



The role of shelterbelt for soil management in Ethiopia

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Summary: Soil is a vital component for the growth of trees and shrubs in the shelterbelts agroforestry practices. Management of trees has a critical contribution to soil improvements. People's use of shelterbelts is varying across agroecology zones of Ethiopia. Some nations use it as their cultural expression, while the others use it as area demarcation (farming and home). In shelterbelt agroforestry practice, *Millettia ferruginea*, *Sesbania sesban* and *Acacia abyssinica* legumes tree species were deliberately planted for soil management across agro-ecologies. Considering the population and the farm size of farmers in Ethiopia, most farmers' knowledge of shelterbelts for soil management is scanty documented. This is due to a low level of awareness and expert consultancy. Therefore, this paper reviews the soil management roles and possible threats, opportunities, and challenges of shelterbelts. This review paper was developed through using related published papers. Scientists reported that areas covered by well-managed shelterbelts had good soil physical, biological, and chemical properties. The soil quality and fertility of the area further improved through good soil microbial activities. The tree crop compatibility, climatic factors, land use policy, and scarcity of land were among the possible threat and challenges to shelterbelts establishment. Generally, good tree and shrub management skills result in a high level of land productivity. Therefore, further development planners should focus on the extensive demonstration of shelterbelt practices as well as training and monitoring of farmers on such issues for their livelihood improvements.

Key words: challenges, opportunities, threat, tree, shelterbelt, soil quality

Introduction

Population pressure on natural resources is increased from time to time. In the rural area, agricultural activities are the main source of livelihood to the households. The presence of intensified agricultural activity aggravates the forest (natural & plantation) degradation of the areas (Anderson et al., 2014). The protection and management of the planted tree is still insubstantial. Though green legacy as land greening (including rural afforestation) starts recently in countries like Ethiopia, it is not guided by proper land use policy. Due to this, the suitability, adaptability and productivity of such a program are under question. Clear understanding and implementation of rural afforestation program requires the knowledge of land use policy, soil management and agroforestry.

Soil management is the way of improving soil fertility, quality and productivity by protecting soil from erosion and other factors via tree planting there by addition of organic matter or recover nutrient cycle in biological protection mechanism. Soil is managed differently in midland, highland and lowland agro-ecologies (Komatsuzaki and Ohta, 2007; de Villiers et al., 2014; Lal, 2015). In most cases, farmers' preference of selecting soil management option is influenced by land area size, local knowledge, and level of technology, finance, government police and others. Some farmers preferred tree planting while others make terraces alone as soil management option on the degraded land. The idea of agroforestry is necessary for managing soil in the proper way. The term "agroforestry" refers to a dynamic, ecologically

based method of managing natural resources that integrates tall woody plants and trees into agricultural landscapes and farms to increase social, economic, and environmental benefits (Schroth et al., 2004).

Shelterbelt is a well-known agroforestry practice expressed by trees and shrubs planted in linear arrays to create advantage for the land users (Burke, 2016). Farmers use shelterbelt to divide farmland or put vacant land to productive or other advantageous use. This is doable on a budget by using woody perennials and farm settings. Shelterbelts prevent erosion and nutrient runoff by improving the soil water percolation capacity, decomposing falling leaves (as well as covering the soil surface), and anchoring soil particles through tree and shrub root systems in fields (Jose and Gordon, 2007; Norman et al., 1988). The fertility, quality, and productivity of the soil are maintained by trees along the edge of agricultural land. More than a billion hectares of the world's agricultural land, or 43%, have more than 10% tree cover (Zomer et al., 2009). More than half of the sixty million hectares of farm land were covered by trees. The presence of trees is the main component of "evergreen agriculture," which has the potential to improve productivity and system stability.

Trees that are protected, cultivated, and managed have been very important in many of Kenya's high-potential agricultural regions (Deweese and Saxena, 1997). By concentrating on pine trees that grew on dunes in northern California, USA, Zinke (1962) conducted one of the earliest studies into how specific trees affect soils. He reported that pH, nitrogen, and cation exchange capacity were varied with distance from the tree trunk and peaked at a specific distance in trees close to the shelterbelts. Later, studies revealed that patterns in the variation of soil characteristics were influenced by trees (Belsky et al., 1989; Burke, 2016; Frost and Edinger, 1991; Reich et al., 2005). Soil under a specific tree crown has higher concentrations of mineralizable nitrogen, microbial biomass, phosphorus, potassium, and calcium (Belsky et al., 1989). The decomposition of trees and shrubs or a fire, however, can turn such soil changes around. Trees/shrubs have an effect on soil fertility in addition to providing food for large animals and birds that use trees for shelter (Belsky et al., 1989). The farm's soil is fertile due to the presence of trees/shrubs (such as *G. robusta*, *Sesbania spp.*, *Croton macrostachyus*, *Acacia abyssinica*, and *Cordia africana*) and the use of enhanced fallows. Trees planted along farm boundaries improve soil nitrogen content, pore space, and structure, resulting in improved water infiltration and soil retention (Zomer et al., 2009).

Trees and shrubs in the shelterbelt contribute significantly to nutrient cycling. They absorb and assimilate nutrients washed down to lower soil horizons due to their deep roots. Additionally, they spread out the leaves, fruits, flowers, and branches that decompose and provide nutrients to shallow-rooted plants that are unable to access the nutrient resources of deeper soil horizons. Deep roots break up hard pans and decomposed materials improve the soil's structure, which reduces surface runoff and increases infiltration and the soil's ability to retain water (Norman et al., 1988). Deep roots reduce food crops' water competition because they use groundwater. The soil fauna is fed by tree litter, which improves soil porosity and infiltration. The enhanced land in general and the increased crop output in particular are strong indicators of the shelterbelt's beneficial effects on the soil. The enhanced land in general and the increased crop output in particular are strong indicators of the shelterbelt's beneficial effects on the soil. (Kort, 1988).

Maize grown with legumes species performed better than maize grown alone. Additionally, compared to monoculture maize, the density of millipedes and earthworms was higher in shelterbelt agroforestry (Sileshi et al., 2006). The variation in macro fauna densities could be explained by total combined litter fall, leaf biomass, and re-sprouted biomass under legume species (Sileshi and Mafongoya, 2007). Under shelterbelt ecosystem microbes, which influence the litter transmission and quality of organic input, are produced (Sileshi et al., 2006).

Legumes species planted as a shelterbelt puts significant impact on the yields of maize their by affecting weed and soil insects (Sileshi and Mafongoya, 2007; Sileshi et al., 2006). The amount of biomass and its interaction with other factors had a significant impact on the abundance of *Striga asiatica*. Fast-decomposing biomass species did not tend to affect striga abundance in maize, but slow-decaying biomass species did (Sileshi et al., 2006). The amount of nitrogen mineralization and degradation of organic residues, as compelled by quality as a function of carbon to nitrogen + polyphenol ratios, were used to calculate influence of legumes fallow on witch weed species *Striga*

hermontica (Gacheru and Rao, 2001). This makes the process whereby legume fallows sway striga more complex than simply increasing soil fertility. Among many of the legumes tested, *Sesbania* appeared to be the most successful in reducing striga invasion in maize in eastern Zambia (Sileshi et al., 2006). Fertilizer trees have indeed lowered arable weed problems (Sileshi and Mafongoya, 2007; Sileshi et al., 2006).

Earlier research demonstrated that biomass exchange using legumes species in shelterbelt and other system is a more environmentally friend to maintain nutrient balances in crop. It has been demonstrated that biomass transfer can increase the yield of other high-value crops such as garlic, as well as vegetables such as cabbage, rapeseed, onion, and tomato, as well as maize grown on vegetable harvests (Anderson et al., 2014). Though massive tree planting was known by its provision of environmental, cultural and economic value to the households, planting trees/shrubs along farm boundaries as shelterbelt agroforestry for direct and indirect financial or economic benefits were not well understood by Ethiopian farmers. Shelterbelt is very typical in most Kenyan and China agricultural areas, even though it does not cover a large area. These kinds of planting occasionally have a significant soil improvement impact besides the direct fuel and fodder provision enhancements roles. But it was rarely done in countries like Ethiopia. As a result, it is not sufficient to consider how the adoption of these practices would affect the household's immediate or future financial or economic well-being (Deweese, 1995). Besides absence of well-known understanding the role of shelterbelt on soil management, different biophysical and anthropogenic factors influence permitted distances for planting trees from boundaries. For instance, in dry savannah where water availability is restricted trees and shrubs can only grow sporadically (Burke, 2016, Ritchie, 1988). The above-mentioned compiled factors were boldly observed on most Ethiopian farmers.

Therefore, this paper aims to (i) provide information for farmers on the soil management roles of shelterbelt as well as (ii) understand the major challenges, threats, and opportunities of shelterbelts establishment for soil management. In this paper, the term expressed for boundary planted tree is also used for shrubs as they are main component of shelterbelts.

Discussion

This review paper was organized by summarizing relevant secondary information from openly available data base like Google scholar. Journal articles, book, and related reviewed guidelines were captured and used in compiling this research works. In order to avoid missing relevant published information, the assessed research papers were not restricted to their year of publication.

A. Impact of shelterbelt on soil fertility

The use of shelterbelt demonstrated how effectively trees can replenish fertility that was depleted during crop production. The soil under the farm's boundary tree is well-structured, has a high capacity to retain water, and contains a reserve of nutrients that are bound up in organic matter. Trees planted in the boundary are likely to be suitable for maintaining or enhancing soil fertility if they have the following attributes:

- A quick biomass production rate for leaves
- A substantial mycorrhizal association is possible thanks to a dense network of fine roots
- There are deep roots
- High rate of nitrogen fixation
- Foliage with a high and balanced nutrient content; superior litter (high in nitrogen, low in lignin and polyphenols)
- A lot of nutrients are found in the root system
- When nutrient release is desired, either rapid or moderate litter decay is required, depending on the need to maintain the soil cover
- The root residues or litter shouldn't contain any toxic substances
- A capability to regenerate soil by growing in subpar soils

- There isn't much crop competition, especially for water
- Invasion to crops is minimal
- Aside from soil advancement, gainful or service functions can be performed

Some of these features are incompatible; for example, high-quality litter is unusual to deteriorate at a moderate rate. The final property, the presence of productive functions, is unrelated to soils but is critical if the tree is to be effective in fertility maintenance. Other than production, a species must be acceptable and desirable in agroforestry systems. A tree may possess all of the desirable characteristics listed above. However, it will not improve soil fertility if it is not planted and cared for. Increased soil additions, decreased soil losses, and improved soil physical, chemical and biological conditions are all ways that trees increase soil fertility. The key processes are those that manage soil runoff and erosion, preserve soil organic matter and physical characteristics, boost nutrient inputs through nitrogen fixation and uptake from deep soil horizons, and encourage more closed nutrient cycling.

B. Impact of shelterbelts on soil physical property

In the system of shelterbelts, tree litter and pruning can significantly support the preservation of soil organic matter, enhance the physical characteristics of the soil, and simultaneously supply nutrients. The volume and size distribution of pores, which control the amount of available water holding capacity, and the degree of aggregation between ped determine the physical properties of soils. Although texture and clay type are the main factors affecting these parameters, soil organic matter and fungi mycelia can bind soil particles into aggregates that have a desirable pore size distribution, structural stability, and adequate water holding capacity. These aggregates also resist surface erosion. When soil organic matter is lost, surface crusting, compaction, and pan formations result, it is clear how important this function is to the soil.

All position of a tree affects the physical characteristics of the soil, such as the ability to hold water, erodibility, water repellency, compaction, and infiltration. Trees effectively slow the rate of soil erosion because their canopy and leaf litter provide soil cover. The nutrient status of the soil is improved by organic matter amendments. Soil particle aggregation, structural stability, and biological activity are all enhanced as a result. A soil's ability to retain water can be enhanced by the addition of organic matter, which can also have an impact on the fauna of the soil, especially earthworms. Tree roots can aid in the binding of the soil and the promotion of direct water infiltration. In addition to having more water-holding capacity and macro porosity, soil under the tree a canopy is also richer in nutrients and organic matter, which is advantageous for soil water infiltration and redistribution (Van Schaik et al., 2008).

C. Soil chemical and biological property modification roles of shelterbelts

Its effect on soil chemical property

Because of chemical changes in the rhizosphere, roots have a big impact on how plants acquire nutrients (i.e. pH). The Cation Exchange Capacity of soil is directly influenced by the organic matter that is added to it from tree species that are grown on the farm's edge, particularly in areas where sandy soil predominates. Mycorrhizal associations have a significant impact on nutrient uptake and cycling by allowing plants to access organic nutrients directly from litter, by increasing phosphate activity, and by making the system less "leaky."

Reduction of acidity: By introducing bases to the soil's surface, trees typically reduce the effects of leaching. Due to the orders of magnitude, it is unlikely that tree litter can significantly raise the pH of acidic soils unless bases that have built up over many years of tree growth are released, as in the clearing of forests or cut the branches of tree/shrubs then piled in the centre of clearing for burning like in the chitemene system of shifting cultivation.

Reduction of salinity or sodicity: Saline and alkaline soils have been successfully reclaimed through afforestation. For instance, in Kernel, India, electrical conductivity and topsoil pH were both decreased under *Acacia nilotica* and *Eucalyptus tereticornis* over the course of five years, and tree establishment was aided by the addition of gypsum and manure (Zamperlini et al., 1997).

Unquestionably, improved ditch drainage and better leaching contribute to the soil improvement in this type of reclamation forestry. By contrasting them to control plots that received the same drainage, soil improvement, and other management practices but lacked trees, it would be possible to evaluate the contribution of trees.

D. Shelterbelts for soil quality improvement

Trees' non-specific and general effects

The ability of soil to create ecosystem boundaries is referred to as soil quality. This is done in order to sustain biological productivity, maintain environmental quality, and improve plant and animal health (Doran and Parkin, 1994). The level of a management practice's protection of the soil from degradation (caused, for example, by erosion) and the adoption of "best management practices" (BMP) or other practices within an area of interest determine the quality of the soil (a farm, catchment, or region) (White, 2005). On the quality of the soil, trees have three main effects. They have an effect on the nutrient content, fauna, and flora of the soil.

Shelterbelts for soil structure improvement

Two things happen to soil structure when trees are present in and around crop fields. The trees start by adding organic matter to the soil (litter fall, twigs, root turnover, and pruning by-products); significant increases (from 4 to 7%) have been seen in alley cropping systems with red alders planted there (Seiter et al., 1999). Second, the trees grow thick root systems that penetrate deeply compacted soil layers where crop roots cannot grow, and they work to improve those layers (Schroth, 1999). The two phenomena's combined effects on soil structure have seven significant effects. By increasing soil cover, trees reduce wind and rain erosion (Rigueiro-Rodríguez et al., 2009). The development of root systems and more organic matter reduce soil compaction (Jose et al., 2008), enhance water infiltration (Chander et al., 1998; Jose et al., 2004), and increase soil porosity (Jose, 2009; Chander et al., 1998). Additionally, they increase soil aggregates' weight diameter, which improves soil stability and lowers the risk of erosion during rainy conditions (Gupta et al., 2009). And finally, the trees increase the soil's capacity to hold water and supply nutrients (Jose et al., 2008). The capacity of plants to absorb and export water and nutrients from the soil is improved by these seven effects, which can be advantageous for crops (Jose et al., 2008). Additionally, they might enhance the biology of the soil.

Shelterbelts for soil micro and macro biology changes

Numerous studies on the dynamics of microbial communities in ecosystems with trees (Lejon et al., 2005; Seiter et al., 1999) revealed a link between the presence of trees and an increase in microbial and fungal active biomass in the top 15 cm of soil. The increased input of C-rich organic matter has also increased the ratio of fungi to bacteria and the quantity of earthworms near the trees. The trees likely provide fungi and bacteria with a physical habitat and a substrate that is rich in nutrients based on these observations. The rooting zone/rhizosphere microorganisms' environment is actually improved by the presence of organic matter in the topsoil (Jose et al., 2008), but these microorganisms are essential players in the biochemical breakdown of organic matter. As part of the recycling process, soil microorganisms transform crop residues, litter, and pruning byproducts into nutrients that are available to crops and are mineralized (Lejon et al., 2005).

Lejon et al. (2005) and Seiter et al. (1999) concentrated on the composition of microbial biomass and the various mycorrhizal associations. Although it is believed to have a significant impact on the rate of organic matter decomposition and the kinds of nutrients released by trees, other crucial variables include the acidity, quality, and quantity of organic matter input as well as variations in root exudates between conifer and hardwood species. There are two different types of microbial, rhizospheric, and mycorrhizal organisms that interact with tree root systems and have an effect on nutrient availability: phosphorus-solubilizing organisms and/or associations and those that fix nitrogen (Schroth, 1999).

Soil nutrients influencing role of shelterbelts

The presence of trees in the farm boundary can influence the nutrient content of the soil via its impacts on the soil structure and on the soil biology. This is due to presence of different level of interaction among them. The interaction of tree as their particular function on soil nutrient content of the farm can be seen at three levels.

To begin with, they enrich the soil with fresh nutrients. When leaves fall to the farm, for instance, tree canopies collect atmospheric depositions that are later incorporated into the soil. In areas where trees have been planted, the soil's Na content is especially high, claim (Augusto et al., 2003). In addition, trees' deep roots can draw nutrients and minerals from the soil and rock and transport them to the canopy, where they contribute to the cycle of nutrients (Chander et al., 1998). Additionally, some tree species associate with mycorrhizal or rhizospheric organisms that fix nitrogen or dissolve phosphorus, making these nutrients available in the soil to all plants in the ecosystem (Chander et al., 1998).

Second, trees can contribute significantly to the processes involved in nutrient (re)cycling (Bayala et al., 2008). In these agroecosystems, nitrogen is added to the topsoil through the use of fertilizer and/or manure applied in the alleys, biological atmospheric fixation (by N-fixing tree species), and mineralization of organic matter (also influenced by trees), particularly through root exudates, improved soil conditions, and root turnover (Lehmann et al., 1998). The problem is that runoff can easily transport nitrates through different soil layers due to their high solubility.

They contaminate rivers and the water table, making the water unfit for human consumption and causing eutrophication in downstream ecosystems. Because of their extensive root systems, which act as a "safety net" and can absorb nutrients in deeper soil layers than crop roots can, trees are advantageous in preventing such seepages (Rowe et al., 1999; Jose et al., 2004; Jose et al., 2008). Trees help to prevent erosion and nutrient losses (Chander et al., 1998), maintain the nutrient pool and soil fertility (Young, 1997), and increase the effectiveness of nutrient use in agroecosystems by actively capturing leached nutrients and pumping them back to the canopy and then to the topsoil (Rigueiro-Rodríguez et al., 2009).

Last but not least, human intervention can enhance some of the functions of trees in the nutrient cycle. As their organic matter decomposes, nutrients are released into the topsoil, and litter fall and pruning by-products are significant organic matter inputs (Chander et al., 1998; Jose et al., 2008). Pruning byproducts, however, must take precedence. If we don't, we won't be able to get the nutrients we want from it when we decompose it or use it as mulch (Seiter et al., 1999). If the nutrients are used as mulch or chipped wood, the agroecosystem can recycle them. The nutrient content of tree pruning can satisfy the crop's needs for N, Ca, Mg, and K under specific circumstances and with specific species.

Additionally, trees affect the C/N ratio (Augusto et al., 2003), root turnover can improve soil by introducing nutrients, particularly carbon (Schroth, 1999; Gupta et al., 2009). However, root management techniques like root pruning hasten root turnover and enhance lateral root nutrient redistribution (Chander et al., 1998). The nutrients found in the tree roots are plentiful and easily disperse throughout the root system. By pruning the roots, we cause nutrient release from the topsoil in the entire crop field. Next to this let us see some management practice which relates with nutrient soil productivity enhancing methods.

E. Shelterbelt management practice as alternatives to enhance soil productivity

Most farmers plant tree species in plot (farm) boundary for demarcating land. However, they also have significant impact on soil quality though it depends on the types of management practice given. Optimize computation between tree and crop component helps to stabilize the nutrient use efficiency and cycle on the soil (Schroth, 1995). This is done by first proper type of species selection and planting space determination which means tree species planted on farm boundary shouldn't have adversely compete with nearby crop. This is done by planting tree species where crop roots are absent (avoid close spacing between tree and crop); identify tree species which take soil nutrient from lower layers of soil and closely plant with crop species which takes nutrient from top soil layer. Another management option is root pruning via trenching and tillage. The width and depth of trench vary per the rooting characteristic of the preferred species. For instance in northeastern China, ditches of 2 meter width by 2 meter depth was common in a poplar shelter belted farmlands (Wu et al., 2018). From this we can enhance the quality of soil through addition of organic matter by decomposing the turnover root and at

same time we reduce competition between tree and crop (Schroth, 1995). Thus, help us sustainably increase productivity of a given farm lands (Jose et al., 2004).

Once they interact positively with crop, their availability on the boundary of plot (farm) enrich soil with organic matter, maintain soil biomass, improve nutrient cycle via root production and turnover, reduce leaching losses by uptaking mobile nutrient, pump up nutrients from subsoil layers to top soil, improve soil penetrability for crop root, fix atmospheric N, create appropriate condition for soil mycorrhizal and rhizospheric microorganisms (N-fixing and P-solubilizing) (Schroth, 1995; Schroth, 1999). Besides the preferred shelterbelt species, the amount of nutrients recycled and used by the crop on the farmland varies per the depth and width of the established ditches between the farmland and the shelterbelt. For instance, samples taken after the establishment of ditches of 2 meters in width by 2 meters in depth between farmland and shelterbelt revealed a higher amount of potassium in the shelterbelt than in the neighboring farmlands (Wu et al., 2018).

F. Challenges, threats and opportunities of shelterbelts establishment for soil management

Challenges

- Shortage of land and land use policy, population pressure
- Absence of management skill
- Lack of sufficient information on species improving capacity and nutrient content.
- Problems in creating awareness of farmers about shelterbelts' soil management impact.

Threats

- Due to low level of knowledge on the use of tree and shortage of arable land farmers may totally replace farm boundary tree by annual crop.
- Climatic factors may change the regular growth habit of trees and later on convert their function from good to bad (allow them to be invasive on the area).
- Absence of proper tree root management may enhance competition in between tree and adjacent crop species.
- The presence of tree on farm boundary may act as host for birds and locust during crop prematurity which poses a risk for yield loss.

Opportunities

- Availability of experts
- Labor availability for tree management

Conclusions

Generally, in suitable condition to bring soil more productivity, the right type of tree planted/naturally grows on farm boundary requires appropriate management practice. Shelterbelts help to maintain soil fauna and flora. If trees are absent from farm boundary the severity of erosion by wind and runoff adversely influences soil quality, fertility, productivity, cation exchange capacity, base saturation, soil structure, texture, and finally expose the land to degradation. This in turn influences land productive capacity. Tree and shrub roots zone or rhizosphere determine the soil mycorrhizal and symbiosis relationship present in the soil. Low levels of farmers' knowledge and absence of proper management practice reduce the soil quality, fertility and productivity. Besides proper site and establishment design selection, shelterbelts as soil management practices should be done through compromising both local and scientific knowledge in selecting and managing appropriate species. Sustainably producing tree and shrub varieties that positively cope with crop and easily adapt to change in soil and climatic factors in the shelterbelt agroforestry practice needs further research works. The capacity of farmers on managing soil via shelterbelt practices should be built strongly.

References

- Anderson, K., Rausser, G., & Swinnen, J. (2014). Agricultural policy: a global view. *Encyclopedia of Agriculture and Food Systems*, 179-194. <https://doi.org/10.1016/B978-0-444-52512-3.00120-0>
- Augusto, L., Dupouey, J.L., & Ranger, J. (2003). Effects of tree species on understory vegetation and environmental conditions in temperate forests. *Annals of Forest Science*, 60, 823-831. <https://doi.org/10.1051/forest:2003077>
- Bayala, J., Van Noordwijk, M., Lusiana, B., Ni'matul, K., Teklehaimanot, Z., & Ouedraogo, S. (2008). Separating the tree-soil-crop interactions in agroforestry parkland systems in Saponé (Burkina Faso) using WaNuLCAS. *Toward Agroforestry Design: An Ecological Approach*. Springer.
- Belsky, A., Amundson, R., Duxbury, J., Riha, S., Ali, A., & Mwonga, S. (1989). The effects of trees on their physical, chemical and biological environments in a semi-arid savanna in Kenya. *Journal of Applied Ecology*, 26, 1005-1024. <https://doi.org/10.2307/2403708>
- Burke, M. W. (2016). *Shelterbelt Density Dynamics and Their Driving Forces in Grand Forks County, North Dakota, 1962 to 2014*. The University of North Dakota.
- Chander, K., Goyal, S., Nandal, D. & Kapoor, K. (1998). Soil organic matter, microbial biomass and enzyme activities in a tropical agroforestry system. *Biology and Fertility of Soils*, 27, 168-172. <https://doi.org/10.1007/s003740050416>
- De Villiers, J., Hobbs, K. & Hollebrandse, B. (2014). Recursive complements and propositional attitudes. *Recursion: Complexity in Cognition*, 221-242. https://scholarworks.smith.edu/phi_facpubs/29
- Deweese, P. A. (1995). Trees and farm boundaries: farm forestry, land tenure and reform in Kenya. *Africa*, 65, 217-235. <https://doi.org/10.2307/1161191>
- Deweese, P. A. & Saxena, N. (1997). Tree planting and household land and labour allocation: case studies from Kenya and India. *Farms, Trees and Farmers: Responses to Agricultural Intensification*, 242-270.
- Doran, J. W. & Parkin, T. B. (1994). Defining and assessing soil quality. *Defining Soil Quality for a Sustainable Environment*, 35, 1-21. <https://doi.org/10.2136/sssaspecpub35.c1>
- Frost, W. E. & Edinger, S. B. (1991). Effects of tree canopies on soil characteristics of annual rangeland. *Rangeland Ecology & Management/Journal of Range Management Archives*, 44, 286-288. <https://doi.org/10.2307/4002959>
- Gacheru, E. & Rao, M. (2001). Managing Striga infestation on maize using organic and inorganic nutrient sources in western Kenya. *International Journal of Pest Management*, 47, 233-239. <https://doi.org/10.1080/09670870110044616>
- Gupta, N., Kukal, S., Bawa, S. & Dhaliwal, G. (2009). Soil organic carbon and aggregation under poplar based agroforestry system in relation to tree age and soil type. *Agroforestry Systems*, 76, 27-35. <https://doi.org/10.1007/s10457-009-9219-9>
- Jose, S. (2009). Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforestry Systems*, 76, 1-10. <https://doi.org/10.1007/s10457-009-9229-7>
- Jose, S., Allen, S. C. & Nair, P. R. (2008). Tree-crop interactions: lessons from temperate alley-cropping systems. *Ecological Basis of Agroforestry*, 6000, 15-36.
- Jose, S., Gillespie, A. & Pallardy, S. (2004). Interspecific interactions in temperate agroforestry. *Agroforestry Systems*, 61, 237-255. <https://doi.org/10.1023/B:AGFO.0000029002.85273.9b>
- Jose, S. & Gordon, A. M. (2007). *Toward Agroforestry Design: An Ecological Approach*. Springer Science & Business Media.
- Komatsuzaki, M. & Ohta, H. (2007). *Soil Management Practices for Sustainable Agro-Ecosystems*. Springer.
- Kort, J. (1988). Using shelterbelts to maximize economic yield. *Soils and Crops Workshop*.
- Lal, R. (2015). Managing carbon for restoring degraded soils. *Sustainability*, 7, 31.
- Lehmann, J., Weigl, D., Droppelmann, K., Huwe, B. & Zech, W. (1998). Nutrient cycling in an agroforestry system with runoff irrigation in Northern Kenya. *Agroforestry Systems*, 43, 49-70. <https://doi.org/10.1023/A:1026447119829>
- Lejon, D. P., Chaussod, R., Ranger, J. & Ranjard, L. (2005). Microbial community structure and density under different tree species in an acid forest soil (Morvan, France). *Microbial Ecology*, 50, 614-625. <https://doi.org/10.1007/s00248-005-5130-8>
- Norman, D., Baker, D., Heinrich, G. & Worman, F. (1988). Technology development and farmer groups: experiences from Botswana. *Experimental Agriculture*, 24, 321-331. <https://doi.org/10.1017/S0014479700016173>
- Reich, P. B., Oleksyn, J., Modrzynski, J., Mrozinski, P., Hobbie, S. E., Eissenstat, D. M., Chorover, J., Chadwick, O. A., Hale, C. M. & Tjoelker, M. G. (2005). Linking litter calcium, earthworms and soil properties: a common garden test with 14 tree species. *Ecology Letters*, 8, 811-818. <https://doi.org/10.1111/j.1461-0248.2005.00779.x>
- Rigueiro-Rodríguez, A., Fernández-Núñez, E., González-Hernández, P., Mcadam, J. H. & Mosquera-Losada, M. R. (2009). Agroforestry systems in Europe: productive, ecological and social perspectives. *Agroforestry in Europe: Current Status and Future Prospects*, 6, 43-65. https://doi.org/10.1007/978-1-4020-8272-6_3
- Ritchie, K. A. (1988). 24. Shelterbelt plantings in semi-arid areas. *Agriculture, Ecosystems & Environment*, 22, 425-440. [https://doi.org/10.1016/0167-8809\(88\)90037-0](https://doi.org/10.1016/0167-8809(88)90037-0)
- Rowe, E., Hairiah, K., Giller, K., Van Noordwijk, M. & Cadisch, G. (1999). Testing the safety-net role of hedgerow tree roots by 15 N placement at different soil depths. *Agroforestry for Sustainable Land-Use Fundamental Research and Modelling with Emphasis on Temperate and Mediterranean Applications*. Selected papers from a workshop held in Montpellier, France, 23-29 June 1997. Springer, 81-93.
- Schroth, G. (1995). Tree root characteristics as criteria for species selection and systems design in agroforestry. *Agroforestry: Science, Policy and Practice: Selected papers from the agroforestry sessions of the IUFRO 20th World Congress*,

- Tampere, Finland, 6–12 August 1995. Springer, 125-143.
- Schroth, G. (1999). A review of belowground interactions in agroforestry, focussing on mechanisms and management options. *Agroforestry for Sustainable Land-Use Fundamental Research and Modelling with Emphasis on Temperate and Mediterranean Applications*: Selected papers from a workshop held in Montpellier, France, 23–29 June 1997. Springer, 5-34.
- Schroth, G., Da Fonseca, G. A., Harvey, C. A., Gascon, C., Vasconcelos, H. L. & Izac, A.-M. N. (2004). *Agroforestry and Biodiversity Conservation in Tropical Landscapes*. Island Press.
- Seiter, S., William, R. & Hibbs, D. (1999). Crop yield and tree-leaf production in three planting patterns of temperate-zone alley cropping in Oregon, USA. *Agroforestry Systems*, 46, 273-288. <https://doi.org/10.1023/A:1006204018212>
- Sileshi, G., Kuntashula, E. & Mafongoya, P. (2006). Effect of improved fallows on weed infestation in maize in eastern Zambia. *Zambia Journal of Agricultural Science*, 8, 6-12.
- Sileshi, G. & Mafongoya, P. (2007). Quantity and quality of organic inputs from coppicing leguminous trees influence abundance of soil macrofauna in maize crops in eastern Zambia. *Biology and Fertility of Soils*, 43, 333-340. <https://doi.org/10.1007/s00374-006-0111-8>
- Van Schaik, N., Schnabel, S. & Jetten, V. (2008). The influence of preferential flow on hillslope hydrology in a semi-arid watershed (in the Spanish Dehesas). *Hydrological Processes: An International Journal*, 22, 3844-3855. <https://doi.org/10.1002/hyp.6998>
- White, R. E. (2005). *Principles and Practice of Soil Science: The Soil as a Natural Resource*. John Wiley & Sons.
- Wu, Y., Wang, W., Wang, Q., Zhong, Z., Pei, Z., Wang, H. & Yao, Y. (2018). Impact of poplar shelterbelt plantations on surface soil properties in northeastern China. *Canadian Journal of Forest Research*, 48, 559-567. <https://doi.org/10.1139/cjfr-2017-0294>
- Young, A. (1997). *Agroforestry for Soil Management*. CAB International.
- Zamperlini, G., Silva, M. & Vilegas, W. (1997). Identification of polycyclic aromatic hydrocarbons in sugar cane soot by gas chromatography-mass spectrometry. *Chromatographia*, 46, 655-663. <https://doi.org/10.1007/BF02490527>
- Zinke, P. J. (1962). The pattern of influence of individual forest trees on soil properties. *Ecology*, 43, 130-133. <https://doi.org/10.2307/1932049>
- Zomer, R. J., Trabucco, A., Coe, R. & Place, F. (2009). *Trees on Farm: Analysis of Global Extent and Geographical Patterns of Agroforestry*. ICRAF Working Paper-World Agroforestry Centre.

Uloga zaštitnog pojasa u upravljanju zemljištem u Etiopiji

Melkamu Terefe Asmare

Sažetak: Zemljište je vitalna komponenta za rast drveća i žbunja u agrošumarskim praksama zaštitnih pojaseva. Upravljanje drvećem ima ključan doprinos poboljšanju zemljišta. Upotreba zaštitnih pojaseva od strane ljudi varira u agroekološkim zonama Etiopije. Neki narodi to koriste kao svoj kulturni izraz, a drugi za razgraničenje svog imanja (poljoprivrednog i kućnog). Vrste *Milletia ferruginea*, *Sesbania sesban*, *Acacia abissinica* i druge vrste drveća mahunarki zasađene su u cilju upravljanja zemljištem u praksama zaštićenih pojaseva u agroekologiji. Uzimajući u obzir populaciju i veličinu farme u Etiopiji, znanje većine farmera o zaštitnim pojasevima za upravljanje zemljištem je oskudno dokumentovano. To je zbog niskog nivoa svesti i stručnog savetovanja. Stoga, ovaj rad razmatra uloge upravljanja zemljištem i moguće pretnje, mogućnosti i izazove zaštićenih pojaseva. Korišćeni su relevantni objavljeni radovi. Naučnici su izvestili da područja pokrivena dobro vođenim zaštitnim pojasevima imaju dobra fizička, biološka i hemijska svojstva tla. Kvalitet zemljišta i plodnost područja dodatno su poboljšani zahvaljujući dobrim mikrobnim aktivnostima u zemljištu. Kompatibilnost useva drveća, klimatski faktori, politika korišćenja zemljišta i nedostatak zemljišta bili su među mogućim pretnjama i izazovima za uspostavljanje zaštitnih pojaseva. Generalno, dobre veštine upravljanja drvećem i žbunjem rezultiraju visokim nivoom produktivnosti zemljišta. Zbog toga, planeri daljeg razvoja treba da se fokusiraju na opsežnu demonstraciju prakse zaštitnih pojaseva, kao i na obuku i praćenje poljoprivrednika o takvim pitanjima radi poboljšanja njihovih sredstava za život.

Ključne reči: izazovi, mogućnosti, pretnje, drveće, kvalitet zemljišta, zaštitni pojas