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Contribution of agroforestry practice in reducing deforestation and improving livelihood of household in Ethiopia

Contribución de la práctica agroforestal para reducir la deforestación y mejorar los medios de vida de los hogares en Etiopía

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Abstract

Agroforestry practice produces different benefits and products, which enhance household incomes and sources of wood products. This review was aimed to review the contribution of agroforestry practice for reducing deforestation and improving livelihood in Ethiopia. Agroforestry also plays a significant role in reducing pressure on the natural forests and shrub lands by providing fuel and construction wood as well as other forest products. Agroforestry practices also contributing to ecological benefits, such as woody plant species conservation, carbon sequestration, soil nutrient improvement and reducing pressure on natural forest through provision of wood and non-wood products. However, due to so many factors such as social factors, institutional factors, policy problem, extension gap, infrastructure and the like agroforestry practices are not fully adopted in all parts of the country. Therefore, for further adoption of the agroforestry practices it is necessary to create better awareness for society and formulate clear policy.

Resumen

La práctica agroforestal produce diferentes beneficios y productos, que mejoran los ingresos de los hogares y las fuentes de productos madereros. Esta revisión tuvo como objetivo examinar la contribución de las prácticas agroforestales para reducir la deforestación y mejorar los medios de vida en Etiopía. La agrosilvicultura también desempeña un papel importante en la reducción de la presión sobre los bosques naturales y los matorrales al proporcionar combustible y madera para la construcción, así como otros productos forestales. Las prácticas agroforestales también contribuyen a beneficios ecológicos, como la conservación de especies de plantas leñosas, el secuestro de carbono, la mejora de los nutrientes del suelo y la reducción de la presión sobre los bosques naturales mediante el suministro de productos madereros y no madereros. Sin embargo, debido a tantos factores como factores sociales, factores institucionales, problema de política, brecha de tensión, etc., la infraestructura y las prácticas agroforestales similares no se adoptan completamente en todas partes del país. Por lo tanto, para una mayor adopción de las prácticas agroforestales es necesario crear una mejor conciencia para la sociedad y formular una política clara.

Introduction

More than 80 % of the rural population in sub-Saharan Africa is poor and traditionally relies on forests for most of their livelihoods including fuel wood and timber as well as other non-timber forest products[1]. Besides, ecosystem services are the benefits that people gain from the ecosystems for their well-being[2]. Nevertheless, the products and services people get from forests are progressively declining globally. Deforestation as the loss of trees' cover is usually as a result of forests being cleared for other land uses[3]. The problem of deforestation is much higher in East Africa than in other parts of the continent[4]. The increasing populations of smallholder farmers in developing countries are the main driving force for deforestation and land degradation meant for intended benefits such as agricultural expansion, fuel wood, and fodder[5]. In Ethiopia, the steadily growing population pressure and the need for agricultural expansion and fuel wood consumption increased the exploitation of forest resources which can ultimately lead to unsustainability and depletion of the total forest area[6]. In the country, the dependence of urban dwellers on surrounding rural areas for fuel wood consumption for long periods of time and the associated population growth has aggravated the level of deforestation and forest degradation, especially in recent times[3].The causes of deforestation are varied but may broadly be categorized into anthropogenic and natural factors. For the anthropogenic factors, increased wood fuel collection, clearing of forests for agriculture, illegal and poorly regulated timber extraction, social and environmental conflicts, increasing urbanization, and industrialization are the primary known causes for the loss of forests and woodlands whereas the natural factors, the impacts of drought and natural forest fires[7].

The main driving force for deforestation in developing countries, including Ethiopia is population growth[8]. Population pressure is the main cause for the depletion of forest resources which in turn poses many social and economic problems in Ethiopia[9]. Ethiopia follows an Agricultural Development Led Industrialization (ADLI) policy, however, agricultural production is mostly subsistence in its nature, and a large part of commodity exports are provided by the smallholders' agricultural cash crop sector[10]. The low productivity of the agricultural sector leads to an increasing demand of food, in Ethiopia to feed the growing population. As population has been increasing through time, there is an obvious fact that the deforestation rate becomes very high in subsistence farming system leading to changes in land use/cover from forest to cropland, grazing land and settlement areas.

One way of reducing deforestation problem and improving the livelihood of household in Ethiopia is through agroforestry (AF). The integration of trees with crops on farmlands has a great potential for enhancing land productivity while providing essential services to people and the environment and shielding forests from further deforestation and land degradation problems common in the highlands of Ethiopia. AF systems such as woodlots do supply fuel wood and can therefore alleviate the demand from natural forests and therefore reduce deforestation[11]. On the other hand, it is also pointed out that AF has a great potential for reduction of deforestation and forest degradation, providing for rural livelihoods and habitats for species outside formally protected areas, and alleviate resource user's pressure on conservation area[12-14]. Trees and shrubs grown in AF practices have the potential to reduce deforestation rate, improving income for smallholder farmers and directly or indirectly contributing to soil fertility improvement[15]. AF can be a good strategy for climate change (CC) adaptation by diversifying farmers' production

systems and enhancing sustainability due to their ability to maintain production during wetter and drier years[16]. It may increase farm profitability through improvement and diversification of output per unit area of tree/crop/livestock, through protection against damaging effects of wind or water flow, and through new products added to the financial diversity and flexibility of the farming enterprise, while also substantially contribute to CC mitigation[17]. It helps farmers to diversify their income and AF plays a better role in increasing agricultural productivity by nutrient recycling, reducing soil erosion, and improving soil fertility and enhancing farm income compared with conventional crop production. Furthermore, AF also has promising potentials for reducing deforestation while increasing food, fodder, and fuel wood production[18]. Some of the benefits that AF offers are: soil-fertility improvement, provision of wood products (fuel wood, poles, timber, fruits, medicines, etc.), improved beekeeping, control of erosion, stabilizing of river and stream banks trees and shrubs can contribute to better microclimate (shade, windbreak, etc.,) and provision of fodder, especially in the dry season. Ethiopia is one of the countries having AF practices[19].

Nevertheless, adequate research and extension is limited in AF in the country[20]. Therefore, working on adequate research and extension work is necessary for further adoption of AF practice in Ethiopia. Therefore, this review paper was carried out to review the contribution of agroforestry practice in reducing deforestation and improving livelihood of household in Ethiopia.

Development

AF and AF practices. Is a land use system that deliberately integrates trees or shrubs with agricultural crops and livestock in the same land management system[21]. AF can contribute to sustain agricultural production improve food security[22] and helps alleviate temporal shortages of water and energy[23]. AF practices involve combinations of trees, crops and animals in various spatial arrangements or temporal sequences in the landscape[24]. AF practices involve combinations of trees, crops, and animals in various spatial arrangements or temporal sequences on the landscape[25].

Concept of deforestation, its causes and consequence. Deforestation is the long-term or permanent conversion of forest to other land uses, such as agriculture, pasture, water reservoirs, infrastructure and urban areas. The cause of deforestation is depending from geographical, biological and socio-economic conditions. The main drivers of deforestation are all likely to increase in coming years because of continued increases in population and economic growth, urbanization, global demand for wood products and agricultural commodities, and the impacts of climate[26]. The causes of deforestation are depending from geographical, biological and socio-economic conditions and problems caused by deforestation emerge on different scale levels[27]. The main drivers of deforestation are likely to increase in the coming years as a result of population growth, economic growth, urbanization, global demand for timber and agricultural products, and the effects of climate change[28].

Additionally, the main driving forces behind deforestation are the expansion of agricultural land, unrestrained exploitation of forest resources for fuel, fodder and construction, overgrazing and establishment of new settlements into forested land coupled with increasing population pressure[28-31]. Fuel wood consumption together with slash and burn agriculture has accelerated forest degradation in the region[32]. The extensive need for energy, which leads to widespread cutting of trees, is also becoming another threat in the country for the remaining forest and soil fertility[33,34]. The majority of the Ethiopian population relies on biomass fuel for energy production as a result scarcity of firewood has become severe problem in many

parts of the country[35]. Thus, the high dependency on forest resources for fire and construction wood from natural open access forest represents further burden on the national forest resource of Ethiopia. Moreover, the production of fuel wood outside the forest might also have the potential to replacing the fuel wood.

Livelihood. A livelihood comprises the capabilities, assets and activities required for means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base[36]. 78 % of rural populations of developing countries depend up on the forest resources and subsistence agricultural for their livelihood[37]. Tree-based AF practices could bring opportunities for rural development through promoting agro industries and improving local economies by reducing unemployment. Tree and shrub integration on farmlands has been encouraged as a means of enhancing rural livelihoods through sustaining provision of services and products by the watershed area[38,39] also pointed out that advance in AF is one of the most important tools to meet Millennium Development Goals (MDG) in reducing poverty.

AF practices and their contribution. AF is one of the best low-cost alternatives that could be applied by the poor rural population to fulfill their wood requirements and to generate extra income. AF practices have an immense role in environmental amelioration, food security, CC mitigation and adaptation. AF systems could enhance carbon sequestration, minimize environmental degradation, diversify and sustain production for increased economic benefits for land users at all levels. Microclimatic improvement through AF changes crop performance as trees can regulate climatic extremes that affect crop growth[17]. Particularly the shade of AF trees can buffer temperature and atmospheric saturation deficit, and thereby, reducing exposure to supra-optimal temperatures, under which physiological and developmental processes and yield become increasingly vulnerable. Scattered trees in agro forestry farms can enhance the understory growth by reducing incident solar radiation, air and soil temperature, while improving water status, gas exchange and water use efficiency[40]. Despite its role in increasing the resilience of tropical farming systems[16,41,42] pointed out the most mentioned beneficial functions of AF trees were wood for construction (98 % of households), fuel (95 %), sale (84 %), fodder (82 %), land improvement (69 %), and fencing material (47 %). However, the most mentioned drawbacks of AF trees were detrimental shade (78 % of households), resource depletion (16 %), and barrier for cultivation (13 %).

Scientists claimed that research is needed regarding the integration of ecological knowledge and socio economic constraints to scaling up AF and to enable promote tree based farming[23,43]. This could enhance yields of tee foods and improve the synergy of food production in smallholders' AF systems[41]. As vulnerability of smallholder farmers and pastoral and agro-pastoral communities and their production systems to CC is growing over time, it is important to investigate the traditional AF systems that diversify livelihoods and thereby, enhance adaptation to and mitigation of CC[20,44] found a total of 123 tree, 146 shrub, 25 climber and 135 herbaceous species in various AF systems. The greatest plant species richness occurs in south Ethiopia (50-198), followed by southwest (149), central (27-114) and north Ethiopia (17-40).

Environmental Benefit of AF practice. Environmental benefits of AF include soil erosion control, improvement of soil quality through increased nitrogen input, improvement of water dynamics[45], and increased activity of soil biota[46]. AF systems such as woodlots do supply fuel wood and can therefore alleviate the demand from natural forests and therefore reduce deforestation. They have also shown that they

can sequester carbon, though at different rates depending on the species used and management regimes and systems[11].

Studies in Ethiopia also showed practices AF have greater potential in improving soil nutrient status[34,47,48] compared with conventional mono-cropping systems. On the other hand[47], also indicated that the soil loss due to rill and inter-rill erosion is higher in open fields than agro-forested fields. Understanding site and species-specific variations in tree-soil interactions in AF have crucial and immediate concern to farmers and expertise to improve land productivity[49]. AF practices have a potential to provide a valuable organic matter, which improve the nutrient and water holding capacity, increased cation exchange capacity, buffering of the soil against acidification as well as aluminum and iron toxicity[50]. The occupation of phosphorus fixation sites by organic matter also increases phosphorus availability[10].

Roles of AF Practices in Reducing Deforestation and Carbon Sequestration. AF can also potentially reduce deforestation while increasing food, fodder and fuel wood production[51]. A general problem of practices AF, farmers may also perceive trees as incompatible with their farming activities and may not benefit from planting and managing trees and shrubs on their farm plots[15]. This can also influence the adoption and implementation of practices AF in wider areas. Lack of knowledge on the benefits of the trees and shrubs on farmlands also leads to the perception that the mono-cropping activities are the only preferred methods for smallholder farmers**.** As indicated by[7], between 1990 and 2000, the deforestation rate of the Ethiopia was very high compared with the successes in plantation. One of the reasons for the failure of the attempts was the perception of farmers towards deforestation problems[52], indicated that farmers' decision to preserve natural resources is determined by their knowledge on the severity of the problems and the perceived benefits of conserving the natural resource base. Trees and shrubs grown in practices AF have the potential to reduce deforestation rate, improving income for smallholder farmers and directly or indirectly contributing to soil fertility improvement[15].

AF is considered to be more compatible with society's ecological and environmental goals than conventional agriculture. Carbon sequestration rates are highly negative on forest clearance: -92 t C ha^{-1} yr^{-1} during the first 2 years after slash-and-burn - a period that is normally under annual cropping or pasture establishment[53]. Table 1 shows that carbon sequestration rates become positive with secondary forest fallows (5-9 t C ha^{-1} yr^{-1}); complex agro forests (2-4 t C ha^{-1} yr^{-1}); and simple agro forests with one dominant species such as oil palm, rubber, or *Albizia falcataria* (7-9 t C ha^{-1} yr^{-1}). The lower carbon sequestration rate of some AF systems in relation to natural secondary succession is partly because AF products are removed from the system for family use or for sale. This finding underscores the important tradeoffs between a global public good (carbon) and a private good (economic gain)[54]. Croplands, pastures, and degraded grasslands lost carbon at a slow rate or showed modest positive rates (-0.4 to +3 t C ha^{-1} yr^{-1}). Land-use systems that include trees, therefore, produce higher carbon sequestration rates than those that are limited to annual crops, pastures, or grasslands. According to[55] in order to optimize its Greenhouse Gas mitigation potential it is important to avoid overgrazing by using adequate stocking rates, to select high effect density pasture and fodder species and to implement high tree-planting density designs.

AF as source of domestic wood market. AF practices including hedgerow intercropping (woodlots, scattered trees and boundary planting) play an important role in the supply of fuel wood because of the availability of many multifunctional trees and shrubs satisfy fuel wood characteristics such as rapid growth, coppicing ability and high productivity rates. The importance of farm trees in providing fuel wood to-

Table 1 Contribution of different land use system for carbon sequestration

Land use practices	Carbon uptake Rates (t Carbon ha^{-1} $year^{-1}$			Duration (yr)	Carbon stocks (t C ha^{-1}			Difference in model C stocks (t C ha^{-1}	
	Low	Modal	High		Low	Modal	High	Forest	Grassland/ Pasture
Primaryand logged forest	n/a[b]	n/a[b]	n/a[b]	?	192	230	276	-	-201
Cropping after slashing and burn	-76	-92	-112	2	39	46	52	-184	+17
Crop/bush/fallow	2	3	4	4	32	34	36	-196	+5
Tall secondary forest fallow	5	7	9	23	95	112	142	-118	+83
Complex agroforests	2	3	4	25-40	65	85	118	-145	+56
Simple agrooforest	5	7	9	15	65	74	92	-156	+61

farmers in the present study, collaborated by many other studies that have shown AF systems as the best alternative to produce wood products and to conserve natural resources[56].

Table 2 Reason for practicing agroforestry practice

Reason for practicing agroforestry	Frequency	Percentage
Fuelwood	71	44.4
Building materials and fuelwood	40	25
Additional income	28	17.5
Timber	7	4.4
Shade	14	8.7
Total	160	100

Over 90 % of the populations in Ethiopia depend on fuel wood for their energy needs. Increased tree growing and better management of existing resources could provide for products such as fuel wood, poles, fruits and timber which have not only become scarce but increasingly expensive. Thus, such commodities could be produced both for subsistence and for cash. Scarcity of fuel wood may influence both the amount of food cooked and its type. Further, since fuel wood collection is women's work further away the source of fuel woods the greater their workload becomes. Consequently, they have less and less time and energy to spend on other activities such as caring for children or engaging in income-generating activities. Thus, the scarcity of fuel wood has a direct impact on the family's nutrition.

From the above table 44.4 % of the household surveyed was practice AF for the purpose of getting fuel wood, 8.7% of the household practice AF for getting shade, 25 % of head of the household's for building materials and fuel wood, 17.5 % for additional income, 4.4 % of head of the household's practices AF for the purpose of getting timber[57]. head of the household's.

Role of AF practice as strategy for livelihood diversification. AF enhances food and nutritional security by supporting crop production and through provision of edible tree and livestock products[41]. The parkland AF has much potential for supplying fodder, poles, farm equipment, fuel wood and agricultural improvements[58]. Trees provide household energy for cooking, heating and lighting. AF provides farmers with products, many of them high in value, which can be sold in rural and urban markets such as selling timber, poles, charcoal and honey. Many trees and shrubs have medicinal value that keeps the farm family healthy and generate additional income. AF is often defined as an economically viable land-use option on the environmental rehabilitation and sustainable agricultural development[59].

In terms of land use arrangement, AF systems cannot be grouped under forestry, rather they are systems that deliver tree products and services[60]. Some researchers[61] consider it as a joint forest production system whereby farm inputs are combined to produce trees and agricultural crops on the same plot of land. In Northwest Ethiopia, where the study was conducted, farm households simultaneously adopt AF and non-farm income diversification activities. Farm income includes livestock as well as crop income and comprises both consumptions in the form of own farm output and cash income from output sold. Off-farm earnings typically refer to wage or exchange labour on other farms, that is, within agriculture. It also includes labour payments in-kind, such as the harvest share systems and other non-wage labour contracts that remain prevalent in many parts of the developing world. On the other hand, non-farm income refers to non-agricultural income sources which include non-farm rural wage employment, non-farm rural self-employment, property income (rents, etc.), urban-to-rural remittances arising from within national boundaries, and international remittances arising from cross-border and overseas migration. For the sake of convenience in this study both off-farm and nonfarm diversification activities considered just as non-farm activities[62].

The severity of the environmental degradation coupled with poverty expresses itself in the large proportion of the country's population lacking food security. Many countries in the world face drought, yet not all occurrences of drought end up with famine. The famine in Ethiopia is only an expression of the complex interrelated problems of environmental degradation, poverty and lack of alternatives[63]. Indicated that the combination of several types of products which are both subsistence and income generating, helps farmers to meet their basic needs and minimizes the risk of the production system's total failure[21]. A great economic advantage of the AF is that villagers can harvest something daily for their own consumption, for sale in the market or for raw materials for their home consumption. Increased production and improved handling of vegetables have great potential to enhance the nutrition of the rural and urban poor in the developing countries, as well as to increase their incomes and provide greater opportunities for employment.

Table 3 The role of agroforestry practice as income diversification

Source of income Household	Average total annual income	Contribution
Agroforestry practice	**Total**	**80.2**
Horticulture	5543	25
Khat	8425	38
Coffee	532	2.4
Livestock	1663	7.5
Wood	1441	6.5
Fruit	177	0.8
Non Agroforestry practice	**Total**	**19.8**
Vegetable and Khat trading	1663	7.5
Petty trading	111	5
Labour	776	3.5
Firewood and Charcoal	44	2
Remittance	399	1.8

Ethiopian home gardens AF has two-fold functions: some products are mainly for home consumption, while others generate income generation. Consequently, they represent an important foundation for rural livelihoods, economic earnings, floristic richness and the application of local knowledge to the farming, processing and use of plants, animals and

products[44]. Farmers have adopted intensive production system involving intercropping of several crops on the same plot and multiple cropping whereby different crops were grown on the same plot during different seasons of the year. As shown in Table 3, about 38 and 25 % of the farmers earn their livelihoods from khat, and horticulture production, respectively. Due to limited grazing area, only 7.5 % of the respondents depend on livestock production, which was major source of income following crop production. Firewood collection for sale as a livelihood strategy the livelihood diversification model incorporates the situation of farmhouse hold income diversification activities towards participating in on-farm, nonfarm and off-farm livelihood diversification activities. The living standard of household was dependent largely on household's income. Improvement in existing AF practices was mentioned to bring prosperity in their lives.

Contribution of AF for household income. As can be seen from the table below half of the respondents (50 %) believe AF is increasing their income by diversifying. But still some consider the involvement and productivity of AF activity to income diversification of the family has been decreasing from time to time mainly because the productivity of the land is decreasing there by land is fragmented when it is re distributed to children from the central family. Some of the respondents are not clear with whether change is there or not and they hope the change is not seen significantly yet.

Table 4 Contribution of agroforestry for household income

No	Contribution of Agroforestry systems to the income of the family	No of respondents	Percentage
1	Has been increasing significantly	16	50
2	Decreasing from time to time	7	21.5
3	Not significant change	19	28.5
	Total	32	100

Factors that affect adoption of AF practice in Ethiopia. Similar to any other new technologies, AF adoption is a complicated process that may be influenced by a number of factors, such as socioeconomic characteristics of farmers, access to and level of resources, provision of extension, infrastructure and market, and other institutional factors. Farm level studies can provide insights into key social and economic factors affecting farmer use and management of AF practices and their effects on household resource base. AF systems, however, can often be more complex than existing crop and other farming practices[64]. Thus there is the need to isolate factors that might specifically affect the adoption of AF technologies. This is even more important because sometimes where trees are especially scarce, rural people may be unwilling to grow them. It is unlikely that the reason for this is ignorance of the benefits of trees or of the technologies used in cultivating them, it is far more likely that there is other real constrains[65].

Conclusion

The importance of agroforestry in providing fuel wood to farmers in the present was shown that the best alternative to produce wood products and to conserve natural resources. AF plays a significant role in reducing pressure on the natural forests and shrub lands by providing fuel and construction wood as well as other forest products. Additionally, agroforestry practices were contributing to ecological benefits, such as woody plant species conservation, carbon sequestration soil nutrient improvement and reducing pressure on natural forest through provision of wood and non-wood products. Incomes obtained

from agroforestry products are not as much as from agricultural crops and livestock keeping because of few trees established, narrow range of alternative tree species and poor management in some agroforestry practices. AF were the major sources of fuel wood and other wood products, mainly generated from small scale woodlots, boundary planting and scattered trees included poles, fuel wood and timber. Therefore, agroforestry was high contribution for reducing deforestation by filling energy demand for the livelihood of household. The review focused mainly on the contribution of AF for reducing deforestation and improving livelihood. Therefore, based on this review the following recommendation are suggested. i) Concerted effort required on scaling up of best and management of AF practices for more household income diversification. ii) Creating awareness at the grass roots level about wise utilization of the woody species in the area was crucial in order to prevent the loss of valuable tree species. iii) The government and other stakeholders should promote tree farming as AF practice in the area so as to prevent deforestation and land degradation in search of fire wood and construction poles from nearby natural forest or bush land vegetation. iv) The governmental and nongovernmental organizations should promote different AF practices to conserve indigenous woody species. v) Further study is required on innovative AF practices which can improve the livelihood of households. vi) There is a need to focus on research, training and extension for better adoption of best AF practices so that adaptive capacity of smallholder farmers could be enhanced. vii) To improve the forest cover of the area, realistic community-based forest management strategies should be developed with the participation of the farmers in addition to participating different AF practices. viii) Encouraging an introduction of alternative income sources and livelihood diversification should be given greater attention. ix) The government should give capacity building to encourage people to plant trees as AF practice for own consumption and at the same time to restore the degraded forest area. This will help to empower the farmers in conserving the forest which has been degraded through deforestation.

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Conflicts of interest

No potential conflict of interest

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Ethical considerations

I declared that this manuscript is not submitted for possible publication to other journal publishers. In addition to this, I confirmed that this result is free of research misconduct.

Research limitations

Ethiopian population cannot be considering future outcome of forest clear rather than fulfill want they

needs, so by doing the review Ethiopian have a hint the impact of forest clear in their future event.

Authors' research contribution

Cheru Gelesa Urge and Kasu Hailu Biru conceived of the presented idea, developed the theory and performed the computations, to investigate [a specific aspect] and supervised the findings of this work. All authors discussed on the reviews and contributed to the final manuscript.

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