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Review on Woody Species and Socio-Economic Roles of Traditional Agroforestry Practices in Ethiopia

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Abstract

The indigenous knowledge of deliberate maintenance of diverse plant species on farmers' managed landscape characterizes different forms of traditional agroforestry systems in Ethiopia. Nonetheless, very little of this knowledge has been recorded in the country. These review woody plants maintained in different forms of traditional agroforestry practices with respect to conservation and rehabilitation of biodiversity and their biophysical and socio-economic roles and benefits to household. In Ethiopia, countries are located in different agro-ecological zones (lowland (1540-1680 masl), transitional zone (1680-1800 masl), mid-altitude (2100-2300 masl) and highland (2740-2800 masl). Relatively, more species richness and low evenness was observed in the mid-altitude. Farmers deliberately retained tree/shrub species on their farms for multiple uses and to optimize production of crop and livestock and ultimately for their socio-economic and livelihood development. Diversity and significance of woody species uses are variable from one agro-ecology to another. Generally, the traditional agroforestry practices are rich in indigenous tree/shrub species.

Keywords: Traditional agroforestry; Biodiversity; Agro-ecological zone; Diversity; Evenness; Richness

Introduction

Indigenous knowledge and biodiversity are complementary phenomena essential to human development. Global awareness of the crisis concerning the conservation of biodiversity is assured following the United Nations Conference on Environment and Development held in June 1992 in Rio de Janeiro. Of equal concern to many world citizens is the few documentations of the indigenous knowledge that reflect many generations of experience and problem solving knowledge of thousands of ethnic groups across the globe. Very little of this knowledge has been recorded, particularly in the African context; it has long been ignored and maligned by outsiders. The indigenous knowledge of deliberate maintenance of diversity of domesticated and non-domesticated plants and animals characterizes farming systems across the African continent as well as in most other parts of the world, providing an important opportunity for systematic *in situ* maintenance of genetic resources [1].

Maintenance of biodiversity is not a luxury at all. Biodiversity is the resource from where several cereals, fruits, vegetables, quality firewood, quality lumber, palatable fodders, domesticated animals, etc. have been screened from through millennia. There are still many more that are potentially useful either as food or medicines in the rich wild. Furthermore, biodiversity is at the core of ecosystem health as it is the engine of a balance of natural-full functioning ecosystem. The balance of nature is a robust phenomenon, tending to resist stress and to protect nature (humankind) from perturbations, including our own thoughtless actions [2].

Nowadays diminution of biodiversity as a result of converting primary forest to unsustainable agricultural landscape has increased in many developing counters. For instance, environmental degradation in the form of deforestation and loss of biodiversity and soil fertility is one of the most prominent features of the Ethiopian highlands. About 27 million hectares of land in highlands of Ethiopia have been significantly degraded out of which 2 million hectares are degraded to the extent that they will not produce crops in the future [3]. The underlying causes of land degradation in Ethiopia include the familiar themes of forest clearance, exposure of surface soil to erosion and overgrazing which generally leads to a loss of biodiversity.

Environmental degradation, particularly loss of biodiversity, calls urgently for conservation, or planting of the right tree species at the right place for the appropriate purpose [4] along with management of remnant tree resources in the form of on-farm trees, other forms of agroforestry trees in rangelands and the like [5]. There is enough evidence to indicate that trees and shrubs, if managed properly, can make significant contributions to maintaining and improving fertility and overall productivity of soils in agro-ecosystems [6]. In many part of the world, there are also numerous examples of traditional land management practices involving the combined production of trees and agricultural crops/animals on the same piece of land. In these traditional land-management practices, trees are deliberately retained on or around farmlands, to support agriculture and other livelihood systems [7].

Objectives of the Review

The Specific objectives of this study are:

- To assess the diversity of traditional agroforestry practices.
- To investigate the socio-economic importance of traditional agroforestry systems.

Literature Review

Traditional agroforestry practices in Ethiopia

The most common agroforestry practices in Ethiopia include park-land agroforestry (scattered trees in croplands), home gardens, hedge-

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row intercropping, riparian zone vegetation, enclosures and natural regeneration of species in woodlands and pasture. The intercropping of maize with *Cordia africana* in Bako and western Ethiopia as well as *Faidherbia albida* based agroforestry in the Hararghe Highlands and Debrezeit area are some good illustrations of parklands agroforestry in the country [8,9]. Multistorey Home gardens are also practiced in many parts of the southern and southwestern Ethiopia. The structural complexity of home gardens is varied and ranges from complex and diverse forms containing numerous species, as in Sidama to the less complex forms, with one or two crop/tree mixtures, as in the Gurage Ensete home-compound farms [10-14]. Numerous multipurpose tree and shrub species were used as live fences. Farmers frequently use both home gardens and fields to cultivate most of their crops. The home garden complex is viewed as reminiscent of traditional agroforestry systems [15].

Hedgerow intercropping is practiced in many parts of Ethiopia. The sorghum/maize and chat (*Catha edulis*) hedgerow intercropping in the Hararghe Highlands of eastern Ethiopia is one such an example. Riparian zone vegetation is vegetation along rivers, water banks, streams and the like. In Ethiopia there are numerous perennial and intermittent rivers, some of these rivers and streams do support large numbers of species with relatively dense vegetation. One example of riparian zone vegetation in Ethiopiais vegetation along Awash and Eliwoha waterways where *Acacia tortilis*, *Acacia nilotica*, *Balanites aegyptiaca*, *Tamarindus indica*, *Tamarix* spp., and *Ziziphus* spp. are found. The riparian vegetation is an important source of fodder for livestock during the dry season, and a source of food, medicine, fuel wood, farm tools and wood for utensils for humans. It is also home to many plants and animals. Another agroforestry practice is enclosures and natural regeneration of species [16]. 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 [17]. The enclosures are managed to benefit local people in the form of cut and carry grass production, controlled harvesting of wood products and other minor forest products, which make them a form of agroforestry practices.

Traditional agroforestry for biodiversity and environmental conservation

Traditional agroforestry for biodiversity conservation: The diminution of biodiversity due to converting primary forest to frequently unsustainable agricultural lands has increased in many tropical countries. To resolve the problem, developing sustainable agricultural system is very crucial. The long aged practices of tropical traditional agroforestry systems mainly home gardens are generally regarded as sustainable production systems [18-21], principally due to their high biodiversity and multiuse products with relatively low labor, cash or other inputs [22]. The major functions of home gardens especially in rural areas are uninterrupted subsistence food production and income generation because of high biological diversity in home garden [23].

Home gardens are known for diverse tree /shrub species. According to some research findings, over 149 crop species were identified in home gardens of central Sulawes of Indonesia [24]. In southern part of Ethiopia too, the Sidama home garden agroforestry systems are honored for having high diversity of about 198 plant species out of which 78 species were identified as cultivated crops and the rest are tree/shrub species [25]. In addition, home gardens located in central, eastern, western and southern Ethiopia have about 162 species of plants out of which 78% were recorded as food crops [26]. Home garden is a place where evolution and diversification of many crops of indigenous taxa have occurred. Also, crops introduced in the primal stage of agricultural innovations and species planted at experimental levels are found in home-gardens. It is concluded that the potential of home gardening in Ethiopia is quite significant [27].

Live fences, windbreaks, and isolated trees also contribute much to biodiversity conservation in agricultural lands. The floristic diversity conserved in these agroforestry systems can be high, and a substantial number of animal species may exploit these habitats for feeding, sheltering, and in some cases for reproduction. Live fences, windbreaks, and isolated trees form networks of natural habitats which may also enhance landscape connectivity and contribute much to biodiversity conservation at different scales. Of course, they do not make up complete ecological units and cannot provide the full array of habitats or services of the original habitat. Consequently, the organisms in them are likely to take refuge, at least to some degree, on live fences, windbreaks, and isolated trees found in nearby remnant habitats [28].

Species composition of parkland agroforestry is generally more diverse and variablein areas located further away from villages and sporadically cultivated [29]. However, some parklands such as those in the northern Mandara Mountains in Cameroon or around Kimré in southern Chad comprise immense number of species [30]. For instance, about 22 and 39 species were recorded from cultivated fields in two sites around Kano, northern Nigeria and 46 from northern Côte d'Ivoire [31-33].

Environmental roles of traditional agroforestry practices: In addition to biodiversity conservation, on-farm trees are very important for their roles in environmental or ecological maintenance. In many part of the world, research results revealed that some scattered trees/shrubs in traditional agroforestry land use systems improve the fertility of the soil, improve microclimate, maintain soil moisture and also improve the yields of the crops underneath.

In Hararghe highlands of eastern Ethiopia, the effect of the presence of permanent tree crop (*Faidherbia albida*) on the yield of maize *(Zea mays L.)* and sorghum *(Sorghum bicolour L. Moench) was* compared with the yields from open farmlands without trees. The research findings confirmed that the yield of the two crops increases significantly by 56% on average under the tree canopies. This increase was caused by the improvement in 1000 grain weight and number of grains per plants under the tree, indicating that the trees enhanced the fertility status of the soil and improved its physical conditions in terms of crop growth. In addition, growing agricultural crops under *Millettia ferruginea* trees is an age-old practice in southern Ethiopia. Soil sample study from under the canopy of *Millettia ferruginea* and open land indicates that the level of surface soil P, organic C, exchangeable base-forming cations and cation exchange capacity are all significantly higher under the trees than in the open field [34]. Nutrient levels declined with depth and increasing distances from the tree trunk. Maize plants grown on soils collected from underneath *Millettia* trees resulted in significantly better growth and higher dry matter yield as compared to the control. Socio-economic studies indicated that *Millettia* trees have a good standing in the southern region both because of their desirable biological characteristics and because of their economic benefits [35].

Many *Acacia* species, especially in the drier regions, have extensive, shallow lateral roots to take advantage of any light rainfall that might

occur [36]. Such shallow root systems help to stabilize the soil. The aerial system of trees play great role in reducing wind erosion and ameliorating the surrounding microclimate. Such species as *Acacia nilotica subsp. indica, Acacia senegal, Acacia tortilis and Faidherbia albida* have been widely planted or/and deliberately retained to fix and stabilize sand dunes and combat wind erosion [37]. Moreover, the shade effects of trees are reducing air temperatures that reduce soil evaporation and soil surface temperatures. Study in Kenya testified that mid afternoon soil temperatures beneath the canopy of *Acacia tortilis subsp. spirocarpa* were reduced by 3-12°C. However, in the absence of shade the high surface temperatures attained by bare soils must have an adverse and possibly lethal effect on any dormant and regenerating seeds lying on the soil surface. This discourages regeneration and encourages desertification. The lower shade temperatures also encourage more nutritious ground cover, which is further stimulated by the higher soil moisture in the vicinity of the trunk as a result of stem flow. Measurements of total soil water content under *Faidherbia albida* taken just before the start of the rainy season gave a value of 8% beneath the canopy and 4% outside [38]. Generally the improved physical conditions beneath the canopy could be a positive contribution of trees and lower temperatures could be an additional factor [39]. In seven coffee producing provinces of Hararghe administrative region (Eastern Ethiopia), about 14 permanent shade tree species belonging to two families: Leguminosae and Moraceae.

Socio-economic roles and benefit of traditional agroforestry systems

Traditional agroforestry practices across the African contents have served the people for generations by supplying food, fodder, medicinal products, wood, shade and the like. For instance, the traditional agroforestry system practiced by the sedentary Fur people of Sudan consists of a semi-permanent, rain-fed staple crop (millet), and other subsistence crops are intercropped under multipurpose trees dominated by *Faidherbia albida, Cordia abyssinica* and *Ziziphus spina-christi*. In this traditional agroforestry practice, trees are retained primarily for food, wood, and fodder. In addition, thorn from cut and browsed branches of these trees makes good fencing material [40]. The compound farms of south-eastern Nigeria are home garden type agroforestry system in which multipurpose trees and shrubs are deliberately maintained in association with agricultural crops and livestock. In these farms, the multipurpose trees/shrubs are used for production diversification and risk minimization [41]. The Chagga home gardens of Northern Tanzania are managed by farmers with an intimate knowledge of the functions/uses of crop plants, and of their ecological requirements. The great diversity of Chagga home gardens provides both subsistence and cash crops, as well as insurance against drought, pests and economic risks [42].

Furthermore, *Faidherbia albida* based traditional agroforestry practices in the Hararghe highlands of eastern Ethiopia provide fuel wood, fodder and simultaneously constitute a form of saving and security for the rural population. According to the survey made on agroforestry practices at Dibandiba sites in central Ethiopia and Aleta Wendo in southern Ethiopia, on-farm trees were planted/retained mainly for construction, fuel wood, shade, and cash. Major uses in both sites were fencing, fuel wood, construction and plough handles [43].

Farmers in different parts of the African continent use plants including trees or shrubs from forests, riparian vegetation and crop fields for medicinal purposes. Hence, in Ethiopia, [44] reported that about 80 percent of the total populations rely on traditional plant-derived medicines for their basic health care needs. For instance Me`en people of southwest part of the country used about 52 plant species for medicinal purposes [45]. Tesfay and Zemedy (1999) also confirmed that Berta people of the Benishangul Gumuz region of western Ethiopia used around 24 plant species for medicinal purposes. In other part of Africa, people also use some Acacia species for medicinal purposes. Even though not supported by any clinical studies, medicinal plants have been used successfully for treatment of venereal diseases, diabetes and the like by the local people for centuries. There are active ingredients present in the plant parts which may be efficacious. Gum, for example, has an emollient effect resulting in a softening and soothing action on the skin or irritated internal surface [46].

Socio-economic and physical factors that affect diversity

Overview of major factors: Species composition and diversity of traditional agroforestry practices are influenced by environmental factors such as altitude, slopes, and socio-economic aspects. According to the studies made on home gardens, species diversity and composition were varied with ecological, socio-economic and cultural factors. For example, in Sidama traditional agroforestry practice the largest number of tree species, the largest number of stems and the largest basal area ha^{-1} were recorded on farms of wealthy households. The major factors that affect species composition and diversity of traditional agroforestry practices are discussed under two major topics: socio-economic and physical factors.

Socio-economic settings: The socio-economic factors that affect the diversity of species are commercialization, access to the market, farm size, access to the resources and extent of reliance on off-farm income. Consequently, agricultural systems close to the market or towns, particularly in well-off households, tend to emphasize on high-value cash crops instead of staple foods. In addition from research work in, noted that increased access to resources is strongly associated with decreased or increased species diversity. They also pointed out that the diversity of species increases as per capita landholding size increases. Higher dependence on income from off-farm results in less labor being available to the farm to plant or manage and hence farm level species diversity could be low. Greater access to natural resources is likely to reduce diversity of plants in farmers' fields since they can obtain some of their requirements, such as wood, medicinal plants, etc., from the forest and findings from southern Ethiopian home garden agroforestry shows that smaller farm sizes and enhanced access to road networks decreased native and other multipurpose species such as *Podocarpus falcatus, Cordia Africana* and *Millettia ferruginea*.

Physical environment: The growth diversity and types of woody plant species growing in a given agroforestry land use are affected by altitude and climate. Temperature and rainfall are two important climatic factors that are influenced by altitude which further affect the diversity of species. A study demonstrated from their study on home garden, diversity of plant species decreases with increasing altitude. This is because of the drop in temperature that could affect the growth of some species. Plant diversity assessment in seven land use categories of Bush were Parish, Mbarara district, of south-western Uganda showed that the occurrence of species depended upon environmental factors such as elevation, position on the slope and soil type. And also species utility and occurrence were related to the socio-economic status of the farmers.

Conclusion

Traditional agroforestry practices Ethiopia are rich in indigenous tree/shrub species. Ethiopia in different agroforestry practices across the various agro-ecological zones that stretch over only 37 km distances.

Among these Differences in species composition, evenness and richness exist along the ecological gradients. For instance, *Eucalyptus* spp., *Cupressus lusitanica, Coffea arabica* and *Rhamnus prinoides* are the most widely planted species thus they are the most dominant and frequent species in the mid-altitude due to their lucrative market prices and better market demands. Therefore, their causes disproportionate abundance lower species evenness and diversity in the mid-altitude as compared to the other three agro-ecological zones. This implies that increased commercialization of certain tree crop species in the farmlands decreases species composition which leads to low species diversity. Species variation and composition are known to be affected by physical factors particularly by altitudinal variations across the agro-ecological zones. Socio-economic factors such as farm size and educational background of the household head appear to be responsible for species variation and heterogeneity in planting and management practices.

Recommendation

Farmers are knowledgeable about their environment and they described and listed the uses of various on-farm tree/shrub species for the socio-economic development of their households and soil fertility improvement. Shade trees are very important where sun scorching is a serious problem whereas cash generating trees are more important where environmental factors are favorable and access to market and road networks is also readily available. Usually, farmers deliberately retain tree/shrub species on their farms for multiple uses and to optimize production of crops and livestock mainly for livelihood improvement. To assure sustainable use of on-farm trees, they employ a wide range of management practices. For example, lopping is a common practice in all agro-ecological zones whereas other management practices vary from site to site and from trees to trees.

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