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Assessment of Carbon Stock Potential and Farmers' Perception on Parkland Agroforestry Practice: The Case of Minjar Shenkora; North Shewa, Ethiopia

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Abstract

The anthropogenic global climate change has negative impacts on various sectors and communities who particularly rely on rain-fed agriculture. Parkland Agroforestry practice can contribute to mitigate and adapt to the forthcoming climate change through carbon sequestration. However, empirical studies on carbon stocks of parklands and perception of the local people on the practices are scarce in different localities. This study assessed carbon stocks of the practice and perception of the community on the practice at Minjar Shenkora woreda. By using two-stage stratified random sampling technique, 110 farmers from 4 kebeles were selected for household surveys to assess farmers' perception of socio-ecological roles of the practice and 8 farms/plots/ of 40 m*40 m sample size were selected from each kebele for the vegetation inventory. Tree species-specific allometric equations were used to determine carbon stock's potential of the practice. Likert scale was also used to analyze the perception of farmers on the practices. The result revealed that, almost all farmers well perceived about parkland Agroforestry practice. The AGC, BGC, SOC and TC have significant variation ($p<0.05$) across kebeles. The mean total carbon stock of Bolo Giorgis, Bolo Slase, Agirat and Korma Agere is 48.87 Mg C ha^{-1}, 58.21 Mg C ha^{-1}, 57.81 Mg C ha^{-1} and 73.71 Mg C ha^{-1}; respectively. On average, carbon stock of the practice in Minjar shenkora was 59.65 Mg C ha^{-1}. The perception and carbon stocks result indicated that, the practice has a large potential to deliver various ecosystem services and opportunities to mitigate the impending climate-changing through carbon sequestration and increasing the resilience of the agricultural system at study area. To enhance the ecosystem services of the practices in a sustainable way: local bylaws should be strengthened to avoid illegal tree cutting and free grazing. Moreover, the effect of plowing by tractor and harvesting of a machine on the growth and regeneration of seedlings need attention.

Keywords: Soil organic carbon; Above-ground biomass carbon; Below-ground carbon

Introduction

The main cause of the current global climate change is the rising levels of greenhouse gases (GHGs) in the atmosphere. These gases trap heat and warm up the Earth's surface and oceans. This warming affects many sectors and communities, especially those who depend on rain-fed agriculture for their livelihoods. Asako (2007) defines global climate change as the change in the average temperature and weather patterns of the Earth over a long period. This change has many negative impacts on the environment and human well-being.

Carbon sequestration: One way to reduce the impact of human-caused global climate change is to capture and store carbon dioxide (CO_2) from the atmosphere. This can be done by using natural ecosystems such as forests and Agroforests, which absorb CO_2 through photosynthesis.

Agroforestry: Agroforestry is a farming system that combines trees and crops or pasture in a beneficial way. It has been practiced for a long time in many countries, including Ethiopia. Agroforestry has many advantages for both production and environment. It also helps to mitigate climate change by sequestering carbon in the trees and soil [1].

Climate change mitigation: Agroforestry is recognized as a climate change mitigation strategy under the Kyoto Protocol, which is an international agreement to reduce greenhouse gas emissions. Agroforestry can help to lower the concentration of CO_2 in the atmosphere by storing it in the biomass and soil organic matter. Agroforestry can also reduce emissions from deforestation and land degradation.

Parkland Systems: Parklands are landscapes where trees are interspersed within cultivated fields or fallow land. They are characterized by the presence of mature trees in farming areas, contributing to biodiversity and ecosystem balance.

Agroforestry benefits: The integration of trees and crops in Agroforestry systems, such as parklands, enhances soil quality, moderates climate, minimizes erosion, and facilitates carbon sequestration.

Tree management: In parklands, trees may originate from natural forests, farmer-initiated regeneration, or deliberate planting. These trees provide various products and environmental services.

Crop and tree interaction: The practice involves managing the spacing of trees and shrubs to optimize the growth of field crops beneath them, taking advantage of the differences between C3 (trees) and C4 (crops and grasses) photosynthetic pathways [2].

This approach to land use supports sustainable agriculture and climate change mitigation efforts.

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What are parklands?: Parklands are a type of Agroforestry system, where farmers grow trees and crops together in the same land. Parklands have many benefits for the environment and the farmers, such as improving soil fertility, reducing erosion, storing carbon, and providing food, fuel, and income.

How do parklands help mitigate climate change?: Parklands help mitigate climate change by sequestering carbon in the biomass and soil of the trees and crops. This reduces the amount of greenhouse gases in the atmosphere that cause global warming. Parklands also help adapt to climate change by increasing the resilience and diversity of the farming systems.

Carbon storage in agroforestry systems: Agroforestry systems (AFSs) are land-use systems that combine trees and crops in a beneficial way. AFSs can store carbon in both the soil and the above-ground parts of the plants. Carbon storage is important for mitigating climate change, as it reduces the amount of greenhouse gases in the atmosphere.

How much carbon is stored in AFSs?: The amount of carbon stored in AFSs varies depending on the type, density, and diversity of the trees and crops, as well as the soil conditions and depth. According to the soil accounts for about 60% of the total carbon stock in AFSs, while the above-ground parts account for about 30%. The estimates of carbon stored in AFSs range from 0.29 to 15.21 Mg ha^{-1} yr.– 1 above-ground and 30 to 300 Mg C ha^{-1} up to 1 m depth in the soil.

How does AFSs affect soil carbon?: Recent studies have shown that AFSs can increase the soil organic carbon content and sequester carbon in deeper soil layers near the trees, compared to treeless systems. This is because the trees provide organic matter, nutrients, and shade to the soil, and their roots enhance the soil structure and water retention. The soil carbon content is also influenced by the species richness and tree density of the AFSs [3].

Carbon stock in vegetation: The amount of carbon stored in plants depends on their above-ground and below-ground biomass. The above-ground biomass (AGB) includes the stems, branches, leaves, and fruits of the plants. The below-ground biomass (BGB) includes the roots and soil organic matter. The AGB and BGB of trees and shrubs are estimated by using different methods and factors. A common method is to assume that 50% of the AGB is carbon, and that the BGB is 25-30% of the AGB, depending on the plant species and the environmental conditions. The total biomass carbon (TBC) is the sum of the AGB and BGB carbon.

Parkland benefits for soil conservation: Parklands are Agroforestry systems that have trees and crops growing together in the same land. Parklands can help prevent soil erosion and runoff by reducing the wind speed and the water flow on the land surface. The farmers who practice parklands say that the trees act as windbreaks and protect their crops from damage. They also say that the lands without trees are more prone to soil erosion and runoff, which can affect their productivity and soil quality.

Understanding above-ground tree biomass and soil organic carbon stocks provide opportunities for better management of the carbon pools. However, more rigorous research results are required for Agroforestry systems to be used in global agendas of carbon sequestration.

Trees on the agricultural landscape are important in enhancing farmers' adaptive capacity and reducing the susceptibility of farming systems to climate change impacts. Farmers perceive the importance of parkland Agroforestry practice for food security, microclimate amelioration, economic benefits, environmental protection, income generation, household energy, household utensils, farmhand tool, cultural values, traditional medicines, and fodder, as found at different corners of the world, primarily in the semi-arid and sub-humid zones of Africa. Additionally, trading of the sequestered carbon is a viable opportunity for economic benefit to Agroforestry practitioners, who are mostly resource-poor farmers in developing countries. Global carbon markets have opened up the possibility of payments to farmers for their contribution to climate change mitigation [4].

Agroforestry systems improve the resilience of smallholder farmers through more efficient water utilization, improved microclimate, enhanced soil productivity and nutrient cycling, control of pests and diseases, improved farm productivity, and diversified and increased farm income while at the same time sequestering carbon. Agroforestry practices may indirectly improve the adaptive capacity of farmers by stabilizing the variability of microclimate.

In Minjar Shenkora woreda (Figure 1), like many parts of Ethiopia, there is a remarkable experience of traditional Agroforestry practices mainly with parkland Agroforestry practice on cultivated land. The parkland Agroforestry in the woreda is composed of Acacia tree species and crops like teff, wheat (Triticum aestivum), and sorghum (Sorghum bicolor) production. Moreover, the woreda is known with its mixed farming system where farmers combined the production of crops and animals (livestock, sheep, and goats).Agroforestry systems and practices contribute to combat different economic and ecological problems. Studies on Agroforestry systems have so far mainly focused on their spatial design, food production, soil fertility management, and system interactions, and little attention has been given to their ecosystem services, such as biodiversity conservation and carbon sequestration [5]. Farmers in different localities perceive the ecological and socio-economic roles of parkland Agroforestry practice differently due to variation in farmer's management experience, knowledge, agro-climatic zone, ecological and socio-economic problems they have faced and the culture they have. Likewise, the carbon stock potential of parklands is different in sites due to variation in agro-climatic factors, in tree species, density and structure of tree species, management

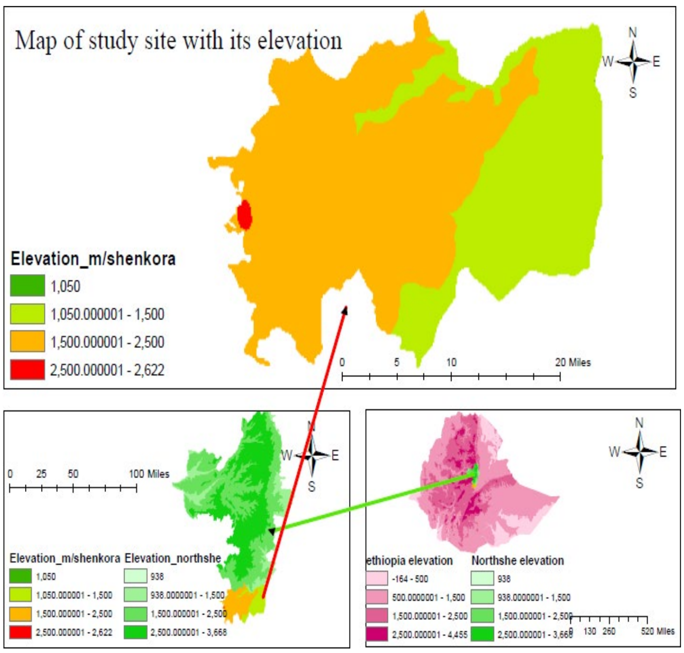

Figure 1: Location map of Minjar Shenkora woreda.

applied to parkland trees, agricultural land management (fertilization, fallowing, cropping of legumes, etc.), topographic factors (aspect, slope, and altitude), soil types, land-use history, etc. The presence of these large sources of variations and confounding factors highlighted that site-specific data is required to understand farmers' perception of ecological and socio-economic roles of parklands and to estimate its carbon stock potentials. On top of that, the potential of the parkland Agroforestry in Minjar Shenkora for climate change mitigation was not investigated. Understanding the context-specific carbon stock of the parkland Agroforestry will help land managers for better management of the carbon pools that are biomass and SOC. Human intervention associated with forest management and silvicultures directly affect C sequestration in modified natural and semi-natural forests. As a result, this study intended to carry out this study on parkland Agroforestry practices at Minjar Shenkora woreda.

The study generated and documented important information on the role of parkland Agroforestry practice in Minjar Shenkora woreda to climate change mitigation through carbon sequestration. This study will contributed to knowledge to the conservation of these unique Agroforestry systems and to the recognition of the ecosystems services they provide to the local communities (food production, and income, soil and water protection, maintenance of soil fertility) and beyond (carbon sequestration and climate change mitigation, and conservation of biodiversity) (Negash, 2013). The sturdy also helps to enhance the perception of farmers about the tree on their farmlands, raises the awareness on ecosystem services of this practice to further, conserve and expand the practice by making experience sharing in other areas. Lastly, this study can be a good source of information for those who are concerned with working for the climate change mitigation program, farmers' perception of parkland Agroforestry practice and natural resource management in the study areas and other similar sites [6].

This study aimed at determining the carbon stock potential of parkland Agroforestry practice in Minjar Shenkora woreda, North Shewa, Ethiopia and to understand and document how the farmers perceive the various ecological benefits of parkland Agroforestry in a view to indicating the climate change mitigation potentials of parklands. The question that addressed in these experiments are:

How much carbon is stored in the parkland Agroforestry practice of the study area? How much carbon is stored in above, below ground and soil carbon pools in the study area? Which tree species have the highest carbon stock potential in the study area? How do farmers perceive the Agroforestry practice implemented in the area? What type of tree management activities do farmers practice in the area?

Materials and Methods

Site description: The study was carried out in Minjar Shenkora Woreda, North Shewa Zone of Amhara Regional State, Ethiopia which is located at about 135 km south-east of Addis Ababa, at 90º 6' and 90º 5' N and 39º 46' and 39º 26' East and has a total area of about 229,463 ha. The administrative town of Minjar Shenkora Woreda is Arerti. The altitude of the study area ranges from 1400-2400 m.a.s.l. Diverse geomorphological features characterize the topography of lands in the woreda. Data from the Woreda agricultural office indicate that plateau or flat plains features (65%), followed by 20% of the land area is mountainous, ravines (10%) and 5% other topographic features.

According to MSDARDO, Minjar Shenkora woreda has different soil types suitable to harvest various kinds of grains. The most dominant soil type in the study area is heavy clay soils known as vertisols especially in flat areas while reddish-brown loam known as cambisol is also common in other slope types [7].

There are also various types of landscapes in Minjar Shenkora woreda. However, plain areas constitute around 65% of the total areas of the locality. Due to its very low degree of steepness, the area has a very great potential for the application of modern agricultural mechanization (Figure 2).

The woreda falls within three major agro-climatic zones, Dega (high altitude), Weyna Dega (Mid altitude) and Kola (low altitude). Meteorological data recorded at Modjo station taken from Addis Ababa National Meteorology Service Agency indicates that the area obtains high rainfall between June to August (Kiremt) and low rainfall in March to May (Belg), and the dry season extends from September to February. The highest mean annual rainfall of the study area within the last ten years was 1028 mm, whereas the lowest mean total was 162.8 mm. According to North Shewa Agricultural and Rural Development Bureau, Minjar Shenkora district has annual average temperature range between 13.210c and 23.020c.

The natural vegetation in the area is degraded and sparsely located only around the periphery of rivers, valleys and steep slope areas which is not suitable for crop cultivation. This vegetation type is Acacia wooded grassland (Ib Friis, 2010). On most of the plain areas on which crop cultivation is dominant, Faidherbia albida, A. tortilis, A. seyal, A. nilotica, Croton macrostachyus, and Ziziphus mauritiana are scattered across with the farm plots, which are the main components of Agroforestry type of agricultural system with agricultural crops. They provide shade for crops and livestock, fuelwood, improve soil fertility and used for the fence.

Based on figures by the Central Statistical Agency (CSA) the woreda has an estimated total population size of 128,741 of whom 66,843 were men and 61,895 women; 12,233 of the population are urban dwellers and the remaining 116,508 live in rural areas (Figure 3).

The majority of people living in Minjar Shenkora woreda belong to the Amhara (93, 78%) ethnic descent, Oromo (3.11%), Argoba (2.65%), and all other ethnic groups constituted 0.46% of the total population. Amharic is a widely spoken language (96.93%), followed by Afaan Oromo (2.79%), and the remaining (0.3%) ones speak other languages Central Statistical Agency (CSA) [8].

The livelihood of most of the population in the woreda is mainly based on agriculture. Annual crops are predominant and rain-fed agriculture is mainly practiced using draught power. Cereals and

Figure 2: Photo of the study area.

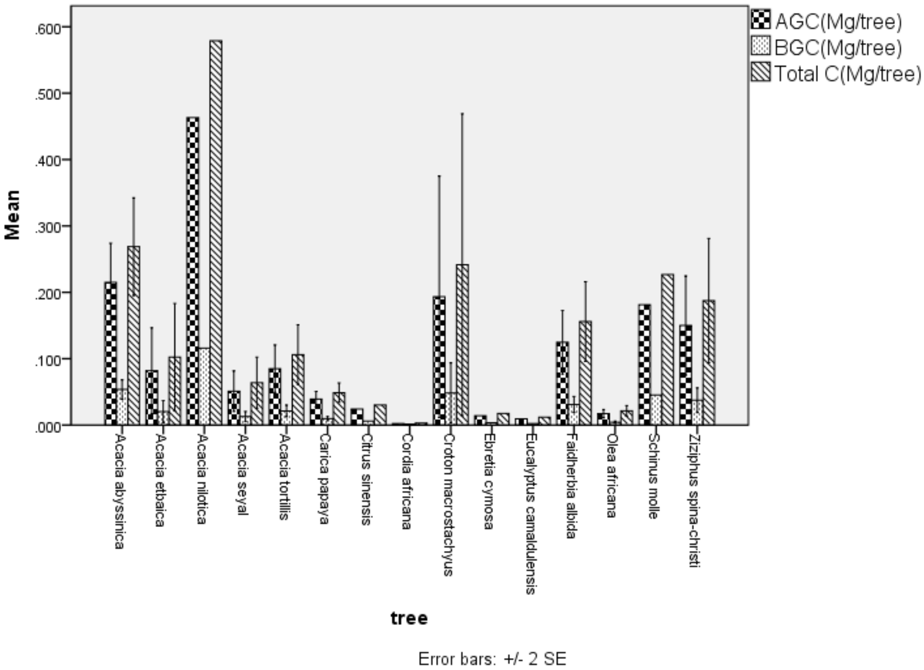

Figure 3: Carbons stock potential of tree species in study areas.

pulses are among the commonly cultivated crops in the area for the purpose of household consumption and income through the sale. These include sorghum (Sorghum bicolor), wheat (Triticum aestivum), teff (Eragrostis teff), barley (Hordeum vulgare), onion (Allium cepa), pea (Pisum sativum), Chickpea (Cicer arietinum) and Horse bean (Vicia faba). Currently, due to the introduction of rainwater harvesting technology through ponds, farmers grow vegetables in small gardens as well as in the fields. According to MSDCO, Onion is very important because of the availability of harvested rainwater that enabled farmers to grow onion seedlings during the dry season making them available for planting at the onset of the rain.

Again, especially in the Kola (low altitude) parts of the woreda, livestock rearing is the other livelihood strategy. Cows, oxen, camels, donkeys, sheep, and goats are the most important livestock breeds of households. Camels and donkeys are important to transport agricultural products and other commodities while oxen are preferred for draught power in the woreda.

Materials: The equipment used for fieldwork should be accurate and durable to withstand the rigors of use under adverse conditions. The type of equipment required depended on the type of measurements. The following materials were used for this study to collect available data meter tape for measuring distances of sample plot, hypsometer to measure height of tree, caliper to measure tree diameter, auger to take soil sample, cloth or paper bags to collect soil sample, core sampler to take soil sample for bulk density and Global Positioning System (GPS) to collect coordinate point of study site.

Sampling methods: The Minjar Shenkora woreda is selected purposively as a study area by considering the extensive presence of parkland Agroforestry practice. A preliminary reconnaissance survey had been conducted to identify the study area. Key informants i.e. development agents, elders and woreda natural resource experts were consulted to identify farmers and study site that contain parklands Agroforestry practice on their lands-based accessibility, resource and time. The word is composed of 27 kebeles out of which parkland Agroforestry practice is found in 21 kebeles. Moreover, the woreda has three agro-ecologic zones: dega with 6 kebeles; weyna dega with 11 kebeles; and kola with 10 kebeles. Based on this information from the woreda office of agriculture, two-stage stratified random sampling technique was used to select the unit of sampling for the study. In the first stage, a total of four kebeles: two kebeles (Bolo Giorgis and Bolo Slase) from weyna dega and two kebeles (Agirat and Korma Ager) from Kola agro-ecologies were selected randomly as specific study areas. In the second stage, by considering the list of farmers who owned farms with parkland Agroforestry practice in the kebeles as a sampling frame, a total of 110 farmers; 24, 33, 27 and 26 were randomly selected from Bolo Giorgis, Bolo Slase, Agirat and Korma Ager, respectively (Table 1). The sample size accounts about 7% of the household and therefore considered adequate to balance reliability and cost. There are different mechanisms to determine the number of samples: the census for small populations, imitating a sample size of similar studies, using published tables, and applying formulas to calculate sample size. Among the listed methods sample size determination using similar studies was employed for the present study [9].

For the carbon stock determination, a total of 32 plots (eight from each kebele) of size 40 m*40 m were randomly selected. Focus group discussion performed with a total of 19 men and 7 women households that are selected purposely from selected kebele to generate more information to the perception of farmers on PLAP.

The plot method was used that involves selecting plots of an appropriate size and number, laying them randomly in the selected strata. Plots can be marked at four corners in conspicuously (for example, by sinking available material below the ground and navigating to plot using a GPS. The plot size chosen was large enough to encompass the diversity of tree species on the smallholdings.

Data Collection Methods

Household survey: When I collected social data by participating local people, I introduce the objective of survey, take care their

Table 1: Sampling frame for perception study: total population in selected kebele and number of households included in the formal survey.

Site (Kebele)	Agro-ecology	Total Households	Number of household practicing Agroforestry	Number of the household included in the survey
Bolo Giorgis	Midland (weyna dega)	1027	265	24
Bolo Slase	Midland (weyna dega)	868	560	33
Agirat	Lowland (Kolla)	612	398	27
Korma Ager	Lowland (Kolla)	1023	383	26
Total				**110**

willingness for the asking the question. The prepared question is free from culture, color, religious and sex. When asking the question if the participant not willingness, I jump the question. In Ethiopia, there are not institute for giving human participant ethics documents like this works.

A household survey was conducted since 12/02/2019-25/03/2019 to collect data on the perception of a farmer about the parkland Agroforestry practice. Primary data was collected through the use of structured questionnaires comprising closed- and open-ended questions. The questionnaires were tested and revised as appropriate before final implementation. The survey covered four domains, i.e., description of the household, characterization of the farming system, the farmer's perception of farming practice and tree management activity. The collected data mainly focused on: tree management practice, uses, the opportunity and challenges of scattered trees on farmland in the study area. The sources of secondary data were official written documents including annual reports and different published documents. All the collected data were entered into the computer and ready to make an analysis.

Vegetation inventory: Carbon stock of woody species (dead trees, live trees), below-ground biomass (stumps plus coarse roots; >2 cm diameter and fine roots) and soil organic carbon were estimated. The farmland of sample households was used as a sample plot for inventory. Accordingly, woody species inventory was carried out on the farmlands of selected households located in the kebeles. In present study, woody species data were collected from 40 m × 40 m sample size quadrates, but the quadrat size in the study of the mentioned author is 50 m*100 m because of low density of trees on farmland in the study area, However; in our case as the density of trees on farmland is relatively high, a sample plot of 40 m*40 m was considered as an optimum plot size. The collected data were the name of species, tree diameter at breast height, tree height, tree diameter at stump height, number of trees and shrubs per plot, soil sample, and location of the plot using GPS. All the woody species in each sample plot ≥ 5 cm DBH (diameter at breast height) were measured because below these DBH there are insignificant amount of biomass. At every sampling point, a number of individuals per plot, DBH, height, and DSH of live trees were measured and recorded by using a measuring tape, caliper, and hypsometer.

At every sampling point from the selected study site, 20 m × 20 m square subplots were taken for soil sampling from each corner and at the center of the plot. The most common depth for sampling is 30 cm but sometimes SOC is sampled to up to 1 m. The importance of sampling beyond the surface soil cannot be overemphasized while studying tree-based systems such as Agroforestry, not only because tree roots extend to deeper soil horizons, but also because of the role of subsoil in long-term stabilization of C. From the top (0-20 cm) and subsoil (21-40 cm) soil depths, samples were taken by using auger and core sampler. Two sets of soil samples were taken, one set for the determination of SOC contents and fine root (<2 cm diameter) biomass and one set for the determination of soil bulk density (1 m*1 m; the size of subplot to take soil sample for bulk density in each corner and at the center of subsample plot 20 m*20 m). In each case, samples of the 0–20 cm and 21–40 cm layers were taken from the four corners and center of each of 20 m×20 m tree inventory plot and composited by layer while following. Two soil samples were taken from each sampling point after compositing the same depths together to get one representative soil sample. Four replication *eight plots for each replication * two soil depth, and hence a total of 64 soil samples were taken for soil carbon analysis [10].

Data analysis: The non-destructive method was used for the estimation of carbon stock. The C content of tree biomass had been taken to 48%, the biomass weighted mean value for trees grown in Agroforestry systems in Kenya. To estimate biomass of tree species-specific allometric equation from woody biomass inventory for Ethiopia was used for almost all tree species but for Citrus sinensis general allometric equation was used.

AGB = 0:0905 * DBH2:4718; R2 = 0:98; n = 72 (1)

This equation was developed in areas having similar environmental conditions (climate and soils) with the study area. CO2 was calculated using this formula; the amount of carbon is multiplied by the ratio of the molecular weight of carbon dioxide to the atomic weight of carbon (44/12).

Below ground biomass (BGB) (stump plus coarse roots, >2 cm diameter and fine root) was estimated by using the allometric equation.

BGB = 0.490AGB0:923; R2 = 0.95; n = 72 (2)

Laboratory analysis: The soil samples were analyzed to determine SOC, soil organic matter, pH, soil texture, and bulk density in Debre Dirhan Agricultural Research Center soil laboratory. We determined the soil bulk density by dividing the weight of oven-dried soil sample by the volume of core.

SOC is determined through laboratory analysis of the soil carbon concentration, volume of the soil sample, and the bulk density of soil samples collected in the study area. The soil samples were dried in oven-dry by 70^{o}C for SOC content (%) and 105 oc for bulk density until getting constant weight; 24 hours and analyzed. Before that, the soil samples were treated with HCL acid to remove inorganic carbon. Then the soil organic carbon was determined following the wet digestion method, and the percent organic matter was computed from the percent organic carbon using a conversion factor of 1.724. A correction factor of 1.33 was applied to account for the incomplete oxidation of organic carbon that is known to occur with the Walkley-Black method.

Soil organic carbon (SOC) was determined by using the equation;

SOC (Mg/ha) = BD (g/cm3) × depth (cm) × carbon%×10-1. (3)

Where: BD= bulk density and 10-1 is a unit factor (10_9 mg Mg_1 × 108 cm^2 ha_1).

BD (gm/cm^3) = (oven-dry weight of the soil) / (volume of the core) (4)

Statistical analysis: Descriptive statistics such as means, percentage, and standard deviation were used to characterize the farmer perception and tree management activities of the study area. Farmers' responses were analyzed using a Chi-squared test. Qualitative data was analyzed by Chi-squared test. Quantitative data through a formal survey; farmer's opinions were analyzed using descriptive statistics with the help of (IBM SPSS versions 20) software. The qualitative data were narrated in brief.

To test variation between biomass C and SOC stocks in different kebeles one-way analysis of variance (ANOVA) at $p<0.05$ had been computed with the help of (IBM SPSS versions 20). Post hoc test was performed to evaluate the mean difference between the study kebeles.

Results

Demographic characteristics of the respondents: Demographic characteristics of the respondents (gender, educational level, marital status and main occupation are presented in (Table 2). On average, the respondents have 48±0.16 years old, 5±0.16 family size, 1.5±0.07 ha farm size and 43±3.4 tree per hectare on their farmlands.

Farmer's perception of PLAP : The result obtained from the focus group discussion (FGD) confirmed that almost all the respondents agree with the importance of parkland Agroforestry practice for regulation ecosystem service, fencing, fodder, save time to collect fuelwood, conserve soil and water resource, fuel and construction wood, improve the livelihood of the household, increase soil fertility but unsure with the parkland Agroforestry practice can be source of medicinal value, create work opportunity to youth in around.

They perform tree management activities like pollarding, pruning and coppicing. They collect the manure after dry for the source of fuelwood and sell it in the market. The major crops that grow in the study area are teff (Eragrostis teff), sorgum (Sorghum bicolor), chickpeas (Cicer arietinum), and wheat (Triticum aestivum); trees are Acacia etbaica, Acacia seyal, Acacia abyssinica, and Faidhrebia albida.

Focus group discussion support the result of the household interview; that is 23.6% of the respondents pointed out that they perform management practice traditionally; they do not get any advice from extension agents. From the respondents, 76.4% of respondent get advice from extension agents in once a month (30%) and twice a year (20.9%). More common Agroforestry practices in the study area are parkland (89.1%) and farm boundary (10%) Agroforestry practice. The management practice applied in the area is coppicing and pollarding (32.7%), pruning and thinning (43.6%). The farmers conserve and

Table 2: Demographic characteristics of the respondents in the study area.

		Frequency	Percent
Genders	Male	107	97.7
	Female	3	2.3
Marital status	Single	2	1.8
	Married	104	94.5
	Divorced	2	1.8
	Widowed	2	1.8
Main Occupation	Crop production	95	86.4
	Mixed	15	13.6
Education status	Illiterate	15	13.6
	Read and Write	62	56.4
	Grade 1-4	17	15.5
	Grade 5-8	8	7.3
	Grade 9-12	7	6.4

manage multipurpose trees and shrubs on their farmland for the use of fuel and construction wood, for soil fertility, income generation and fencing (54.5%). The appropriate time to Pollard and coppice trees from farmland is at the end of the dry season (98.2%). Fifty-seven percent (57.3%) of respondents said that coppicing and pollarding are important management practices to resolve the shading effect of the trees on crops. From the respondents, 26.4% strongly agree and 68.2% agree on the adverse effect of PLAP to the adjust crop. Thirteen percent (13.6%) respondents said that Acacia etbaica has a negative effect on the crop.

The shading effect of the tree on the crop is reducing the growth of crop and grain yields, and also hosting for birds (50%). The respondents said that the residual of the crop serves as a feed for animals (22.7%), both feeding by animals and remain on the land (37.3%) and only remains on the land (25.5%). The mode of weed control management is both use of herbicide and manual (54.5%) and only manual (44.5%).

The respondents said that there are major factors that challenge the sustainability of the practice like free grazing, land scarcity, drought, harvesting machine and plowing by a tractor. To curb the existing problems which affect the sustainability PLAP in the study area, some farmers (21.82%) recommended the following strategies: stopping free grazing; enhancing the awareness of the local community through training; and managing natural regeneration. The survey result on the perception of PLAP using five points Likert scale (Table 3), has shown that about half of the respondents strongly agree with the question of PLAP has provision, supportive and regulation service like; climate change mitigation, livestock feeding, fencing, conserve soil and water resource, save time on collecting fodder and fuelwood, improved environmental condition. On the other hand, 55.5% of respondents strongly disagree with the question of PLAP have a negative impact on the environment. Respondents also confirmed that: the shade provided by parklands is a resting place for farmers and also mostly used by livestock during the dry season when the temperature is very high.

Effect of Demographic Characters for the Perception of Farmers: The effect of age, sex, education status, farm size, marital status and wealth status on the perception of households for parkland Agroforestry practice in the study area was presented in effect.

The age of respondents statistically positively affected their perception for PLAP can increase soil fertility and can be a source of construction and fuelwood but other perceptional statements can't affect statistically. Gender affects the perception of the farmer for PLAP important to recreational value and improved livelihood. Marital status affects the perception of the farmer for PLAP importance to climate change regulation and has disadvantage in the crop, like the shading effect (Table 4). A farmer said, the main reason for the conservation of PLAP is it's important for fuelwood, take rest for lunch eating, shading for animals, live fence, farm hand tools, fodder, soil improvements and erosion controls.

Biomass Carbon Stocks in Parkland Agroforestry Practice: The species-specific allometric equations that used to estimate biomass of tree species are selected based on their developed agro ecology that relates with the study site. There was a variation in the mean above-ground carbon stock between the kebeles on PLAP in study areas (Table 5). PLAP in Bolo Slase kebele had higher AGC (9.39 Mg/ha.) by 64.64% as compared to Agirat (3.32 Mg C ha^{-1}). The mean AGC and BGC along kebele were significantly different ($F= 3.09$, $p < 0.05$). The difference in variation in BGC is similar to AGC in study kebels. The carbons stock in below ground of PLAP was higher in Bolo Slase (3.6 Mg C ha^{-1}) than Agirat (1.39 Mg C ha^{-1}.) at 0.05 significance levels.

Table 3: Perceptions of farmers about parkland Agroforestry practice in M/shenkora.

Perceptional statement about PLAP	Likert scale measurements (%)					Weighted mean	X^2 test p-value
	Strongly agree (5)	Agree (4)	Unsure (3)	Disagree (2)	Strongly disagree (1)		
Importance to ecosystem regulation service	69.1	29.1	0.9	0	0.9	4.65	0
Importance to cultural spiritual	32.7	66.4	0	0	0.9	4.3	0
Disadvantage in crop, like shading effect	26.4	68.2	0.9	0.9	3.6	4.13	0
Important to fencing.	56.4	43.6	0	0	0	4.56	0.182
Increase soil fertility	47.3	49.1	2.7	0.9	0	4.43	0
Conserve soil and water resource	50	49.1	0.9	0	0	4.49	0
Save time on collecting fuel wood	58.2	41.8	0	0	0	4.58	0.086
Improved environmental condition	51.8	48.2	0	0	0	4.52	0.703
Improves the livelihood	20.9	74.5	2.7	1.8	0	4.15	0
Increase social interaction	32.7	62.7	3.6	0.9	0	4.27	0
Used to medicinal value	18.2	46.4	30	4.5	0.9	3.76	0
Can be source of construction wood	41.8	52.7	0.9	4.5	0	4.32	0
Create employment for local community	8.2	68.2	13.6	6.4	1.8	3.76	0

Table 3: Perceptions of farmers about parkland Agroforestry practice in M/shenkora.

Perceptional statementS	Age	Sex	Marital status	Wealth status	Education status	Farm size in Hectare
	Cof.	Cof.	Cof.	Cof.	Cof.	Cof.
Increase soil fertility	.155*	0.012	-0.034	-0.047	0.031	0.016
conserve soil and water resource	0.026	-0.054	-0.077	0.034	-0.037	-0.105
Save time on collecting fodder and fuel wood	0.061	-0.084	-0.092	-0.002	0.019	0.091
Improves the livelihood	0.125	-.169*	-0.099	0.021	0.095	0.119
Used to medicinal value	0.136	0.046	-0.031	.179*	.285***	0.063
Can be source of construction fuel and wood	.222**	0.087	0.089	0.041	0.02	.185*
Important to recreational value	-0.08	-.265***	-0.097	-0.093	.171*	-.185*
Create employment for local community	0.012	-0.149	-0.116	0.088	.241**	-0.042
PLAP importance to regulation ecosystem service	-0.059	0.009	.204**	0.033	0.02	0.05
PLAP importance to cultural spiritual	-0.134	-0.126	-0.029	-0.072	0.097	-0.137
PLAP disadvantage in crop, like shading effect	-0.113	-0.041	-.209**	-.171*	-0.06	-0.115
						Con…
Tree on farm land important to livestock feeding, fencing.	-0.098	-0.152	-0.073	-0.117	0.089	-0.11

Table 4: Spearman correlation among household demographic characters and their perceptions.

Perceptional statementS	Age	Sex	Marital status	Wealth status	Education status	Farm size in Hectare
	Cof.	Cof.	Cof.	Cof.	Cof.	Cof.
Increase soil fertility	.155*	0.012	-0.034	-0.047	0.031	0.016
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PLAP disadvantage in crop, like shading effect	-0.113	-0.041	-.209**	-.171*	-0.06	-0.115
						Con…
Tree on farm land important to livestock feeding, fencing.	-0.098	-0.152	-0.073	-0.117	0.089	-0.11

The contribution of above-ground and below-ground biomass carbon stock for total biomass carbon stock in parkland Agroforestry practice is 71.58% and 28.42%, respectively.

SOC, attitude, and pH (1:2.5) are correlated with each other (Table 6). Above-ground carbons stock in Acacia nilotica (0.46 Mg/tree), Acacia abyssinica (0.215 Mg C ha^{-1}) and Croton macrostachus (0.193 Mg C ha^{-1}.) were higher than other tree species in parkland Agroforestry practice in study areas. Acacia nilotica, Acacia abyssinica, and Croton macrostachus sequestered 2.12 Mg, 0.98 Mg, and 0.88 Mg CO_2 respectively (Figure 3). There is strong variation in AGC, BGC and CO_2 sequestration potential of tree in study areas ($F=4.34$, $p<0.01$).

Soil Organic Carbon Stock: Unlike AGC and BGC, Soil organic carbons were higher in korma Agree (66.59 Mg ha^{-1}.) than Bolo Giorgis (40.34 Mg ha^{-1}.). Similar to our hypothesis; the mean soil organic

Table 5: The species and their allometric equations were applied in the study area.

Species	Allometric equation used	R^2	Reference
Acacia seyal	AGB=(0.9103*DSH)+(0.6782*(DSHexp1.7))	0.9	(WBISPP, 2004)
Acacia abyssinica	AGB=(0.0497*DSH)+(0.0300*(DSHexp2.8))	0.9	(WBISPP, 2004)
Acacia etbaica	AGB=(-0.1024*DSH)+(0.1502*(DSHexp2.3))	0.88	(WBISPP, 2004)
Acacia nilotica	AGB=(2.3624*DSH)+(0.0035*(DSHexp3.4))	0.96	(WBISPP, 2004)
Acacia tortillis	AGB=(0.1725*DSH)+(0.0106*(DSHexp3.0))	0.97	(WBISPP, 2004)
Carica papaya	AGB=(0.02445*DSH)+(0.2451*(DSHexp2.6))+(-0.1022*(DSHexp2.8))	0.92	(Kuyah et al., 2012)
Croton macrostachyus	AGB=(0.3679*DSH)+(0.0459*(DSHexp2.5))	0.99	(WBISPP, 2004)
Ebretia cymosa	AGB=(0.8808*DSH)+(0.0348*(DSHexp2.5))	0.98	(Larwanou M., 2010)
Faidherbia albida	AGB = 7.985Dbh + 32.277	0.33	(Larwanou M., 2010)
Olea africana	AGB=(0.6806*DSH)+(0.0422*(DSHexp2.7))	0.91	(WBISPP, 2004)
Ziziphus spina-christi	AGB=(0.0340*DSH)+(0.0431*(DSHexp2.6))	0.97	(WBISPP, 2004)
Eucalyptus camaldulensis	$AGB=0.0155(DBH)^{2.5823}$	0.99	(Hailu, 2002)

Table 6: Pearson correlation among the studied characters.

	AGB (Mg C ha^{-1})	SOC (0-40 cm) Mg C ha^{-1}	Number of trees/ha	pH (1:2.5)	Altitude (M)
AGBC (Mg C ha^{-1})	1	-0.22	-0.101	0.086	0.134
SOC(0-40 cm) Mg C ha^{1}	-0.22	1	-0.046	-0.139	-.638**
No.of trees/ha	-0.101	-0.046	1	.512**	0.332
pH (1:2.5)	0.086	-0.139	.512**	1	.509**
Altitude (M)	0.134	-.638**	0.332	.509**	1
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 7: Mean (± standard error) biomass (Mg ha^{-1}), biomass carbon, SOC and total carbon stocks (Mg C ha^{-1}) for each of the kebele and results of one-way ANOVA (at α = 0.05).

Biomass and carbon pool	Kebeles					
	B/giorgis (M.altitude)	B/slasi (M.altitude.)	Agirat (L.altitude)	Korma ager (L.altitude)	GM.	Sig.
AGB (Mg ha^{-1})	12.71(2.88) ^{ab}	19.54(4.81) ^{a}	6.92(1.35) ^{b}	10.56(1.77) ^{ab}	12.44	*
BGB (Mg ha^{-1})	5.07(1.05) ^{ab}	7.50(1.72) ^{a}	2.89(0.53) ^{b}	4.28(0.68) ^{ab}	4.94	*
AGC (Mg ha^{-1})	6.1(1.38) ^{ab}	9.38(2.31) ^{a}	3.32(0.65) ^{b}	5.07(0.85) ^{ab}	5.97	*
BGC (Mg ha^{-1})	2.43(0.5) ^{ab}	3.6(0.83) ^{a}	1.39(0.25) ^{b}	2.05(0.33) ^{ab}	2.37	*
SOC Mg ha^{-1}. 0-20 cm	20.85(1.42) ^{b}	23.84(1.18) ^{b}	26.55(1.64) ^{ab}	33.14(2.65) ^{a}	26.09	***
SOC Mg ha^{-1}. 21-40 cm	19.49(1.09) ^{b}	21.38(2.38) ^{b}	26.55(1.71) ^{ab}	33.45(2.22) ^{a}	25.22	***
SOC Mg ha^{-1}. 0-40 cm	40.34(1.84) ^{b}	45.22(3.36) ^{b}	53.10(3.25) ^{b}	66.59(4.62) ^{a}	51.31	***
TC (Mg ha^{-1})	48.87(2.53) ^{b}	58.2(4.56) ^{b}	57.81(3.18) ^{b}	73.71(2.27) ^{a}	59.65	***

carbon along kebele was significant different (F= 11.29, $p < 0.001$). The average carbon stock of parkland Agroforestry practice in soil organic carbon in the study area was 51.31 Mg ha^{-1}. The bulk density of soil found in the study site was ranged from 1.01 g cm^{-3} of minimum to 1.38g cm^{-3} maximum value with the average value of 1.21 g cm^{-3}. Soil organic matter was range from 1.14% to 3.38%. There was strong variation in soil organic carbon stock in parkland Agroforestry practice between the studied areas (Table 7).

Total Carbon Stock of PLAP: Total carbon stock of parkland Agroforestry practice across kebele have statistically significant difference (F=7.74, P<0.001). Total carbon stock potential of parkland Agroforestry practice in M/Shenkora on average was 59.65 Mg C ha^{-1}. The highest total carbon stock density scores in korma Ager (73.71 Mg C ha^{-1}) and the lowest in Bolo Giorgis (48.87 Mg C ha^{-1}). The contribution of AGC, BGC, and SOC for total carbon was 10.02%, 3.98%, and 86.08%; respectively. Low altitude agro ecology has the higher carbon stock by 33.7% than mid altitude agro-ecology in the study area.

Discussion

Farmer Perception of Parkland Agroforestry Practice: The result of the present study shows that the majority of respondents have a good awareness on the multiple socio-ecological roles and services of PLAP. However considerable proportion of respondents had doubt on the medicinal value of PLAP. The possible reason for this could be low information sharing among farmers on the role of trees for traditional medicine. The participants indicated that they perceived the importance of PLAP for ecological, economic, social and environmental value, improve livelihood, management that required the practice. These are in line with the results of who reported that parkland trees are important to improve livelihood, increase soil fertility, improve and maintain environment. The age of the respondents' is positively correlated with their perception on the role of PLAP for increasing soil fertility and source of construction wood. This shows that: the older farmers in the study area more perceived about PLAP than the younger one in these perceptional statements. The possible reason for this result could be elders might have lived for a longer time and got a better experience on the PLAP and be able to notice the socio-ecological role of PLAP.

According to our findings, marital status of respondents positively correlated with their perceptions of PLAP importance to regulation ecosystem service. Because of the married and divorced women have connection with the regulation service of PLAP that is soil erosion control, environmental protection, water purification; therefore, both are perceived this service. The wealth status of respondents' is positively correlated with the perceptional statement of PLAP used to medicinal value. Almost all of the respondents are managing the trees on farmland in the study areas to reduce the density of tree, competition for light, water and nutrients. Parkland trees can compete with crops for different resources such as; for light, water and nutrients and decrease crop yield especially when density and size of trees are high. Because competition is often more significant on trees, farmers will often reduce the number of trees on their farms in order to promote the growth of their crops. The management practices they perform (pollarding, coppicing, thinning and crop residue) have an advantage like increase soil fertility, soil moisture and modify micro-climate, then in turn increase crop yield.

The farmer perceived there are the constraints that affect the expansion and sustainability of the PLAP in the study area. Those are free grazing, scarcity of land, plowing by tractor and Machin harvesting that are major factors for the growth of natural regeneration of seedling which is more important for the sustainability of the practice. Land scarcity due to population pressure, free grazing, the land tenure system, expansion of market-oriented products, and climate change are a major problem for expansion of parkland practice.

Biomass Carbon Stock of PLAP: Biomass carbon stock of parkland Agroforestry practice showed that there is significant variation along with different kebele of agro ecology; these are due to biomass affected by stand age, tree species and structure, managements, diversity and composition. Our result indicates that mean biomass and its carbon stock of PLAP was higher in mid altitude (B/Giorgis and B/Slase) agro-ecology than low altitude (Agirat and Korma Ager) agro-ecology. These are due to number of tree per hectare was higher in mid altitude agro ecology because of the presence of favorable environmental condition than low altitude agro-ecology so that; the presence of species characterized by large individuals and also possibly due to the favorable conditions for tree growth in the middle altitude, because few large individuals can account for a large amount of above and below ground carbon. The biomass carbon stock is higher in high gradient elevation than low gradient elevation. This agrees with the results of Gebrewahid et al., 2018 that was carried out in Tigray, North Ethiopia. However, the result of who reported that above and below-ground tree biomass and its carbon stock decline with an increase in altitude is not agree with the result of this study.

The present study show that, individual tree's biomass carbon stock range from 0.002-0.29 Mg C. Carbon storage in individual tree species varies from 0.04 Mg C to 25.65 Mg C. Tree species as they vary widely in properties that drive carbon sequestration such as growth, mortality, decomposition and their dependency on climate.

The mean total biomass carbon stock of PLAP in the study area was 8.34 Mg C/ha. The result was substantially higher than the parkland Agroforestry system in Gununo Watershed, Wolayitta Zone, Ethiopia, However lower than that of the study of that was carried out in Tigray and (Montagnini and Nair, 2004). This could be due to lower diameter trees documented in my study. The average above-ground carbon storage potential of Agroforestry systems in semiarid, sub-humid, humid and temperate regions has been estimated to be 9, 21, 50 and 63 Mg C ha-1, respectively. The total biomass carbon stock of PLAP in the study area was in the range of 0.98-26.89 Mg C/ha. Therefore, this result was within the range reported on a global scale Agroforestry system stores 12 to 228 Mg C ha^{-1}. The trees on farmland frequently are managed by pollarding, thinning and coppicing every year at the end of the dry season to reduce its shading effect and competition for light and nutrition on the crop; that case to reduce tree biomass.

Soil organic carbon: Soil organic carbon is a significant carbon pool because it has the longest residence time among organic carbon pools. Our results show that soil organic carbon had an inverse relationship with soil pH and elevation gradient. At low soil pH the decomposition rate is reduce due to that there are high accumulation of SOC. Soil organic carbon of PLAP in the study area ranged between 29.66 Mg C ha^{-1} and 92.86 Mg ha^{-1}. These results are in line with the range of 18.5–52.5 Mg C ha^{-1} and 22.4–54.0 Mg C ha^{-1} that reported in stocks of cultivated and grazing land of East and West Africa and that of parkland Agroforestry practiced in southern Ethiopia was ranges in 28.2–98.9 Mg ha^{-1}. The result shows that, SOC is higher in low land agro ecology than midland agro ecology due to SOC has an inverse relationship with elevation gradient. The increasing tendency of carbon density with decreasing altitude may be because of soil leaching, better mineralization and stabilization of SOC at lower altitudes. The range of SOC that in the study that was carried out in Tigray, was 2.28 and 40.5 Mg C ha^{-1} (Gebrewahid et al., 2018). The mean soil organic carbon of PLAP in the study area was 51.31 Mg C ha^{-1}. SOC in our study was remarkably high as compared to results conducted in semi-arid Acacia etabica woodland in southern Ethiopia (43 Mg ha^{-1}), carried out in Tigray (20.07 Mg C ha^{-1}), in the wolayitta zone (49.05 Mg ha^{-1}) and Agroforestry systems in Central India (27 Mg ha^{-1}). However, the SOC in our study remarkably lower as compared to results that conducts in Cheha woreda, Gurage zone for cultivated land (73 Mg C ha^{-1}). As report the soil organic carbon stock for the tropical forest, tropical savannah, and tropical agricultural land was 121–123 Mg C ha^{-1}, 110–117 Mg C ha^{-1}, and 80–103 Mg C ha^{-1} respectively.

Soil organic carbon stock studied in different agro ecology has a significant difference. These are due to the composition, land-use history, management and structure of vegetation along the agro-ecology zone, which may accumulate the different amount of organic matter due to high inputs from root biomass and above-ground. Diversified tree species have high fine root production due to that the SOC is high. Thinning and pruning of trees may reduce SOC sequestration by reducing litter fall and accelerating decomposition due to changes in understory light, air/soil temperature, and soil moisture regimes.

Total Carbon Stock of PLAP: The distribution of carbon stocks between biomass and soil differed among agro ecology and varied among kebeles. The mean total carbon stock of PLAP in the studied area was 59.65 Mg C/ha. This is higher than total carbon stock of parkland Agroforestry practice in the wolayitta zone (51 Mg C ha^{-1}), carried out in Tigray (31 Mg C ha^{-1}), and 46 Mg C ha^{-1} in the Sahel. The total carbon stock of the study area is in the range of 36.24 Mg C ha^{-1} - 94.08 Mg C ha^{-1}. The average total carbon stock of PLAP was within range of tropical Agroforestry 7.9–105 Mg C ha^{-1}, Cocoa-based Agroforestry practiced in Nigeria that ranged 16–96.01 Mg C ha^{-1} and traditional Agroforestry system of humid subtropical ranges 10.29–31.86 Mg C ha^{-1}.

The difference of total carbon stock of the practice in the study areas between kebeles arise from difference in farm size, socio-economic needs, species diversity, the age of trees, local climate, number of tree coverage, and tree spacing among Agroforestry system and higher levels of disturbance (pruning and damage), intensive management practices, and small land size that forces scattered trees on farmland not only having a higher density of woody perennials but also an accumulation of other plants and crops per unit area.

Conclusion

Carbon sequestration potential of parkland Agroforestry practice in Minjar Shenkora woreda and the perception of farmers to the various ecosystem services of the practice were studied. The large majority of respondents perceived the provisioning, regulation, cultural and supporting ecosystem services of parkland Agroforestry practice. Although farmers generally consider trees and shrubs as part of the agricultural system, farmers will not maintain them in the system if they do not perceive their value. The farmers perceived the importance of PLAP to improve their livelihoods, augment crop production, soil and water conservation, enhance soil fertility and its contribution to cope with and adapt to the changing global climate by providing wood for sale, energy and construction. They applied various tree management practices that required for the sustainable utilization trees.

The parkland Agroforestry practice in the woreda has stores 59.65 Mg C ha^{-1}. This could be an attractive opportunity for farmers to benefit economically from scattered trees on farmland if the carbon sequestered can be sold through carbon trade. However, this carbon sequestration potential of the practice varied among sites (i.e., among each kebele), which is due to differences in vegetation structure, the density of trees per hectare and management practice. The biomass carbon stocks were significantly less than the SOC stocks in almost all studied kebeles. In spite of the aforementioned perceived ecosystem services of the practice and positive attitude of the farmers to maintain and manage it sustainably, the parkland Agroforestry practice of Minjar Shenkora woreda has faced some challenges like: cutting of trees by theft due to high demand for tree products, change of plowing and harvesting techniques such as use of tractors and machine harvesters and free grazing that threatened its long existence. Hence, this calls for an integrated action in all levels to control the problem and avoid the damage on the trees and the growth of naturally regenerated seedlings that are important to sustain the practice. The practice should be conserving and promote by climate change program to sustain the practice and improve carbon storage potential of the practice. The governments should give attention for Agroforestry practice because of its role for climate change mitigation.

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Authors' contribution

Reta E. Designed and conducted the experiments at field, data collection, analysis, interpret the results and finally prepared the draft manuscript. Seid M. and Solomon M. Designed the experiments, interpret the results, review the full manuscript and improve the contents of these manuscripts.

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Ethics declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interest

The authors declare that they have no competing interests in this section.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

1. Rosenzweig C, Casassa G, Karoly DJ, Imeson A, Liu C, et al. (2007) Assessment of observed changes and responses in natural and managed systems. 79-131.
2. Dalla Valle M, Codato E, Marcomini A (2007) Climate change influence on POPs distribution and fate: A case study. Chemosphere 67: 1287-1295.
3. Karavoltsos S, Sakellari A, Mihopoulos N, Dassenakis M, Scoullos MJ (2008) Evaluation of the quality of drinking water in regions of Greece. Desalination 224: 317-329.
4. Whitehead PG, Wilby RL, Battarbee RW, Kernan M, Wade AJ (2009) A review of the potential impacts of climate change on surface water quality. Hydrological sciences journal 54: 101-123.
5. Sinclair RG, Jones EL, Gerba CP (2009) Viruses in recreational water□borne disease outbreaks: A review. Journal of applied microbiology 107: 1769-1780.
6. Funari E, Manganelli M, Sinisi L (2012) Impact of climate change on waterborne diseases. Annali dell'Istituto superiore di sanita 48: 473-487.
7. Khan S, Shahnaz M, Jehan N, Rehman S, Shah MT, Din I (2013) Drinking water quality and human health risk in Charsadda district, Pakistan. Journal of cleaner production 60: 93-101.
8. Delpla I, Jung AV, Baures E, Clement M, Thomas O (2009) Impacts of climate change on surface water quality in relation to drinking water production. Environment international 35: 1225-1233.
9. Langan SM (2009) Flares in childhood eczema. Skin therapy letter 14: 4-5.
10. Benelam B, Wyness L (2010) Hydration and health: a review. Nutrition Bulletin 35: 3- 25.