REVIEW ARTICLE Agricultural Reviews, Volume 41 Issue 3: 216-226 (September 2020)

Opportunities and Challenges of Scaling up Agroforestry Practices in Sub-Saharan Africa: A Review

Tamirat Wato, Mekides Amare

10.18805/ag.R-154

ABSTRACT

Agroforestry is land-use systems and technologies where woody perennials are deliberately used on equivalent land management units as crops and/or animals. Its systems combine tree growing with the assembly of different crops or animals. Hence, developing positive ecological and economic interactions between components, agroforestry systems aim to produce a variety of environmental, economic and social advantages to farming communities. It plays a major role in soil conservation and global climate change mitigation particularly due to its tree component. Trees control soil degradation through their roots and accumulate greenhouse emission (GHG) in their biomass. What is more, it conjointly helps in global climate change adaptation. It's a long-time undeniable fact that despite our gift effort at global climate change mitigation (GHG reduction), there is an additional pressing ought to address the impact of global climate change (adaptation). Peoples ought to be acutely aware regarding the scope and advantages of agroforestry and that they ought to participate in the implementation and development of agroforestry within the country. Thus, this paper reviews different analysis findings on the opportunities and challenges for scaling up agroforestry practices. Therefore, the agroforestry system is economically and ecologically sound practices with an improvement of overall farm productivity, soil enrichment through litterfall, maintaining environmental services like international global climate change mitigation (carbon sequestration), phytoremediation, watershed protection and biodiversity conservation.

Key words: Agroforestry, Climate change, Phytoremediation, Soil conservation.

Agriculture within the 21st century faces multiple challenges: it's to provide additional food and fiber to feed a growing population with a smaller rural working class, additional feedstocks for (Silvana *et al.,* 2016) most likely large bioenergy market, contribute to overall development at intervals the many agriculture dependent developing countries, adopt a lot of economical and property production methods and adapt to climate (FAO, 2016; Tamirat, 2019). Endemic knowledge-based agriculture depends on low input technologies practiced for hundreds of years, by using natural ideas or models to optimize long-run productivity instead of short-term gains.

The reintegration of endemic technical knowledge into current farming practices to stop the disruption of social relations, which regularly results in rural poverty and famine. Agro-ecology with its core ecological principles paved the method for the emergence of agroforestry as a discipline within the 1970s to provide a mixture of parts that make heterogeneous, profitable and safer land-use systems (Zemede, 2001; USDA, 2017). Adding trees to farms will restore soil fertility, turn out animal feed, facilitate the combination of stock into croplands, secure organic fertilizer within the sort of manure, alleviate the fuelwood shortage, mitigate deforestation and global climate change and especially, improve agricultural yields and incomes, making certain safer keep for peoples (Susila *et al.,* 2012; Srivastavaa *et al.,* 2012).

Agro-forestry may be a new scientific term for a group of an old practice of land management within which trees, crops and animals move within the same house and time (Dover *et al.,* 1987; Dove, 1992; Jean Baptiste, 2013).

Department of Plant Science, College of Agriculture and Natural Resource, Bonga University P.O. Box 334, Bonga, Ethiopia.

Corresponding Author: Tamirat Wato, Department of Plant Science, College of Agriculture and Natural Resource, Bonga University P.O. Box 334, Bonga, Ethiopia.
Email: tamiratwato1@gmail.com

How to cite this article: Tamirat W. and Mekides A. (2020). Opportunities and Challenges of Scaling up Agroforestry Practices in Sub-Saharan Africa: A Review. Agricultural Reviews. 41(3): 216-226.

Submitted: 09-06-2020 **Accepted:** 22-08-2020 **Published:** 11-09-2020

Agroforestry may be a collective name for a land-use system and technologies wherever woody perennial, crops and animals are deliberately used on constant land management or temporal sequence (Lundgren and Raintree, 1982; USDA, 2017). This definition implies that agroforestry ordinarily involves two or additional species of plants/animals, a minimum of one among that is woody perennial perpetually has two or additional outputs, the cycle is over one year and additional complicated in ecologically (structurally and functionally) and economically than the mono-cropping system. Currently given the prevalence of environmental degradation, food insecurity and economic condition within the developing countries, agroforestry is seen because the leading practice to assist innumerable families to address hunger, malnutrition, alleviate economic conditions, enhance food security, solve environmental issues and ecological quandary (Sanchez, 1995; Jean Baptiste, 2013; PDA, 2018).

According to Thomas (1990) cited in Nair (1993) despite the opportunities of agroforestry, there are several

challenges to retard the scaling up of agroforestry practices. These are issues regarding social (demographic factors, land possession, the unavailability of markets, infrastructure), economic (financial incentives, economic benefits) and environmental (soil erosion, water quality, global climate change) constraints are essential to the success of agroforestry programs.

This paper review was attempting to focus on the most important challenges and opportunities scaling up agroforestry practices in Sub-Saharan Africa. Prevailing in depth sorts of literature that are centered on opportunities and challenges in scaling up agroforestry practices and connected documents were reviewed. Additional central sources were books, journals, online materials, totally different reports and different relevant revealed documents. Moreover, Google was conjointly a vital method of carried out to access different connected publications. Finally, materials from the general library of Bonga University in 2018-2020 were reviewed. Different authorities were consulted through personal communication.

History and concepts of agroforestry

According to Divine *et al.* (2015) according that cultivating trees and crops in intimate combination with each other is an ancient apply that farmers have used throughout the globe. Consistent with King (1987) cited in Nair (1993) states that in Europe, it had been the overall custom to a clear-fell degraded forest, burn the slash, cultivate food crops for variable periods on the cleared space and plant or sow trees before, along with, or when sowing crops (Nair, 1993; Srivastavaa, *et al.,* 2012).

In tropical America, a farmer would plant coconut or papaya with a lower layer of bananas or citrus, a woody plant layer of the low or angiospermous tree, annuals of various stature like maize (Nair, 1993) and at last a spreading ground cowl like squash. Such an intimate mixture of assorted plants, every with a unique structure, imitated the bedded configuration of mixed tropical forests (Wilken, 1977) cited in (Nair, 1993). In Asia, the Hanunoo of the Philippines practiced a fancy and somewhat subtle form of “shifting” cultivation (Jean Baptiste, 2013; ASI, 2017). In clearing the forest for agricultural use, they deliberately spared bound trees that, by the tip of the rice-growing season, provided a partial cover of the latest foliage to stop excessive exposure of the soil to the sun (Conklin, 1957; Nair, 1993; PDA, 2018).

Incontinent of southern Nigeria; yams, maize, pumpkins and beans were usually grown along beneath a canopy of scattered trees (Forde, 1937; Srivastavaa *et al.,* 2012). The Yoruba of western Nigeria, who have long practiced an intensive system of blending non-woody, shrub and tree crops, claims that the system may be a suggests that of preserving human energy by creating full use of the restricted house won from the dense forest and maintaining the soil’s fertility, furthermore as combating erosion and nutrient natural process (Ojo, 1966; Sanz *et al.,* 2017).

In Ethiopia, the variety in altitude, climate, soils and different physical features have created a range of agro-ecological zones that bring about to various forest flora and agricultural systems with opportunities for agroforestry in an exceedingly completely different setting (SUAF, 2018). Within the forested areas of Southwest Ethiopia, home gardens are started within the forest that permits year-around production of food, reduces the risk of production failure, reduces the risk of pests and disease, will increase productivity and output flexibility and improves the microclimatic and soil condition (Zemede, 2001; FAO, 2016).

Many factors and developments within the 1970s contributed to the overall acceptance of agroforestry as a system of land management that applies to each farm and forest. These factors enclosed the re-assessment of development policies by the magnetic flux unit, the reexamination of biological science policies by FAO of the United Nation, the reawakening of scientific interest in each intercropping and farming systems, the deteriorating food scenario in several areas of the developing world, the increasing unfold of tropical deforestation and ecological degradation, the energy crisis of the Seventies and sequent worth step-up and absence of fertilizers and also the institution by the international development center of North American country of a project for the identification of tropical biological science analysis priorities (Nair, 1993).

When the thought of agroforestry was given a concrete form in 1975s, it had been outlined as a permanent system of land use that upgrades the overall production of the soil through the permanent or consecutive growing of perennial food crops, principally tree crops and also the use rolled plants, either or not together with animal breeding, management and designing of the system ought to correspond as closely as doable to the cultural pattern of the individuals concerned, whereas on the market labor ought to be used as efficiently as possible (Wassink, 1977; Dumont *et al.,* 2014). Agroforestry is a very important habitat/ category planted a forest that has the potential to supply farmers, communities, associated society at massive with a big range of forest-related product and services and progressively being known as an integrated land use which will directly enhance plant diversity whereas reducing home ground loss and fragmentation (Noble and Dirzo, 1997; PDA, 2018).

Classification of agroforestry systems

The most common set of criteria used to classify agroforestry systems and practices are the structural basis (the composition and arrangement of the components, each spatial and temporal), purposeful basis (the main operate or role of the components), socioeconomic basis (the intensity or scale of management and goals of the system) and ecological basis (the environmental and ecological quality of systems). All agroforestry systems are characterized by three basic elements namely; the woody perennials (trees/shrubs), the herbaceous plants (crops) and also the animals. Supported these three basic components, agroforestry systems may also be classified as agro-silvicultural, silvopastoral and agrosilvopastoral (Nair, 1989;

Kang, 1996; Tolunay *et al.,* 2007). These are: -

(i) Agrosilvicultural Systems - This is an agroforestry system wherever agronomical crops are combined with shrubs/trees on the same unit of land for higher or better-sustained production of annual crops, fodder and wood.

(ii) Silvopastoral Systems - This is an agroforestry system wherever vary crops and/or animals and trees are combined for higher production of grasses and fodder. It plays a vital role in mitigating risks related to climate variability and unsteady costs by providing short-term (forage and/or livestock) and long-run (timber) financial gain sources (Cubbage *et al.,* 2012; Schoeneberger *et al.,* 2012).

(iii) Agrosilvopastoral Systems - This is an agroforestry application during which trees, livestock and crops are combined, maintains and will increase nutrients levels and so enhances soil structure (Ndlovu and Mugabe, 2002). Once animals, crops and trees are properly managed, the result will produce one in every of the foremost property forms of agriculture. A conceptual map showing three various ways to classify the agroforestry system is shown in Fig 3.1.

Types of agroforestry practice

Scattered trees on cropland

The practice of growing and maintenances of scattered trees on cropland has also supported the protection and management of selected matured trees already on the positioning (Rocheleau *et al.,* 1988; Mehari, 2012). Scattered trees on farmlands function food, fuelwood, construction wood, fodder, mulch, raw materials for creating agricultural implements, household utensils; produce employment and financial gain for the farmers (Mehari, 2012).

Improved fallow

Improved tree fallow is outlined as enrichment of a natural fallow with leguminous trees or shrubs planted at high density to boost soil fertility (Badege *et al.,* 2013). The first aim of improved fallow is the promotion of food security through exaggerated soil productivity. Improved fallow consists of planting trees, chiefly legume tree species, to counterpoint the soil among a shorter fundamental measure, compared with natural fallow.

Rotational woodlots

Woodlot refers to a segment of a woodland or forest capable of small-scale production of forest products such as wood fuel and timber. Many woodlots occur as part of a farm or as buffers and undevel-oped land between properties (Badege *et al.,* 2013), such as housing subdivisions, industrial forests, or public properties. Rotational woodlots associate the philosophies of crop production and forest management to supply several products. The technology involves growing trees and crops in three interrelated phases; initial tree establishment, where trees are intercropped with crops; second tree fallow; and third cropping after tree harvests (Nyadzi *et al.*, 2003; Jean Baptiste, 2013; PDA, 2018).

Alley cropping

Alley cropping is that the planting of trees or woody shrubs in two or a lot of sets of single or multiple rows, with agronomic, horticultural, or forage crops cultivated within the rows (USDA, 2017). This agroforestry practice is used to enhance or diversifies farm products, reduce surface water runoff and erosion, improve utilization of nutrients, reduce water and wind erosion, modify the microclimate for improved crop production, improve wildlife habitat and enhance the aesthetics of the area (Badege *et al.,* 2013).

Live fencing, hedges and boundary markers

Live fencing, hedges and boundary markers will function productive and ecologically valuable elements of agroforestry systems (Badege *et al.,* 2013). The most objective of this follow is to provide another supply of money to farmers and to provide improved. Such tree plantings can even indirectly influence the crop-livestock production system by acting as windbreaks and shelterbelts. The hedges are cropped sporadically throughout the crops' growth to supply biomass and enhance soil nutrient standing (Nair, 1989; Jean Baptiste, 2013).

Windbreaks

Windbreaks are strips of trees and/or shrubs planted and maintained to change wind flow and improve microclimate, thereby protective a selected space. Windbreaks have often been reported to enhance yields of the crops grown between the widely spaced tree lines (Jat and Poonia, 2006). On fairly stable soils and for moderately responsive crops like cereals, the commonly adopted distance between windbreaks is 15-25 H (Badege *et al.,* 2013). For forage crops, the spacing of 10-14 H is also even if the extra yield is enough to balance the losses from the reduced crop production space. Dense crowns, stout boles, retention of lower limbs and uniform rates of growth are all characteristics that contribute to making effective windbreaks (Byington, 1990; USDA, 2017).

Home-gardens

According to Fernandes and Nair (1986), home gardens are defined as land-use practices involving deliberate management of multipurpose woody species in intimate association with annual and perennial horticultural crops and invariably, livestock inside the living compound, the entire crop-tree-animal unit being managed by the household labor. It was thought that home gardens arose from shifting cultivations to beat resource constraints and to establish the rights to natural resources by smallholder farmers (Fernandes and Nair, 1986; Abay, 2019). Home gardens play a significant role as a supply of minerals and nutrients (Asfaw and Woldu, 1997). Additionally, the various product offered year-around contribute to food security particularly throughout dry seasons (Galhena *et al.,* 2013). In keeping with Abay (2019) reported that trees within the home garden are usually used for food security, fuelwood, agricultural

improvement, constriction, fodder drugs and financial gain generation. Besides this, it will function models for the planning of improved agroforestry practices (Kumar and Nair, 2004).

Opportunities of agroforestry practice

The opportunities for the applying of agroforestry principles within the developed countries may be separated into ecological, economic and social elements (Lassoie and Buck, 1991; Ndukwe *et al.,* 2017). Agroforestry has each ecological and economic importance to extend the productivity of land and property of the setting in developing countries (Bjorn, 1991). It additionally generates employment by growing crops and promoting the trees and tree-derived products like fruit, latex, resins, nuts, ginseng, timber, berries and medicative products (Leakey, 1999; Ndukwe *et al.,* 2017). During a broader sense, agro-forestry includes a good vary of practices that involve establishing



Fig 1: This photo shows maize alley cropped with fast-growing Eucalyptus hybrids in commercial farms in Brazil. Photo by Laércio Couto, Brazil.

Table 1: Nitrogen added into the soil through biomass incorporation by different fallow species in western Kenya.

Fallow species	Added nitrogen (kg/ha)
Gliricidia sepium	264
Calliandra calothyrsus	644
Non-coppicing	84
Sesbania sesban	305
Tephrosia vogelii	188

Source: Kiwia *et al.*, (2009); Badege *et al.,* (2013).



Fig 2: Live Fence and Hedgerow (http://www.agroforestry.info, 2014).



Fig 3: Shows home garden agroforestry (Badege *et al.,* 2013).

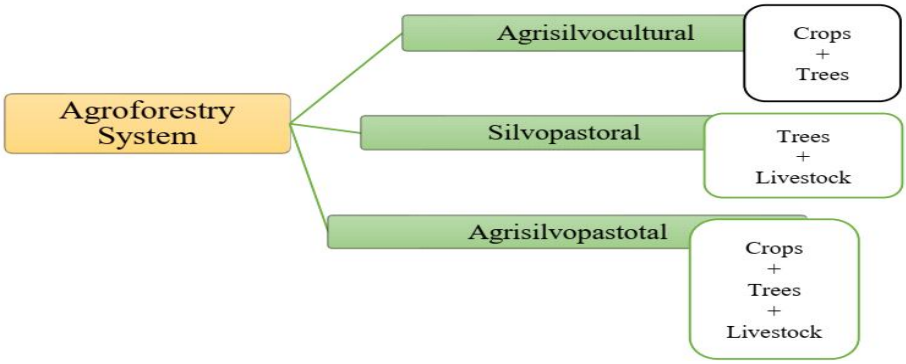

Fig 3.1: Examples of a conceptual map showing three various ways to classify the agroforestry system.

and managing trees by design around or at intervals croplands, pasture lands and stock grounds with the aim of dominant wearing, increase soil fertility, give fuelwood, animal fodder and modify microclimate of the world, developing property agricultural production systems, rising life home ground and rural landscape, mitigating environmental pollution and increasing farm economy through the harvest of tree-based specialty products (Chaturvedi *et al.,* 2009; USDA, 2017). The following points described below are the major opportunities for agroforestry practices. These are: -

Rehabilitation of degraded soil

As reportable by Nair (1993) several factors of development within the 1970s contributed to the final acceptance of agroforestry as a system of land management, that applies to each farm and forest. It is the potential for improvement within the physical, chemical and biological conditions of soils and so the most advantage of agroforestry systems is in their ability to bring favorable changes altogether the three conditions (Maikhuri *et al.,* 1997; Nebiyou *et al.,* 2016).

Soil and water conservation

In several, the world of the planet soil erosion poses economic and environmental issues wherever farming may be a vital and increasing activity like within the tropical uplands. Supporters of agroforestry claim that it is a property land use that may stop or mitigate eating away while not seriously compromising the economic welfare of little farmers in these areas. In many African countries, the introduction of agroforestry practices to rural communities has well improved the farm economy and reduced hunger by up soil fertility and thus increasing crop production (Maikhuri *et al.,* 1997; Garrity, 2004; Ndukwe *et al.,* 2017). Soil fertility is improved or sustained by the addition of vegetative organic matter, i.e. decomposition of bifoliate biomass and roots. Integrated systems of trees and/or shrubs with pasture can reduce runoff by 50 to 80%, sediment transport by 80% and about 50% of total N and total P (Daniels and Gilliam, 1996; Sanz *et al.,* 2017). Additionally, to erosion management, the less controversial biophysical effects of contour hedgerows on soil embody the rise of organic matter and variety, organic process, improvement of physical properties (soil structure, porosity and moisture retention) and increased potency of nutrient use (Nair, 1993; Ndukwe *et al.,* 2017).

Trees have inherent skills to enhance water infiltration, scale back runoff volume and shut down the contaminated runoff and sediment (Rockwood *et al.,* 2004; Khalid and Islam, 2017). In step with Rhoades (1996) reported that exaggerated soil water (4.53% larger than in open) within the crop root zone below agroforestry species canopies. Agroforestry technologies are shown to be effective in reducing pollution from agricultural activities after they are well designed and properly settled within the watershed (Dosskey, 2002).

Soil fertility improvement

In the broad sense, the productivity of the land is its quality for production, the most elements of that are lightweight, water and soil. Tamirat (2019) and Frank Place *et al.,* (2003) outlined soil fertility because of the capability of the soil to support the expansion of plants, on a sustained basis below the given condition of the climate and different relevant properties of the land. Concerning the soil fertility, Eyasu (2002) has reportable that soil fertility contains physical changes, that is that the capability of the soil to produce plants with foothold, wetness and air and chemical conditions that verify the capability of the soil to produce plants with nutrients.

Soil fertility decline results from the combined impact of lowering of soil organic matter, deterioration of physical properties, lowering of nutrient content and in some cases action, which is usually related to the decline in soil fertility (Khalid and Islam, 2017; Tamirat, 2019). Similarly, Udawatta *et al.,* (2002) reportable that maintenance and improvement of soil fertility area unit important for international food security and environmental property. But, if measures do not seem to be taken on time to avoid the loss of soil fertility, it would be a headache to the growing population particularly in developing countries. In line with this, Eyasu (2002) reportable that declining soil fertility in tropical rain-fed agriculture is changing into a heavy downside for a growing range of individuals. Likewise, Kandji *et al*., (2006) reportable that low soil fertility may be a major downside to food production and one amongst the key biophysical constraints to redoubled agricultural growth in Sub-Saharan Africa.

To control the issues of soil fertility, the agroforestry approach would possibly play an optimistic impact. There are differing types of agroforestry practices that improve soil fertility managements like fallows, hedgerows, alley cropping, tree on cropland, plantation on physical structures (Tamirat, 2019). Consistently, Roa *et al.* (1998) and Weil and Brady (2016) reported that herb trees species have shown some potential for soil fertility improvement and conservation since soil fertility improvement is achieved through biomass transfer, long/short term fallows, organic process. Within the same method, Ajayi *et al.* (2008) reported that trees/shrubs improve the physical properties of soils.

Especially, soil aggregation is higher in fields wherever trees are being fully grown and this enhances water infiltration and water holding capability of soils thereby reducing water runoff and eroding. It is conjointly reported by Acharya and Kafle (2009) and Tamirat (2019) that leaf litters in agroforestry systems enrich the soil fertility by providing organic matters, leaves management the speed of the raindrops and permit them to travel right down to the land surface slowly that helps water to infiltrate into lower a part of the soil surface. Agroforestry systems have a high potential in finding the matter of soil fertility compared to nontree/ shrub-based systems. Systematically, Roa *et al.,* (1998) explicit that the upkeep of soil fertility in Agroforestry

primarily based systems might be achieved through an increase or maintain nutrient standing, increasing soil fauna and flora, higher soil aggregation, lower bulk density, improved soil body, increase water infiltration had compared to the bare soil.

Climate change adaptation and mitigation

Climate change is an increased part concentration of GHG (Greenhouse Gases), which ends up from human-induced deforestation and fuel burning, has led to unprecedented precipitation patterns and has caused droughts and floods in several components of the world, particularly in Africa (Jean-Pascal Van, 2017). Global climate change can affect developing countries additional severely owing to their low capability for adaptation (IPCC, 2001; Ndukwe *et al.,* 2017). Moreover, it is a further threat that may affect a country's ability to fulfill pressing rural development demands as well as the advance of food security, financial condition reduction, associated provision of an adequate commonplace of living for growing populations (Louis, 2011; Sanz *et al.,* 2017). Agro-forestry systems have sensible potential to be climate and living good practices (Verchot *et al.,* 2007; Raj, 2016). Considering its wide pertinence, agroforestry encompasses a high potential to mitigate global climate change through carbon sequestration in soil and biomass (IPCC, 2000). Consistent with Vlek *et al.,* (2004) incontestable the challenge of utilizing non-cultivated lands for carbon comes incontinent, suggesting that any program in continent planning to put aside land for the aim of sequestering carbon can run into ethical conflict with the necessity to extend food security (Badege *et al.,* 2013; Ndukwe *et al.,* 2017).

Agro-forestry has importance as a carbon sequestration strategy owing to the carbon storage potential in its multiple plant species and soil further as its pertinence in agricultural lands. For carbon sequestration, the steps might embrace conversion, restoration and rehabilitation of degraded land and wetlands, improved tree management observe to extend growth rates and implementation of agroforestry practices on agriculture pasture land (Chaturvedi *et al.,* 2009; Raj, 2016). Additionally, for carbon sequestration, it is going to be conservation of biomass and soil carbon in existing sinks, improved potency of wood process, hearth protection and simpler use of burning in each forest and agricultural systems and for the carbon substitution increase use of biofuel and increase conversion of wood biomass into the sturdy wood product to be used in situ of energy-intensive materials (Torquebiau, 2013; Ndukwe *et al.,* 2017). The agroforestry system is primarily designed for carbon sequestration, presents a novel chance to extend carbon stocks within the terrestrial region (Table 2).

Socio-economic and employment

Agro-forestry is exclusive in several respects, each as a science and as a follow. One such side is its indivisible mixture of biophysical principles and social objectives. This is often notably apparent once agroforestry is viewed from the event perspective, with special stress on tree-people relationships (Nair, 1993; Ganesamoorthi *et al.,* 2003; USDA, 2017). In different words, the agricultural poor is normally thought about because the primary beneficiaries of agroforestry; consequently, agroforestry technologies square measure expected to be particularly relevant and applicable to small-scale land-users with low capital and energy requirements and to yield product and advantages directed to immediate human wants instead of industrial benefits. Therefore, social acceptableness could be a way more necessary to live of success for agroforestry technologies than for commercially-oriented, high-input agricultural and biology technologies (Chaturvedi *et al.,* 2009; Bijarpas *et al.,* 2015).

Likewise, Dhyani *et al.* (2003) have highlighted the role of agroforestry product and environmental services to satisfy the subsistence desires of low-income households and providing a platform for the larger and sustained resource of society. Forest farming provides possibilities to provide short financial gain from prevailing woodlots, with the smallest amount of capital investment. In general, the social edges of agroforestry are improved in food security, rural diversification and community stability, land use coming up with a tool, choices to accommodate multiple uses and buffer zone within the rural-urban and transition from a protected space to production.

Agroforestry will give an additional numerous farm economy and stimulate the complete rural economy, resulting

Table 2: Potential carbon storage for agroforestry system in different eco-regions of the World (Dixon *et al.,* 2004; Verchot *et al.,* 2007).

	Eco-region	System	Mg C ha^{-1}
Africa	Humid tropical high	Agrosilvicultural	29-53
South Africa	Humid tropical low	Agrosilvicultural	39-102[a]
	Dry lowlands		39-195
Southeast Asia	Humid tropical	Agrosilvicultural	12-228
	Dry lowlands		68-81
Australia	Humid tropical low	Silvopastoral	28-51
North America	Humid tropical high	Silvopastoral	133-154
	Humid tropical low	Silvopastoral	104-198
	Dry lowlands	Silvopastoral	90-175
Northern Asia	Humid tropical low	Silvopastoral	15-18

A Carbon Storage Values were Standardized to 50-year rotation.

in additional stable farms and communities in terms of financial gain and employment generation (Chaturvedi *et al.,* 2009; Hamidian *et al.,* 2011). Economic impacts of agroforestry include redoubled financial gain opportunities, redoubled economic stability, scale back price for establishing plantation, redoubled ability to manage for sustained yield, diversification, cash flow, increase the worth of output during a given space of land, scale back the incidence of total failure and productive use of underutilized land, labor and capital (Chaturvedi *et al.,* 2009; Bijarpas *et al.,* 2015).

Food security and livestock feed production

Adoption of agroforestry depends on several management goals, drivers and discourse factors. In most cases, assets related to ecosystem services and food security are the main motivating factors in agroforestry adoption (DeSouza *et al.*, 2012; Skole *et al.,* 2013; Mbow *et al.,* 2013). Solving the issues of food and nutritionary security needs among different interventions a variety of interconnected agricultural approaches, as well as enhancements in staple crop productivity and therefore the cultivation of a wider range of edible plants that provide fruits, nuts, vegetables, *etc*., for additional varied diets (Frison *et al.,* 2011). Agro-forestry has a crucial role in increasing the yields of vegetables that with fruit, offer varied and nutritionally balanced diets instead of calories alone, providing shade and support for crops that require it, supporting animal production and improving soil fertility (Susila *et al.,* 2012).

Agro-forestry trees offer necessary ecosystem services as well as soil, spring, stream and watershed protection; animal and plant biodiversity conservation and carbon sequestration and storage, all of that ultimately affect food and nutritionary security (Garrity, 2004; Dawson *et al.,* 2014). As agroforestry is that the integration of trees with annual crop cultivation, livestock production will increase farm productivity once the assorted components occupy complementary niches and their associations are managed effectively (Steffan Dewenter *et al.,* 2007; Dawson *et al.,* 2014).

Generally, agroforestry offers several opportunities to govern the temporal arrangement of litter decay and nutrient unleash. This could be achieved through choosing tree species with differing rates of litter decomposition, dominant the temporal arrangement of the addition of pruning to the soil, through adjusting the temporal arrangement of pruning, tree cutting or conveyance of plant residues from external sources, pretreatment, the addition of recent materials or composing and dominant manner of addition that is placed on the bottom surface or plowed into the soil (Chaturvedi *et al.,* 2009; Dawson *et al.,* 2014).

Challenges of agroforestry practice

According to Thomas (1990) argue that a serious constraint is concerned in relevance social (demographic factors, land possession, the availableness of markets, infrastructure), economic (financial incentives, economic benefits) and environmental (soil erosion, water quality, global climate change) constraints are essential to the success of agroforestry programs. Consistent with Nath *et al.,* (2012) reportable that a number of the technical obstacles that limit the fast enlargement of agroforestry are the lack of knowledge regarding the planning and management techniques, choice and domestication of potential tree species, management guidelines, lack of attention given to tree products and services in information assortment, policy constraints and marketing (Kiyani *et al.,* 2017). The basic constraints affecting the agroforestry practices are as follow. These are: -

Unsecure land tenure system

Unsecured or ambiguous land tenure, lack of land use management is common in developing countries, leads to confusion regarding land delineation and rights. If people do not have title to land, there is a perception that there is no point in finance in trees, which may take a long time for benefits to be accomplished. It influences farmers' selections by influencing the look horizon of a farmer. It is expected that farmers that feel secured (sure to inherit land they cultivate to their descendants) build the choice to take a position in future investment (Osemebo, 1987; Rioux, 2011; Holland *et al.,* 2014; Kiyani *et al.,* 2017).

Labor

Cultivation is often done with family labor and also the labor shortage is commonly a reason why agroforestry practices do not seem to be adopted (Angelsen and Kaimowitz, 2004; Weil and Brady, 2016). Most agroforestry innovations demand changes within the labor practices of the farming system into that they are introduced. Moreover, labor necessities are scrutinized by rural individuals before they decide whether or not or to not adopt replacement agroforestry follow (Hoskins, 1987; Rioux, 2011). In line with Hoekstra (1990) reportable that the value of production is going to be increased significantly if extra labor should be employed. Though these extra labor prices are going to be offset by extra advantages, the immediate want for added labor might generally be a deterrence to the scaling up of agroforestry practice (Kang *et al.,* 1990; Weil and Brady, 2016). It ought to be noted that labor intensity is one among the principal's determinative factors in Raintree and Warner's (1986), glorious analysis of intensification of land use from traditional shifting cultivation to intensive high-rise agroforestry practices.

Lack of available marketability of products

The information has indicated that access to markets and raw materials and structure and management skills are among the main constraints to the expansion of those enterprises (FAO, 2016). The choice of appropriate market infrastructure will increase the provision of essential raw materials. Another constraint in delivering tree product to markets for several tree product, markets are poorly structured and coordinated (Roshetko *et al.,* 2007; Weil and Brady, 2016). This ends up in low and unstable returns to farmers and high prices for buyers of tree foods that limit

their consumption. Issues typically cited by producers embrace the absence of a negotiation system, poor transport infrastructure and also the involvement of multiple intermediaries within the supply chain, all of that act to reduce farm prices. Traders additionally face several issues, like poor roads, corrupt officers and also the high value of collection from geographically scattered producers.

Short-term thinking

Unimproved access to markets might encourage farmers to follow unsustainable land management for gaining short profits. The more farmers sell products from their farms, the more severe the soil nutrient depletion becomes occurred. the lack of knowledge in tree seed plant management; pest and disease control; adequate seeds and germplasm provide is another constraint to agroforestry follow (Nkonya *et al.,* 2004; Rioux, 2011). Additionally, the shortage of awareness by farmers within the environmental benefits of trees and misconceptions regarding trees like the worry of trees shade negatively affecting crops and fruit trees (Kiyani *et al.,* 2017).

Lack of resources

Farmers are less likely to worry about soil fertility using manure on distant farm lots and a lot of seemingly to use slash-and-burn for land preparation, which ends up in increased nutrient loss and erosion (Weil and Brady, 2016). Inadequate access to capital and credit is usually considered as a serious constraint for increasing household production and financial gain to invest in additional economical land use. For any improvement of the farming practices, the essential public product funded by the state, like education, health care, agricultural research and extension and also the maintenance of rural roads ought to be in place (Hazell *et al.,* 2007; Jones, 2015; Weil and Brady, 2016).

CONCLUSION

Climate change and soil degradation are the two commonest vital global factors that face all living organisms together with humans and disturbance of natural ecosystems, agriculture and well-being of the individuals. Throughout this case, agroforestry system as a sturdy farming practice addressing food security issues by creating foods to individuals' feeds to animals, management eroding, mitigate adverse effects of global climate change by enhancing environmental quality, face up to economic viability and improve quality of life. Therefore, agroforestry practices and systems comprise numerous models in several regions worldwide, that plays a fascinating role to regulate the negative impact of global climate change and soil degradation by increasing tree-crop diversification that leads to a lot of carbon storage (carbon sequestration) and rehabilitation of degraded soil capability than alone cultivation of solitary crops.

REFERENCES

Abay, B. (2019). Opportunities and Challenges of adopting Home garden Agroforestry Practices in Ethiopia: A Review. Agri Res and Tech: Open Access J. 20(3): 556128. DOI: 10.19080/ARTOAJ.2019.20.556128.

Acharya, A.K. and Kafle, N. (2009). Land degradation issues in Nepal and its management through agroforestry. The Journal of Agriculture and Environment. 140: 230-240.

Ajayi, O.C., Akinnifesi, F.K Sileshi. G., Chakeredza, S., Mgomba, S, Nikkei and Chineke, T. (2008). Local solutions to global problems: the potential of agroforestry for climate change adaptation and mitigation in southern Africa, ICRAF, Nairobi, Kenya.

Angelsen, A., Kaimowitz, D. (2004). Is Agroforestry Likely to Reduce Deforestation? In: Agroforestry and Biodiversity Conservation in Tropical Landscape. [Schroth, G (ed.)], Island Press. ISBN: 1559633573.

Asfaw, Z. and Woldu, Z. (1997). Crop associations of home-gardens in Welayta and Gurage in southern Ethiopia. Sinet, An Ethiopian Journal of Science. 20(1): 1-12.

ASI. (2017). Agricultural Situation in India. P. Agri. 21-07.

Badege, Bishaw and Neufeldt, Henry and Mowo, Jeremias and Abdelkadir, Abdu and Muriuki, Jonathan and Dalle, Gemedo and Assefa, Tewodros and Guillozet, Kathleen and Habtemariam, Kassa and Dawson, Ian and Luedeling, Eike and Mbow, Cheikh. (2013). Farmers' Strategies for Adapting to and Mitigating Climate Variability and Change through Agroforestry in Ethiopia and Kenya.

Bijarpas, M.M., Rostami, T., Shahraji, S., Limaei, M. (2015). Socioeconomic evaluation of agroforestry systems (Case study: Northern Iran). Journal of Forest Science. 61(11): 478-484. Doi: 10.17221/30/2015-JFS.

Bjorn, S. (1991). Agroforestry Today. ICRAF, Nairobi. Kenya. 3(3): 120-130.

Byington, E.K. (1990). Agroforestry in the temperate zone. In: *Agroforestry Classification and Management,* [MacDicken, K.G. and Vergara, N.T. (eds.)], John Wiley and Sons, New York, USA. pp. 228-289.

Chaturvedi, A., Kumar, P.G. and Hate, S. (2009). Community-based forest management and its impact on vegetation: a case study. I Forest 2: 93-98 [online: 2009-06-10] URL: http:// www.sisef.it/iforest/show.php? id=490.

Conklin, H.C. (1957). Hununoo agriculture. FAO Forestry Development Paper No. 12. FAO, Rome, Italy.

Cubbage, F., Glenn, V., Mueller, J.P., Robinson, D., Myers, R., Luginbuhl, J.M. and Myers, R. (2012). Early tree growth, crop yields and estimated returns for an agroforestry trial in Goldsboro, NC. Agroforestry Systems: DOI: 10.1007/ s10457-012-9481-0.

Daniels, R.B. and Gilliam, J.W. (1996). Sediment and chemical load reduction by grass and riparian filters. Soil Science Society of America Journal. 60: 246-251.

Dawson, L. and Carsan, Sammy and Franzel, Steven and Kindt, Roeland and Breugel, Paulo and Graudal, Lars and Lillesø, Jens-Peter Barnekow and Orwa, Caleb and Jamnadass, Ramni. (2014). Agroforestry, livestock, fodder production and climate change adaptation and mitigation in East Africa: issues and options. ICRAF Working Paper No. 178. 10.5716/WP14050.

DeSouza, H.N., DeGoede, R.G.M., Brussaard, L., Cardoso, I.M., Duarte, E.M.G., Fernandes, R.B.A., Gomes, L.C., Pulleman, M.M. (2012). Protective shade, tree diversity and soil

properties in coffee agroforestry systems in the Atlantic Rainforest biome. Agric. Ecosyst. Environ. 146: 179-196.

Dhyani, S.K., Sharda, V.N. and Sharma, A.R. (2003). Agroforestry for water resources conservation: issues, challenges and strategies, In: Agroforestry: Potentials and Opportunities. [(eds) Pathak PS and Newaj, Ram] Jodhpur, India: Agribios.

Divine, Odame Appiah, Patrick Nyarko. (2015). Smallholder Farmers and Agroforestry Land Use Optimization in Forest Fringed Communities in Ghana. International Journal of Scientific Research in Environmental Sciences. 3(12): 0420-0430. DOI: 10.12983/ijsres-2015-p0420-0430.

Dixon, R.K., James, A. Perry, Elizabeth, L. Vanderklein, Francois, H. (2004). The vulnerability of forest resources to global climate change: a case study of Cameroon and Ghana.

Dosskey, M. (2002). Setting Priorities for Research on Pollution Reduction Functions of Agricultural Buffers. Environmental Management. 30: 641-50. DOI:10.1007/s00267-002-2755-y.

Dove, M.R. (1992). Foresters' beliefs about farmers: a priority for social science research in social forestry. Agroforestry Systems. 17: 13-41.

Dover, M.J. and Talbot, L.M. (1987). To Feed the Earth: Agroecology for Sustainable Development. World Resources Institute.

Dumont, S., E., Gnahoua, G.M., Ohouo, L. *et al.,* (2014). Farmers in Côte d'Ivoire value integrating tree diversity in cocoa for the provision of ecosystem services. Agroforest Syst. 88: 1047-1066. https://doi.org/10.1007/s10457-014-9679-4.

Eyasu, E. (2002). Farmers' Perceptions of Soil Fertility Change and Management, SOS SAHEL and Institute for Sustainable Development, Doctoral Thesis, Addis Ababa, Ethiopia and 252 p.

Fernandes, E.C.M. and Nair, P.K.R. (1986). An evaluation of the structure and function of tropical home gardens. Agricultural Systems. 21: 279-310.

Food and Agricultural Organization (FAO). (2016). *State of the World's Forests. Forests and Agriculture: Land-use Challenges and Opportunities.* Rome.

Food and Agriculture Organization of the United Nation (FAO). (2016). Climate Change, Agriculture and Food Security. Rome.

Forde, D.C. (1937). Land and labor in a cross-river village. Geographical Journal. 90(1): 24-47.

Frank Place, Michelle Adato, Paul Hebinck and Mary Omosa. (2003). The Impact of Agroforestry-Based soil fertility Replenishment Practices on the poor in Western Kenya.

Frison, E.A., Cherfas, J. and Hodgkin, T. (2011). Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security. Sustainability. 3: 238-253.

Galhena, H.D., Freed, R., Maredia, K.M., Johnson-Welch, C., Alemu, B., *et al.* (2013). Home gardens: a promising approach to enhance household food security and wellbeing. Agriculture and Food Security. 2(1): 8. https://doi.org/10.1186/2048-7010-2-8

Ganesamoorthi, S., N.R. Gangadharappa and Shivamurthy, M. (2003). Agroforestry - a viable alternative for social, economic and ecological sustainability. The XII World Forestry Congress. Quebec City, Canada.

Garrity, D. (2004). Agroforestry and the achievement of Millennium Development Goals. Agroforest. Sys. 61: 5-17.

Hamidian, Ali and Zehtabyan, Gholamreza and Khosravi, Hassan. (2011). Socio-Economic Benefits of Agroforestry for 1st National Conference of New Approaches in Natural Resources Sustainable Management.

Hazell, Peter and Poulton, Colin and Wiggins, Steve and Dorward andrew. (2007). The Future of Small Farms for Poverty Reduction and Growth. *International Food Policy Research Institute.*

Hoekstra, D. (1990). Economics of agroforestry. In: *Agroforestry Classification and Management,* [MacDicken, K. and Vergara, N. (eds.)]. John Wiley and Sons, New York, USA. pp. 310-331.

Holland, M.B., Free de Koning, M. Morales, L. Naughton-Treves, Brian, E., Robinson and L. Suárez. (2014). Complex Tenure and Deforestation: Implications for Conservation Incentives in the Ecuadorian Amazon. World Development. 55(C): 21-36.

Hoskins, M.W. (1987). Agroforestry and social milieu. In: *Agroforestry: A Decade of Development,* [Steppler, H.A. and Nair, P.K.R. (eds.)], ICRAF, Nairobi, Kenya. pp. 191-203.

Intergovernmental Panel on Climate Change (IPCC). (2000). Summary for Policymakers: The Science of Climate Change. Intergovernmental Panel on Climate Change. IPCC Working Group I, 26 Feb.

Intergovernmental Panel on Climate Change (IPCC). (2001). Climate Change: The Scientific Basis Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, New York.

Jat, B.L. and Poonia, T.C. (2006). Research on Agroforestry-A review. Agric. Rev. 27(2): 103-112.

Jean Baptiste, F. (2013). Agroforestry Systems and Food Security in the Sahel: the case of Toukar, Senegal.

Jean-Pascal Van, Y. (2017). Climate Change: Challenges and Opportunities for International Shipping. [(eds.) Jean-Pascal van Ypersele], International Maritime Organization, London.

Jones, M. (2015). 8 ways Africa can raise farm productivity and boost growth. The World Economic Forum. Africa Competitiveness Report.

Kandji, S.T., Verchot, L. and Mackensen, J. (2006). Climate Change Climate and Variability in Southern Africa: Impacts and Adaptation in the Agricultural Sector, ICRAF, Nairobi, Kenya.

Kang, B.T. (1996). Sustainable Agroforestry Systems for the Tropics: Concepts and Examples. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Kang, B.T., Reynolds, L. and Atta-Krah, A.N. (1990). Alley farming. Advances in Agronomy. 43: 315-359.

Khalid, Md. M. and Islam, S.M. (2017). Reclamation of Degraded Land through Agroforestry Introduction in Bangladesh. Journal of Natural Sciences Research. 7(5): 56-62.

King, K.F.S. (1987). The history of agroforestry. In: *Agroforestry: A Decade of Development,* [Steppler, H.A. and Nair, P.K.R. (eds.)], ICRAF, Nairobi, Kenya. pp. 1-11.

Kiwia, A., Imo, M., Jama, B. and Okalebo, R. (2009). Coppicing improved fallows are profitable for maize production in Striga infested soils of Western Kenya. Agroforestry Systems. 76: 455-465.

Kiyani, P., J. Andoh, Y. Lee and Lee, D.K. (2017). Benefits and challenges of agroforestry adoption: a case of Musebeya sector, Nyamagabe District in the southern province of Rwanda. Forest Science and Technology. 13(4): 174-180. DOI: 10.1080/21580103.2017.1392367.

Kumar, B.M, Nair, P.K.R. (2004). The enigma of tropical home gardens. Agroforestry Systems. 61(1-3): 135-152.

Lassoie, J.P. and Buck, L.E. (1991). Agroforestry in North America: New challenges and opportunities for integrated resource management. In: Proceedings of the Second Conference on Agroforestry in North America, [Garrett HE (ed.)] 18 (21), Columbia, MO, USA. pp 1-19.

Leakey, R.R.B. (1999). Potential for novel food products from agroforestry trees. Food Chemistry. 64: 1-14.

Louis, V. and Hergoualc'h, K. (2011). Stocks and fluxes of carbon associated with land-use change in Southeast Asian tropical peatlands: A review. Global Biogeochemist Cycle. DOI. 25. 10.1029/2009GB003718.

Lundgren, B.O. and Raintree, J.B. (1982). Sustained agroforestry. In: Agricultural Research for Development: Potentials and Challenges in Asia. [Nestel, B. (ed.)]. ISNAR. Hague. The Netherlands. 37-49.

Maikhuri, Rakesh and Semwal, R. and Rao, Kottapalli, and Saxena, K. (1997). Agroforestry for the rehabilitation of degraded community lands: A case study in Garhwal Himalaya. International Tree Crops Journal. DOI: 9. 10.1080/01435698.1997.9752964.

Mbow, Ch., Meine, V.N., Eike, L., Henry, N., Peter, A.M. and Godwin, K. (2013). Agroforestry solutions to address food security and climate change challenges in Africa. Current Opinion in Environmental Sustainability. 6: 61-67.

Mehari, T. (2012). Traditional Agroforestry practices, opportunities, threats and research needs in the highlands of Oromia, Central Ethiopia. Communications in Soil Science and Plant Analysis. 2(5): 2251-0044.

Nair, P.K.R. (ed.). (1989). Agroforestry systems in the tropics. Kluwer Academic Publishers, in Cooperation with ICRAF. 664 pages. Journal of Tropical Ecology. 7(1): 84-84. DOI:10.1017/S0266467400005125.

Nair, P.K.R. (1993). An Introduction to Agroforestry, Kluwer Academic Publisher with Cooperation ICRAF, Dordrecht, London.

Nath, A.J. and Das, A.K. (2012). Carbon pool and sequestration potential of village bamboos in agroforestry systems in Northeast India. Tropical Ecology. 53(3): 287-93.

Ndlovu, L.R. and Mugabe, P.H. (2002). Nutrient Cycling in Integrated Plant Animal Systems: Implications for Animal Management Strategies in Smallholder Farming Systems. In: Natural Resources Management in African Agriculture: Understanding and improving current practices, [Christopher B. Barrett, F. Place, and Abdillahi A. Aboud. Editors (ed.)] Wallingford, Oxon, UK: CABI Pub. pp. 251-260.

Ndukwe, O.O., Aba, S.C., Amu, C.J. and Baiyeri, K.P. (2017). The Role of Trees and Plantation Agriculture in Mitigating Global Climate Change. Food Agric. Nutr. Dev. 17(4): 12691-12707. DOI: 10.18697/ajfand.80.15500.

Nebiyou, M. and Muluneh, M. (2016). The Role of Agroforestry for Rehabilitation of Degraded Soil. A Review Paper. Journal of Biology, Agriculture and Healthcare. 6(5): 128-135.

Nkonya, Ephraim and Pender, John and Jagger, Pamela and Serunkuuma, Dick and Kaizzi, Kayuki and Ssali, Henry. (2004). Strategies for Sustainable Land Management and Poverty Reduction in Uganda. Research Report of the International Food Policy Research Institute.

Noble, I.R. and Dirzo, R. (1997). Forest as a human-dominated ecosystem. Science. 277: 522-525.

Nyadzi, G.I., Otsyina, R.M., Banzi, F.M., Bakengesa S.S., Gama, B.M., Mbwambo L. and Asenga, D. (2003). Rotational woodlot technology in northwestern Tanzania: Tree species and crop performance. Agroforest. Sys. 59: 253-263.

Ojo, G.J.A. (1966). *Yoruba Culture.* The University of Ife and London Press, London, UK.

Osemebo, G.J. (1987). Smallholder farmers and forestry development: A study of rural land-use in Bendel, Nigeria. Agricultural Systems. 24: 31-51.

Public Disclosure Authorized (PDA). (2018). Mozambique Country Forest Note.

Raintree, J.B. and Warner, K. (1986). Agroforestry pathways for the intensification of shifting cultivation. Agroforestry Systems. 4: 39-54.

Raj, D.R. (2016). Role of Agroforestry in Climate Change Mitigation. DOI: 10.13140/RG.2.1.4528.2321.

Rhoades, C.C. (1996). Single-tree influences on soil properties in agroforestry: lessons from natural forest and savanna ecosystems. Agricultural Systems. 35: 71-94.

Rioux, J. (2011). Opportunities and Challenges of Promoting Agro--forestry for Climate Change Mitigation: A Case study of the Mitigation of Climate Change in Agriculture (MICCA) Pilot Project in Tanzania. Nature and Faune. 26(2): 63-68.

Roa, M.R., Niang, A., Kwesig, F., Duguma, B., Franzel, S., Jama, B. and Buresh, R.J. (1998). Soil fertility replenishment in Sub-Saharan Africa: new techniques and the spread of their use on farms. Agroforestry Today. 10(2): 3-8.

Rocheleau, D., Weber, F. and Field-Juma, A. (1988). *Agroforestry in Dryland Africa.* ICRAF, Nairobi, Kenya.

Rockwood, D.L., Cardellino, R., Alker, G., Lin, C., Brown, N., Spriggs, T., Tsangaris, S., Isebrands, J., Hall, R., Lange, R. and Nwokike, B. (2004). Fast-growing trees for heavy metal and chlorinated solvent phytoremediation. In: In Situ and On-Site Bioremediation. Proceedings of the Seventh International. [Magar V.S. and Kelley M.E. (eds)], In Situ and On-Site Bioremediation Symposium, Orlando, FL, Paper F-12, Battelle Press, Columbus, OH.

Roshetko, J.M., Lasco, R.D. and Angeles, M.S.D. (2007). Smallholder agroforestry systems for carbon storage. Mitigation and Adaptation Strategies for Global Change. 12: 219-242.

Sanchez, P.A. (1995). Science in Agroforestry. Agroforestry Systems. 30(1 and 2): 5-55.

Sanz, M.J., J. de Vente, J., L. Chotte, M. Bernoux, G. Kust, I. Ruiz, M. Almagro, J.A. Alloza, R. Vallejo, V. Castillo, A. Hebel and M. Akhtar-Schuster. (2017). Sustainable Land Management contribution to successful land-based climate change adaptation and mitigation. A Report of the Science-Policy Interface. United Nations Convention to Combat Desertification (UNCCD), Bonn, Germany.

Schoeneberger, M., Bentrup, G., Gooijer de, H., Soolanayakanahally, R., Sauer, T., Brandle, J., Zhou, X. and Current, D. (2012). Branching out: Agroforestry as a climate change mitigation

and adaptation tool for agriculture. Journal of Soil and Water Conservation. 67(5):128A-136A.

Silvana, M., Hamid, Bilali, E.L., Mauro, G., Roberto, C. (2016). Towards Sustainable Food Systems: A Holistic, Inter--disciplinary and Systemic Approach. International Journal Agro. For. 1(1). DOI: 10.7251/AGRENG1601103M.

Skole, D.L., Samek J.H., Chomentowski, W., Smalligan, M. (2013). Forests, carbon and the global environment: new directions in research. In Land Use and the Carbon Cycle Advances in Integrated Science, Management and Policy. Edited by Brown DG, Robinson DT, French NHF, Reed BC. USA: Cambridge University Press: 505-522.

Srivastavaa, A.K., Gaisera, T., Cornet, D., Ewert, F. (2012). Estimation of effective fallow availability for the prediction of yam productivity at the regional scale using model-based multiple scenario analysis. Field Crops Research. 131: 32-3.

Steffan-Dewenter, I., M. Kessler, J. Barkmann, Merij, M.B., D. Buchor, S. Erasmi, H. Faust, *et al*., (2007). Tradeoffs between income, biodiversity and ecosystem functioning during tropical rainforest conversion and agroforestry intensi--fication.

SUAF (Scaling Up Agroforestry). (2018). Potential, Challenges and Barriers. A review of environmental, social and economic aspects at the farmer, community and landscape levels. ISBN: 978-91-985041-0-1.

Susila, A.D., Purwoko, B.S., Roshetko J.M., Palada, M.C., Kartika, J.G., Dahlia, L *et al.,* eds. (2012). Vegetable-agroforestry systems in Indonesia. Bangkok: World Association of Soil and Water Conservation; Nairobi: World Agroforestry Centre.

Tamirat, W. (2019). Improvements of Crop Production through Integrated Soil Fertility Management in Ethiopia. Asian Journal of Environment and Ecology. 11(1): 1-11. https:// doi.org/10.9734/ajee/2019/v11i130130

Thomas, G.W. (1990). *Sustainable Agriculture: Timely Thrust for International Development.* Paper presented to the Division of Agriculture, National Association of State Universities and Land-Grant Colleges, Washington, D.C., USA.

Tolunay, A., Korkmaz, M. and Alkan, H. (2007). Definition and Classification of Traditional Agroforestry Practices in the West Mediterranean Region of Turkey. International Journal of Agricultural Research. 2(1): 22-32.

Torquebiau, E. (2013). Agroforestry and Climate Change. FAO Webinar 5 February.

Udawatta, R.P., Krstansky, J.J., Henderson, G.S. and Garrett, H.E. (2002). Agroforestry Practices, Runoff and Nutrient Loss: A Paired Watershed Comparison. J. Environ. Qual. 31: 1214-1225.

United States Department of Agriculture (U.S.D.A). (2017). Agro--forestry: Enhancing Resiliency in U.S. Agricultural Landscapes Under Changing Conditions. https://doi.org/ 10.2737/WO-GTR-96.

Verchot, L.V., Van Noordwijk, M., Kandji, S., Tomich, T., Ong, C., Albrecht, A., Mackensen, J., Bantilan, C., Anupama, K.V. and Palm, C. (2007). Climate change: linking adaptation and mitigation through agroforestry. Mitig. Adapt. Strat. Glob. Change. 12: 901-918.

Vlek, P., Rodr, G., Kuhl I. and Sommer, R. (2004). Energy use and CO_2 production in tropical agriculture and means and strategies for reduction or mitigation. Environment, Development and Sustainability. 6(1): 213-233.

Wassink, J.T. (1977). Agroforestry. Agriculture and Forestry teaming up for the sake of humanity and its natural environment. Koninklijk Instutuut woor de Tropen, Amsterdam, 19p.

Weil, R.R. and Brady, N.C. (2016). Prospects for Global Soil Quality as Affected by Human Activities.In: The Nature and Properties of Soils. [(Eds.) Weil, R]. Edi. 15th, Chapter: 20, Pearson Prentice Hall. pp. 982-1040

Wilken, G.C. (1977). Integration of forest and small-scale farm systems in middle America. Agro- Ecosystems. 3: 291-302.

Zemede, A. (2001). The role of home gardens in the production and conservation of medicinal plants. In: Conservation and Sustainable use of Medicinal plants in Ethiopia. Proceedings of the National Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia. Institute of Biodiversity Conservation and Research, Addis Ababa, Ethiopia. Pp. 76-91.