina brucei, Ficus vasta, Millettia ferruginea, Schefflera abyssinica, Vernonia schimperi, and Oxytenanthera abyssinica are not included among the tree species listed in Table 1 out of the 670 species registeredintheICRAFAgroforestryDatabase (http://apps.worldagroforestry.org/treedb/index.php?keyword½Boundary_barrier_support). Just the following are considered to be among the "top 100" tree species that are most important to plant in tropical and subtropical areas: Acacia nilotica, *Acacia seyal, Acacia tortilis, Olea europaea,* and *Faidherbia albida* [32]. The two species whose conservation has been given the highest priority are *Faidherbia albida* and *Olea europaea* [33]. Trees such as *Cordia africana, Acacia nilotica,* and *Albizia gummifera* are recognized as commercial wood species in the worldwide timber trade [34].

Planting trees for a variety of uses in agroforestry systems

Natural regeneration of seedlings and cuttings is utilized by farmers as a planting material for tree species. These may be cultivated in seedbeds or in prepared locations, and they can be obtained for a low cost from both gardens and natural forests [13]. As an alternative, farmers can immediately transplant, mark, and save desirable spontaneously regenerated seedlings [28, 39]. In agriculture fields, replacing old trees with seedlings from spontaneous regeneration is a typical practice [31, 39].

Farmers take into account the number of open canopy gaps in their properties when choosing which tree species to grow or keep [28]. Seedlings from government nurseries are another source of planting material [39]. There are several benefits to preserving the current natural regeneration as opposed to growing seedlings in nurseries and then transplanting them, including lower labor and expense [31].

Techniques for managing multipurpose agroforestry tree species

Ethiopian farmers generally use traditional agroforestry management practices such as coppicing, thinning, pruning, pollarding, or coppicing to ensure compatibility with various crops and to maximize and harmonize survival with animals and crops [13, 16, 31, 39]. Such management practices in agricultural fields are important for improving soil fertility through mulching, using animal feed as fodder, reducing shade over integrated crops, and facilitating air circulation in stands for fuel wood, timber, and construction wood. These methods are also used for gathering wood for markets, fuel, building houses, and fencing [13]. In order to improve tree-crop interaction, pruning is particularly crucial when controlling overly large tree crowns or when cutting branches from the lower portion of the crown [31, 39].

In order to regulate the amount of shade that coffee and Enset get, pollarding entails pruning branches off of the top of the tree. It is thought that pollarded Cordia africana trees produce more durable timber and wood products, so farmers in Sidama and Gedio, in southern Ethiopia, frequently pollard their trees to encourage the formation of shoots useful as construction poles and/or timber [16, 28]. Coppicing is another ancient tree-management technique that encourages new growth from the roots or stumps of downed trees. Coppice shoots can be used for handles for tools, fences, and fuel. After harvesting, fewer trees need to be planted again because of this [16, 31].

Eliminating undesired shoots that are too small for the intended size or economic worth is known as thinning. The chopped shoots can be sold or used as firewood or construction material [16]. When tree crowns begin to overshadow crops underneath the tree canopy in southern Ethiopia's Gedio agroforestry system, thinning management methods are implemented [28].

Ecological services of multipurpose agroforestry trees

Agroforestry, both conventional and contemporary, is acknowledged as a land-use option where trees offer the local community environmental products and services. Trees shade and mulch the integrated enset coffee systems to prevent soil erosion, manage soil temperature and moisture, enhance soil nutrition, support biodiversity, and generally create ideal conditions for crop growth [9]. Native multifunctional trees contribute to land improvement, erosion control, and environmental air or atmosphere balance by supporting and increasing the agro-ecological processes of managing soil fertility [47]. Farmers therefore believe that these species were essential to the supply of ecosystem services, such as the preservation of soil and water [48], as well as addressing a wide range of global challenges Together, they are essential for preserving biodiversity, reducing the effects of climate change, and boosting ecosystem resilience [49].

Conservation of biological diversity

Trees planted on different farmlands nearby combine to form a better forested area in traditional Ethiopian agroforestry systems, which enhances environmental protection and is essential to the preservation and conservation of regional woody species [18]. Home gardens with a preponderance of trees and a wide variety of other plants in several layers are appealing to animals and provide a vital haven for them, claim Kabir and Webb [50]. As a result, they protect biological variety, including that of flora and wildlife, and safeguard plant genetic resources [19, 51]. Home gardens are a large-scale land-use system that might potentially conserve biodiversity and ease strain on natural forests since they are a common kind of agroforestry [50, 52].

Mitigation of climate change

Given that agroforestry systems store more atmospheric carbon in soil and plant components than traditional monocropping farming systems do [53], and since they include perennial trees, they may be particularly effective in reducing the effects of climate change [14]. Because of their above- and below-ground biomass, a range of multifunctional trees that are planted and maintained on farmers' agricultural land have an impact on carbon sequestration [17, 54]. National and international carbon budgets, it also makes a significant contribution to the carbon pool [54]. Multipurpose trees in agroforestry systems also make a major contribution by serving as methane sinks at the interface between the soil and the decomposing leaves [29]. In Ethiopia's southeast rift valley escarpment, trees accounted for 39–93% of the total biomass carbon stock sequestered by indigenous agroforestry systems, which averaged 67 Mg ha1 (Negash & Starr, 2015]. [55]. Home gardens and nearby coffee-based agroforestry systems can be used in other mixed cropping systems on cropland, pastureland, or rangeland to address the threats of climate change while also improving microclimatic conditions [56]. According to Betemariyam, Negash [57], in agricultural landscapes, these systems improve carbon sinks and lower emissions.

Conserving and improving soil fertility

Agroforestry trees are well-known for their ability to restore the fertility of degraded land and increase crop yields in conventional agroforestry systems. Typically, trees develop into fertile islands or areas where the soil's quality varies. The development of symbiotic relationships with certain soil bacteria, rhizobia, and arbuscular mycorrhizal fungi is partially to blame for this [9]. These advantages are connected to in-situ processes like nitrogen cycling, root activity, and litter fall [12]. Management of soil fertility also involves mulching with tree leaves and short shoots from plants like *Cordia africana* and *Ficus Sur* [15].

Multipurpose tree species such as *Cordia africana, Millettia ferruginea,* and Croton macrostachyus [16, 31, 37, 58] have been demonstrated to improve soil fertility in traditional agroforestry systems in Ethiopia [56]. The best trees for increasing soil fertility in north-central and southern Ethiopia have been shown to be *Cordia africana* and *Millettia ferruginea,* though smallholder farmers also highly value *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* trees [42, 58, 59].

Serving for coffee shade

Due to Ethiopia's significant coffee output, trees that are often used to provide shade for coffee are frequently planted, maintained, and incorporated into agricultural systems for their socioeconomic benefits in addition to their ability to give shade [39, 40]. The morphological characteristics of preferred "shade" species include spreading, whorled crowns that control sunlight interception for a wholesome coffee growth and add leaf litter for speedy decomposition [60]. *Acacia abyssinica, Albizia gummifera, Millettia ferruginia, Croton macrostachyus,* and *Sesbania sesban* are some of the species that are considered to provide "shade"[19]. But you can also find *Cordia africana* and *Ficus sur* growing in home gardens, where they shade crops growing beneath them [12, 61]. Certain species, like *Cordia africana, Millettia ferruginea,* and *Erythrina abyssinica,* shield coffee from heavy rain. [39]. *Acacia abyssinica* is considered to be the most favorable tree species for coffee shade in south-western Ethiopia [24] with *Ficus vasta* appreciated for its' large canopy [48].

Conclusion

Ethiopian agroforestry practices make extensive use of multifunctional agroforestry tree species, which not only provide smallholder farmers with profitable crops but also fulfill important ecological roles. The most important 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.* Farmer's mark and transplant attractive seedlings into desired open places on the farmlands in order to protect naturally regenerating seedlings, therefore introducing these tree species. Many agroforestry practices, including coppicing, pruning, pollarding, thinning, and lopping, are employed once the trees have reached maturity to ensure that they are compatible with a range of crops. Multipurpose trees also play major ecological roles through improving soil fertility, controlling erosion, mitigating climate change and conserving biological diversity.

● **References / Литература**

1. Shapiro A., Frank M. Agroforestry 101: an introduction to integrated agricultural land management systems. *Dovetail Partners.* 2016:1-14.
2. Gebre A.B. Potential effects of agroforestry practices on climate change mitigation and adaptation strategies: a review. *J Nat Sci Res.* 2016;6(15):83-89.
3. Mbow C., Smith P., Skole D., Duguma L., Bustamante M. Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. *Current opinion in Environmental sustainability.* 2014;(6):8-14. https://doi.org/10.1016/j.cosust.2013.09.002
4. Linger E. Agro-ecosystem and socio-economic role of homegarden agroforestry in Jabithenan District, North-Western Ethiopia: implication for climate change adaptation. *SpringerPlus.* 2014;3(1):1-9. https://doi.org/10.1186/2193-1801-3-154
5. Leakey R.R. A re-boot of tropical agriculture benefits food production, rural economies, health, social justice and the environment. *Nature Food.* 2020;1(5):260-265. https://doi.org/10.1038/s43016-020-0076-z
6. Jamala G., Shehu H., Yidau J., Joel L. Factors influencing adoption of agroforestry among smallholder farmers in Toungo, Southeastern, Adamawa State, Nigeria. *IOSR J Environ Sci Toxicol Food Technol.* 2013;6(6):66-72.
7. Abiyu A., Teketay D., Gratzer G., Shete M. Tree planting by smallholder farmers in the upper catchment of Lake Tana Watershed, Northwest Ethiopia. *Small-scale forestry.* 2016;15(2):199-212. https://doi.org/10.1007/s11842-015-9317-7
8. Iiyama M., Derero A., Kelemu K., Muthuri C., Kinuthia R., Ayenkulu E., et al. Understanding patterns of tree adoption on farms in semi-arid and sub-humid Ethiopia. *Agroforestry systems.* 2017; (91):271-293. https://link.springer.com/article/10.1007/s10457-016-9926-y
9. Asfaw Z., Ågren G.I. Farmers' local knowledge and topsoil properties of agroforestry practices in Sidama, Southern Ethiopia. *Agroforestry Systems.* 2007;(71):35-48. https://doi.org/10.1007/s10457-007-9087-0
10. Abebe T., Wiersum K., Bongers F. Spatial and temporal variation in crop diversity in agroforestry homegardens of southern Ethiopia. *Agroforestry systems.* 2010;(78):309-322. https://doi.org/10.1007/s10457-009-9246-6
11. Guyassa E., Raj A.J., Gidey K., Tadesse A. Domestication of indigenous fruit and fodder trees/shrubs in dryland agroforestry and its implication on food security. *International Journal of Ecosystem.* 2014;4(2):83-88. https://doi.org/10.5923/j.ije.20140402.06
12. Yadessa A., Itanna F., Olsson M. Scattered trees as modifiers of agricultural landscapes: the role of waddeessa (*Cordia africana* Lam.) trees in Bako area, Oromia, Ethiopia. *African journal of ecology.* 2009;47(s1):78-83. https://doi.org/10.1111/j.1365-2028.2008.01053.x
13. Yakob G., Asfaw Z., Zewdie S. Wood production and management of woody species in homegardens agroforestry: the case of smallholder farmers in Gimbo district, south west Ethiopia. *International Journal of Natural Sciences Research.* 2014;2(10):165-175.
14. Negash M., Yirdaw E., Luukkanen O. Potential of indigenous multistrata agroforests for maintaining native floristic diversity in the south-eastern Rift Valley escarpment, Ethiopia. *Agroforestry systems.* 2012;85(1):9-28. https://doi.org/10.1007/s10457-011-9408-1
15. Likassa E., Gure A. Diversity of shade tree species in smallholder coffee farms of western Oromia, Ethiopia. *International Journal of Agroforestry and Silviculture.* 2017;5(4):294-304.
16. Lameso L., Bekele W. Farmers local knowledge on Niche selection, management strategies and uses of *Cordia africana* tree in agroforestry practices of Sidama zone, southern Ethiopia. *American Journal of Agriculture and Forestry.* 2020;8(6):258-64.
17. Gebrewahid Y., Gebre-Egziabhier T.-B., Teka K., Birhane E. Carbon stock potential of scattered trees on farmland along an altitudinal gradient in Tigray, Northern Ethiopia. *Ecological processes.* 2018;(7):1-8. https://doi.org/10.1186/s13717-018-0152-6
18. Gebrewahid Y., Abrehe S. Biodiversity conservation through indigenous agricultural practices: Woody species composition, density and diversity along an altitudinal gradient of Northern Ethiopia. *Cogent Food & Agriculture.* 2019;5(1):1700744. https://doi.org/10.1080/23311932.2019.1700744
19. Gemechu H.W., Lemessa D., Jiru D.B. A comparative analysis of indigenous and exotic tree species management practices in agricultural landscapes of Southwest Ethiopia. *Trees, Forests and People.* 2021;4:100059.
20. Bongers G. Dynamics in People-Tree Interactions in Farm Fields; Farmers' Perspectives in Meskan District, Ethiopia. Wageningen: Wageningen University. 2010.
21. Endale Y., Derero A., Argaw M., Muthuri C. Farmland tree species diversity and spatial distribution pattern in semi-arid East Shewa, Ethiopia. *Forests, trees and LiveLihoods.* 2017;26(3):199-214. https://doi.org/10.1080/14728028.2016.1266971
22. Molla A., Kewessa G. Woody species diversity in traditional agroforestry practices of Dellomenna District, Southeastern Ethiopia: implication for maintaining native woody species. *International Journal of Biodiversity.* 2015;2015(iii):1-13. https://doi.org/10.1155/2015/643031
23. Wood P.J., Burley J. A tree for all reasons: introduction and evaluation of multipurpose trees for agroforestry. 1991.
24. Muleta D., Assefa F., Nemomissa S., Granhall U. Socioeconomic benefits of shade trees in coffee production systems in Bonga and Yayuhurumu districts, southwestern Ethiopia: farmers' perceptions. *Ethiopian Journal of Education and Sciences.* 2011;7(1):39-55.
25. Darcha G., Birhane E., Abadi N. Woody species diversity in Oxytenanthera abyssinica based homestead agroforestry systems of serako, northern Ethiopia. *Journal of Natural Sciences Research.* 2015;5(9):18-27.
26. Lodoen D. Paths to prosperity through agroforestry: ICRAF's corporate strategy 2001-20102000.
27. Adane F., Legesse A., Weldeamanuel T., Belay T. The contribution of a fruit tree-based agroforestry system for household income to smallholder farmers in Dale District, Sidama Zone, Southern Ethiopia. *Adv Plants Agric Res.* 2019;9(1):78-84.
28. Negash M. Trees management and livelihoods in Gedeo's agroforests, Ethiopia. *Forests, Trees and Livelihoods.* 2007;17(2):157-68. https://doi.org/10.1080/14728028.2007.9752591
29. Gina T.G., Nigatu L., Animut G. Biodiversity of indigenous multipurpose fodder trees of wolayta zone, southern Ethiopia: ecological and socio-economic importance. *International Journal of Emerging Technology and Advanced Engineering.* 2014;4(5):494-503.
30. Anshiso A., Woldeamanuel T., Asfaw Z. Financial analysis of fruit tree based agroforestry practice in Hadero Tunto Zuria Woreda, Kembata Tembaro Zone, South Ethiopia. *Research Journal of Finance and Accounting.* 2017;8(3):72-80.
31. Mamo D., Asfaw Z. Assessment of farmers' management activities on scattered trees on crop fields at Gemechis district, West Hararge Zone, Oromia, Ethiopia. *International Journal of Agriculture.* 2017;2(1):41-57.

32. Kindt R., Dawson I.K., Lillesø J.-P.B., Muchugi A., Pedercini F., Roshetko J., et al. The one hundred tree species prioritized for planting in the tropics and subtropics as indicated by database mining. *World Agroforestry.* 2021.
33. Khoury C.K., Amariles D., Soto J.S., Diaz M.V., Sotelo S., Sosa C.C., et al. Comprehensiveness of conservation of useful wild plants: An operational indicator for biodiversity and sustainable development targets. *Ecological Indicators.* 2019;(98):420-429.
34. Mark J., Newton A., Oldfield S., Rivers M. A Working List of Commercial Timber Tree Species. 2014.
35. Agize M., Demissew S., Asfaw Z. Indigenous knowledge on management of home gardens and plants in Loma and Gena Bosa districts (weredas) of Dawro Zone, Southern Ethiopia: plant biodiversity conservation, sustainable utilization and environmental protection. *Int J Sci: Basic Appl Res (IJSBAR).* 2013;(10):63-99.
36. Gebretsadik T. Assessment of major Honey bee flora resources on selected districts of Sidama and Gedeo zones of South nations nationalities and peoples regional state, Ethiopia. *Journal of agricultural economics, extension and rural development.* 2016;4(2):368-78.
37. Gindaba J., Rozanov A., Negash L. Trees on farms and their contribution to soil fertility parameters in Badessa, eastern Ethiopia. *Biology and fertility of soils.* 2005;42:66-71. https://doi.org/10.1007/s00374-005-0859-2
38. Ango T.G., Börjeson L., Senbeta F., Hylander K. Balancing ecosystem services and disservices: smallholder farmers' use and management of forest and trees in an agricultural landscape in southwestern Ethiopia. *Ecology and Society.* 2014;19(1):30. https://doi.org/10.5751/ES-06279-190130
39. Nigussie A., Taye E., Bukero G. Survey on potentials and constraints of shade tree species for arabica coffee production in South Ethiopia. International Journal of Recent Research in Life Sciences. 2014;1(1):1-11.
40. Hundera K, Honnay O, Aerts R, Muys B. The potential of small exclosures in assisting regeneration of coffee shade trees in South-Western Ethiopian coffee forests. *African Journal of Ecology.* 2015;53(4):389-397. https://doi.org/10.1111/aje.12203
41. Edo G.Y., Gebremedihn K.G., Woldsenbet A.F., Guta K.K. Growth Performance of Some Multipurpose Tree Species Around the Homesteads in Gimbo District, Southwestern Ethiopia. *Agriculture, Forestry and Fisheries.* 2017;6(1):1. https://doi.org/10.11648/j.aff.20170601.11
42. Gebrewahid Y., Teka K., Gebre-Egziabhier T.-B., Tewolde-Berhan S., Birhane E., Eyasu G., et al. Dispersed trees on smallholder farms enhance soil fertility in semi-arid Ethiopia. *Ecological Processes.* 2019;8(1):1-8. https://doi.org/10.1186/s13717-019-0190-8
43. Eyasu G., Tolera M., Negash M. Woody species composition, structure, and diversity of homegarden agroforestry systems in southern Tigray, Northern Ethiopia. *Heliyon.* 2020;6(12). https://doi.org/10.1016/j.heliyon.2020.e05500
44. Duguma L.A., Hager H. Forest products scarcity perception and response by tree planting in the rural landscapes: farmers' views in central highlands of Ethiopia. Ekológia (Bratislava). 2009;28(2):158-169. https://doi.org/10.4149/ekol_2009_02_158
45. Negese K., Motuma T. Woody plant species diversity and management practices in homegardens of Heban Arsi Woreda, south central, Ethiopia. *EC Agric.* 2021;(7):3–17.
46. Shenkute B., Hassen A., Assafa T., Amen N., Ebro A., editors. Identification and nutritive vale of potential fodder trees and shrubs in the mid Rift Valley of Ethiopa2012: Pakistan Agricultural Scientist's Forum.
47. Mekoya A., Oosting S.J., Fernandez-Rivera S., Van der Zijpp A. Multipurpose fodder trees in the Ethiopian highlands: Farmers' preference and relationship of indigenous knowledge of feed value with laboratory indicators. *Agricultural Systems.* 2008;96(1-3):184-94.
48. Amare D., Wondie M., Mekuria W., Darr D. Agroforestry of smallholder farmers in Ethiopia: practices and benefits. *Small-scale Forestry.* 2019;18:39-56. https://doi.org/10.1007/s11842-018-9405-6
49. Rosenstock T.S., Dawson I.K., Aynekulu E., Chomba S., Degrande A., Fornace K., et al. A planetary health perspective on agroforestry in Sub-Saharan Africa. *One Earth.* 2019;1(3):330-244. https://doi.org/10.1016/j.oneear.2019.10.017
50. Kabir M.E., Webb E.L. Can homegardens conserve biodiversity in Bangladesh? *Biotropica.* 2008;40(1):95-103. https://doi.org/10.1111/j.1744-7429.2007.00346.x
51. Mulia R., Simelton E., Le T., Pham T., Do T. Native and endangered timber tree species in home gardens of northeast and North Central Vietnam. *Biodivers Int J.* 2018;2:40-43. https://doi.org/10.15406/bij.2018.02.00041
52. Legesse A., Negash M. Species diversity, composition, structure and management in agroforestry systems: the case of Kachabira district, Southern Ethiopia. *Heliyon.* 2021;7(3). https://doi.org/10.1016/j.heliyon.2021.e06477
53. Mulhollem J. Agroforestry Systems May Play Vital Role in Mitigating Climate Change. *Penn State News,* February 1. 2018.
54. Zomer R.J., Neufeldt H., Xu J., Ahrends A., Bossio D., Trabucco A., et al. Global Tree Cover and Biomass Carbon on Agricultural Land: The contribution of agroforestry to global and national carbon budgets. *Scientific reports.* 2016;6(1):29987. https://doi.org/10.1038/srep29987
55. Negash M., Starr M. Biomass and soil carbon stocks of indigenous agroforestry systems on the south-eastern Rift Valley escarpment, Ethiopia. *Plant and soil.* 2015;393:95-107.
56. Teketay D., Tegineh A. Shade trees of coffee in Harerge, Eastern Ethiopia. *International Tree Crops Journal.* 1991;7(1-2):17-27.
57. Betemariyam M., Negash M., Worku A. Comparative analysis of carbon stocks in home garden and adjacent coffee based agroforestry systems in Ethiopia. *Small-Scale Forestry.* 2020;19:319-334. https://doi.org/10.1007/s11842-020-09439-4
58. Hailu T., Negash L., Olsson M. *Millettia ferruginea* from southern Ethiopia: Impacts on soil fertility and growth of maize. *Agroforestry Systems.* 2000;48:9-24. https://doi.org/10.1023/A:1006274912762
59. Kiros G., Fisseha I., Abraham M. Evaluation of locally available fertilizer tree or shrub species in Gozamin Woreda, north Central Ethiopia. *Res J Agricult Environ Manag.* 2015;4:164-8.
60. Hundera K. Shade tree selection and management practices by farmers in traditional coffee production systems in Jimma Zone, Southwest Ethiopia. *Ethiopian Journal of education and sciences.* 2016;11(2):91-105.
61. Lemage B., Legesse A. Management and socioeconomic determinants of woody species diversity in parkland agroforestry in Tembaro District, Southern Ethiopia. *Biodivers Int J.* 2018;2(5):456-462. https://doi.org/10.15406/bij.2018.02.00100

About the Authors:
Kasu Hailu Biru – Researcher,
https://orcid.org/0000-0002-0332-0486, Correspondence Author,
kasuhailu128@gmail.com
Urge Cheru – Researcher

Об авторах:
Касу Хайлу Биру – исследователь,
https://orcid.org/0000-0002-0332-0486, автор для переписки,
kasuhailu128@gmail.com
Урге Черу – исследователь