WOODY SPECIES PREFERENCE, MANAGEMENT PRACTICES AND THEIR CONTRIBUTION TO SOIL PRODUCTIVITY OF PARKLAND AGROFORESTRY IN ASSOSA DISTRICT, WESTERN ETHIOPIA

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ABSTRACT: This study aims to assess woody species preference, management practices and their effect on the soil productivity of parkland agroforestry in Assosa District, western Ethiopia. Three administrative kebeles and 114 households were randomly selected for the study. Descriptive statistics were used to analyze the data. Additionally, focus groups and key informant interviews were included in the data collection process. The results revealed that 34.2 % of the total respondents manage trees/shrubs for soil improvement, 21.9 % for fuel wood, 20.2% as a source of timber/construction, 8.8 % for making different tools, 4.4% for shelter, 3.5% as a source of food, 3.5% for fodder, 2.6% to generate income and the rest (0.9%) for medicine. Pruning (62.28%), lopping (24.56%), and coppicing (6.14%) were the most important woody species management practices for enhancing soil productivity by reducing the competition between tree-crop interfaces. The majority of the household respondents (95.6%) perceived woody species management practices to increase soil productivity under tree canopy. Species such as *Cordia africana*, *Mangifera indica*, *Melia azedarach*, and *Sesbania sesban*, were the suggested woody species to increase soil productivity of the parkland agroforestry systems by applying different management practices. Therefore, it is recommended that maintaining and managing these versatile woody species is crucial to minimize the tree-crop interaction and improve soil productivity in the parkland agroforestry system in the study area.

Keywords: Productivity, Scattered tree, Soil fertility.

INTRODUCTION

Agroforestry is the intentional integration of woody vegetation, such as trees and shrubs, with crops and/or livestock simultaneously or sequentially on a land management unit at any scale (Van Noordwijk et al., 2019). It is a well-known strategy that is being used in many parts of the world, particularly Africa, to improve food security and nutrition, diversify economies, and build resilience (Abreha and Gebrekidan, 2014; Bajigo and Abraham, 2017; Brown et al., 2018; Kuyah et al., 2020; Sheppard et al., 2020;

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Gebreegziabher et al., 2020). In different parts of Ethiopia, indigenous agroforestry practices developed over time are prevalent (Alemu, 2016), with parkland agroforestry being a commonly adopted practice. Parkland agroforestry is the constant existence of well-grown trees in cultivated or late-plowed fields (Achiso and Masebo, 2019). The presence of scattered trees on croplands has been found to have effects on the micro-climate, flora, fauna, and other components of the ecosystem through bio-recycling of mineral elements, environmental modifications, and changes in flora and fauna composition (Manjur et al., 2014). Parkland agroforestry practices can play an important role in a sustainable agricultural production that is characterized by combining scattered woody perennials with annual crops and/or animals in the same piece of land (Matocha et al., 2012; Mbow et al., 2014; Gebrewahid et al., 2018).

Parkland agroforestry practices in Ethiopia have demonstrated a beneficial impact on soil properties, encompassing enhanced soil fertility, improved nutrient cycling, effective soil erosion control, and efficient water management (Madalcho and Tefera, 2016; Wolle et al., 2021). The specific characteristics of tree species are crucial in determining which species to plant on farmland, considering factors like utility, drought resistance, compatibility with other crops, and potential for improving soil fertility (Bannister and Nair, 2003). The primary goal of the land use system in the parkland is to preserve soil-improving trees to enhance agricultural production. Thus, the interacting species within this ecosystem must contribute to the long-term sustainability of soil productivity (ICRAF, 2000). These practices have long been utilized by local communities and farmers in Ethiopia, in promoting sustainable agriculture and land management in the region.

Previous studies (Asfaw, 2016; Yismaw and Tadesse, 2018; Bussa and Feleke, 2020; Gebrewahid and Meressa, 2020; Wolle et al., 2021; Tsedeke et al., 2021) have examined tree species diversity and its relationship with carbon stock in the parkland agroforestry practices, but farmers' woody species preferences and the purpose of keeping scattered trees in parkland agroforestry remains poorly understood. Moreover, there is a lack of detailed understanding regarding the potential effects of woody species management practice and their role in soil productivity of parkland agroforestry practice in the study area. Thus, an investigation of woody species preference, management practices, and their role in the soil productivity of parkland agroforestry was conducted to answer the following questions: (1) how and why do local farmers keep woody species on their parkland agroforestry in the study area? (2) How do local farmers manage woody species in their parkland agroforestry in the study area? (3) How do local farmers perceive the practice of managing woody species to enhance soil productivity in parkland agroforestry in the study area? The present study provides information about appropriate species selection, management practices, and their role in the soil productivity in the parkland agroforestry, by reducing competition and enhancing soil productivity of the areas.

MATERIALS AND METHODS

Study area

The study was conducted in the Assosa District, Assosa Zone, Benishangul Gumuz Regional State, Western Ethiopia. It is located between 9º 42' 0" to 10º 12' 0" N latitude and 34º 12' 0" to 34º 42' 0" E longitude (Figure 1) and at a distance of 687 km from the capital city, Addis Ababa.

Assosa district has 74 kebeles' (CSA, 2020) and out of these about 49 kebeles' (66.22 %) of the district's households in the kebeles practice parkland agroforestry while, the other 25 kebeles (33.78%) households depend on daily labor, shifting cultivation, monoculture, trade, traditional mining, etc. (ADANRMO, 2023). The area is renowned for its extensive home garden and parkland agroforestry practices, as well as its rich indigenous knowledge of traditional plant uses (Kifle and Asfaw, 2016).

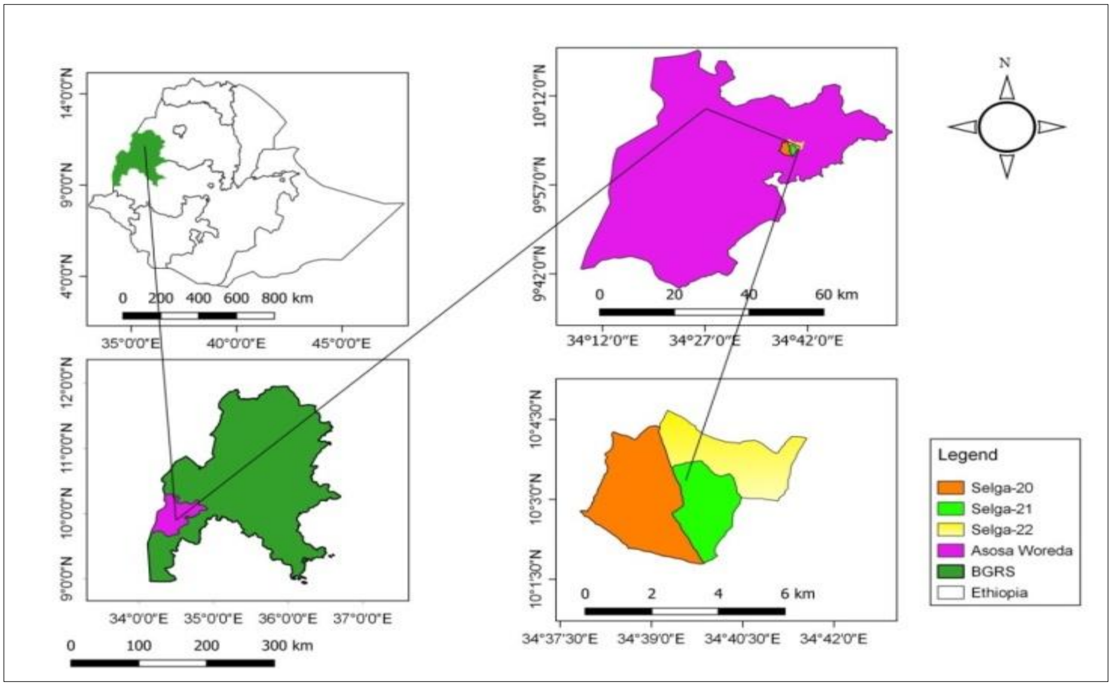

Figure 1. Map showing geographic location of the study area.

The total population of Benishangul Gumuz region was 460,459 which gives a population density of 9 persons/Km^2. Assosa zone, has a total area of 1,519 Km^2 and a population of 28, 970 (population density of 19.1 persons/Km^2) (CSA, 2020). The topography of the study area is characterized by undulating elevation which decreases gradually toward the western part to an average altitude of 500 m along the Ethiopia - Sudanese border (Mosissa and Wakjira, 2020). The study area has a mono-modal rainfall pattern ranging from the end of April to October. The average annual rainfall in the area is approximately 1240 mm (IFPRI, 2017).

The soils are characterized by very poor organic carbon and nitrogen contents, indicating a low soil fertility status which is driven by the limited use of both organic and inorganic fertilizers and the loss of nutrients mainly through leaching (Kifle and Asfaw, 2016). Subsistence agriculture is the major economic activity, engaging approximately 80% of the population. Major agricultural products are cotton, soybeans, sesame, millet, sorghum, maize, and mango. These crops are produced by rain-fed and to some extent irrigated agriculture (Mosissa and Wakjira, 2020).

Sampling techniques and sample size determination

A multi-stage sampling technique was selected to ensure accurate and comprehensive primary data from the sample households. First, out of 49 kebeles within the district three kebele were selected randomly based on the existence of parkland agroforestry practices namely; Selga-20, Selga-21, and Selga-22. Then, two villages were randomly selected from each kebele administration. The number of sample households was determined by using proportionate random sampling following a simplified formula provided by (Yamane, 1967) at 92 percent confidence interval.

$$n = \frac{N}{1 + N(e^2)}$$

$$n = \frac{422}{1+422(0.08^2)} = 114$$

Where, n = the sample HHs of the study area, N=the population size of the study area, e = allowed errors which is 8%.

Thus, using a simple random sampling technique, from the three kebeles, 114 HHs were randomly selected from a total of 422 kebele households provided by the Kebele agricultural development office and Kebele administration. The total number of households from which sample size was determined in each village (KA) were; from Selga-20 kebele 221 HHs (Ketena 1 = 112, Ketena 2 = 109), Selga-21 kebele 98 HHs (Ketena 2 = 48, Ketena 3 = 50), and Selga-22 kebele 103 HHs (Ketena 1 = 47, Ketena 2 = 56).

A 'Ketena' or village is the smallest sub-unit of a kebele, and it contains several sub-units called 'Gots'. In total, 422 (N) households in the sampled Kebeles were the target households of the study. A proportional sampling formula was applied to each Kebele to ascertain the sample household size.

$$n1 = \frac{N1}{N} * n$$

Where, n1= sample household size in KA1, N1= is the total household in KAs 1, n = is a total sampled household from the three KAs and N = is the total households in the three kebele. Hence, from Selga-20 kebele 59 HHs (30 from Ketena 1, 29 from Ketena 2), from Selga- 21 kebele 27 HHs (13 from Ketena 2, 14 from Ketena 3), and from Selga-22 kebele 28 HHs (13 from Ketena, 15 from Ketena 2) were randomly selected proportionally based on the number of households heads residing in each Kebele.

Method of data collection

To achieve the study's objectives quantitative and qualitative data and both primary and secondary data sources were used. Secondary data were collected from published and unpublished sources. The primary data were gathered through household surveys, key informant interviews, and focus group discussions. Closed and open questionnaires were developed and semi-structured and face-to-face interviews were conducted to collect qualitative and quantitative data from respondents. The household questionnaires were prepared in English and translated into Benishangul, Amharic, and Afan Oromo, the languages spoken in the study area. Enumerators who were knowledgeable about the area were involved in data collection. Before interviewing household respondents, the objectives of the study were explained to enumerators, and they were trained in data collection and interview methods. For qualitative data, both key informant interviews and focus group discussions were conducted. In this study, key informants are individuals who are knowledgeable about woody species, the purpose of keeping them, and management practices, and residents who lived in the respective kebele for more than 30 years. The key informants were selected using the snowball sampling method (Bernard, 2017). Twelve key informants (six per kebele) were interviewed for the entire study. The purpose of selecting key informants was to identify the local names of tree species and cross-check the number of households practicing parkland agroforestry in their kebeles. The following points were addressed during key informant interviews: farmer's woody species preferences, purpose of keeping, management practices, and their effect on the soil productivity of parkland agroforestry practices in the study areas. In the focus group discussion, model farmers, youths, and women households were selected from each kebele. The purpose of the discussions was to verify farmers' tree needs and management practices. The information generated here was used to validate the information obtained from household respondents.

Data analysis

The data were analyzed by using both quantitative and qualitative methods. The farmers' woody species preference, management practices and their contribution to soil productivity of parkland agroforestry practice were analysed and described in terms of frequency, percentage, and means by using Statistical Package for Social Sciences (SPSS), Version 20.0 (IBM Corporation, USA) and Microsoft Excel 2010. Data from key informant interviews and focus group discussions were analyzed qualitatively to support the quantitative data.

RESULTS

Purpose of keeping scattered trees in the parkland agroforestry system

Regarding the maintenance of a variety of tree species, farmers in the research area keep and cultivate trees for various reasons (Table 1). No single tree species can be considered optimal for every household's needs.

Table 1. Reasons for keeping scattered trees and percent of respondents.

No.	Uses of tree/Shrubs	% of HH respondents
1	Soil improvement	34.21
2	Fuelwood	21.93
3	Timber/Construction	20.18
4	Tools	8.77
5	Shade/Shelter	4.39
6	Fodder	3.51
7	Food	3.51
8	Income	2.63
9	Medicine	0.88

Woody species management practice

The study area's farmers employ a variety of management techniques for the various woody species that inhabit their parklands (Table 2).

Table 2. Response of surveyed households on management practices of some woody species recorded in different parklands of the study area (N=114).

Woody species	Woody Species Management Practice				
	Coppicing	Pruning	Thinning	Lopping	Pollarding
Ziziphus mucronata	-	4	-	3	2
Cordia africana	5	34	1	15	-
Mangifera indica	1	4	1	2	1
Ficus sycomorus	-	2	-	-	2
Albizia gummifera	-	1	-	-	-
Terminalia brownii	-	3	-	-	-
Combretum molle	-	5	-	-	-
Syzygium guineense	-	12	-	-	-
Melia azedarach	-	4	-	7	-
Stereospermum kunthianum	-	1	-	-	-
Oxytenanthera abyssinica	1	-	-	-	-
Sesbania sesban	-	1	-	-	-
Dombeya torrida	-	-	-	1	1
Percentage	**6.14**	**62.28**	**1.75**	**24.56**	**5.26**

Farmer's perception on the impact of woody species management on soil productivity

Information acquired from focus group discussion and key informants showed that the management of woody species is a strategy for managing the competition between trees and crops in parklands (Figure 2). The effectiveness of the parkland agroforestry system in the study areas was influenced by the choice and management of the woody species introduced.

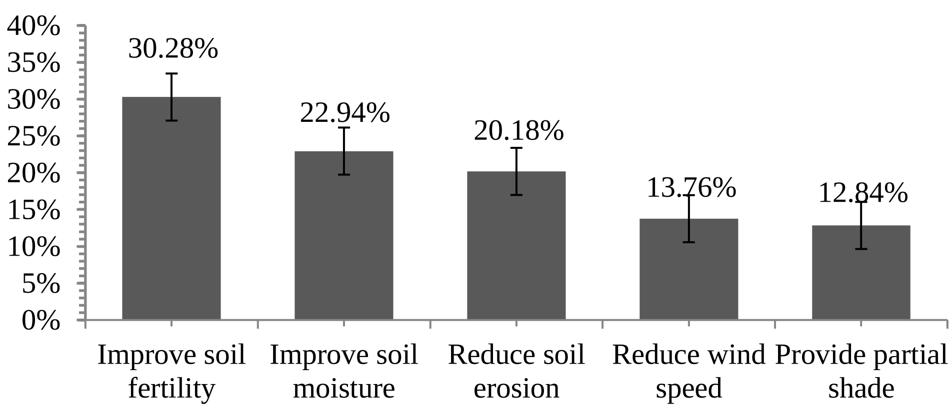

Figure 2. Household perceptions (%) on why soil productivity increased under tree canopy in the parklands of the study areas.

Preferred woody species for soil productivity

The farmers in the study area were familiar with both woody and non-woody components of parkland agroforestry. As a result, they can identify the specific characteristics of woody perennials that make them suitable for agroforestry practices in parklands. The preferred species are indicated in table 3.

Table 3. Some preferred woody species for soil productivity in the parkland of the study area.

No.	Species	% of HH respondents
1	*Cordia africana*	41.23
2	*Mangifera indica*	11.40
3	*Melia azedarach*	9.65
4	*Ziziphus mucronata*	7.89
5	*Sesbania sesban*	7.89
6	*Syzygium guineense*	7.02
7	*Combretum molle*	4.39
8	*Ficus sycomorus*	3.51
9	*Terminalia brownii*	2.63
10	*Dombeya torrida*	1.75
11	*Albizia gummifera*	0.88
12	*Stereospermum kunthianum*	0.88
13	*Oxytenanthera abyssinica*	0.88

DISCUSSION

Participants in this study explained the benefits of the tree species preferred in parkland agroforestry system which include soil fertility improvement, animal fodder, bee forage, timber, food, income generation, house construction, fuel wood, shade, and medicine and farm tools. This result is consistent with research by Yakob et al. (2014), Lemage and Legesse (2018), and Legesse and Negash (2021), who reported that planting or keeping various woody species depends on the practical benefits and services they provide to the farm household.

Participants in the focus group discussion and key informants stated that farmers in the study area traditionally managed the retained/planted tree species in their parklands to get multiple benefits. Pruning and lopping were the most important woody species management practices for enhancing soil productivity by reducing the competition between tree-crop interfaces in the study area. This outcome is in consistent Negash (2007) which indicated the presence different approaches to manage woody species in parkland agroforestry, the two main ones being pollarding and lopping of side branches. According to other studies, several regions of Ethiopia have similar woody species management practices (Agidie et al., 2013; Madalcho and Tefera, 2016; Misgana et al., 2020).

Soil productivity was defined by farmers in the study area as the capacity of soil to increase a particular crop yield under a specified management system. Key informants explained that the purpose of woody management practices undertaken by household members in the study area was mainly to enhance soil productivity by improving soil fertility through litter fall decomposition, preserving soil moisture, and mulching, to provide partial shade, and to reduce competition for lights.

Household respondents indicated that farmers in the study area have the knowledge of different woody species management practices and of which woody species require a different set of management practices and appropriate time to accomplish these activities in order to improve soil productivity. Accordingly, the suitable time for woody species management was at the end of the dry season or early summer to enhance the decomposition of litterfall and the dead wood materials that maintain soil fertility. Similar perception reported from Meskan District, Ethiopia (Bongers (2010).

The management of woody species is perceived to have an effect on the parkland's soil productivity, according to all the HH respondents. Of those, 95.6% (N=109) of the HH respondents said that the woody species management technique raises soil productivity beneath tree canopy by preserving soil moisture, lowering wind speed, minimizing soil erosion, and giving partial shade for understory crops in the study area. This outcome is consistent with studies conducted by Guyassa and Raj (2013) in the Southern Zone of the Tigray region; Dilla et al. (2018) in Ethiopia's Central Rift Valley; and Bussa and Feleke (2020) in the West Guji Zone of Ethiopia. These studies found that the goals of using various woody species management practices were to increase soil productivity by minimizing the detrimental effects at the tree-crop interface and to obtain tree products for different purposes.

In this study, key informants and participants of focus group discussion indicated that crop yield was higher under tree canopies than in the open fields due to improved soil nutrient concentrations and moisture levels associated with greater organic matter. This result is in line with the findings of Hadgu et al. (2009) who reported similar results in the highlands of Tigray; Tesfaye et al. (2018); Dilla et al. (2018) who reported similar results in the Central Rift Valley of Ethiopia.

Household respondents indicated that the choice of tree species for the parkland agroforestry system depends on the farmer's objective, whether it's ecological or economic. According to HH respondents, woody species that shed their leaves have high biomass, decompose quickly, and are added to parklands because they can increase soil productivity by breaking down dead wood, as well as by fallen litter (leaves and twigs) for composting. *Cordia africana*, *Mangifera indica*, *Melia azedarach*, *and Sesbania sesban* were among the suggested woody species to increase soil productivity of the parkland agroforestry systems by applying different management practices. Moreover, these species are highly preferred by farmers in the study area due to their ease in adaptability, propagation, and management regimes. This finding is in consistent with the findings of Abdella et al. (2020) who observed comparable outcomes in Eastern Oromia, and Mamo and Asfaw (2017) who reported similar results in West Haraghe zone, Ethiopia.

The focus group discussion and key informants described how farmers in the study area perceive that certain woody species in parklands can improve soil productivity. They observed that the fallen leaves of these trees decompose more easily in comparison to other tree species, such as *Oxytenanthera abyssinica*. This result is similar to the finding of Lemage and Legesse (2018) who reported a similar outcome in Tembaro District, Southern Ethiopia.

CONCLUSION AND RECOMMENDATION

The present study has provided valuable information on the assessment of farmers' preferences for woody species and woody species management practices and their contribution to the soil productivity of parkland agroforestry in Assosa district, western Ethiopia. The result of this study showed that employing different woody species management practices for different woody species reduces tree-crop competition and increases soil productivity in the parkland agroforestry system in the study area. Pruning, lopping and coppicing were reported to be the most important woody species management practices for enhancing soil productivity by reducing the competition between tree-crop interfaces in the study areas. These management practices need to supported by governmental and non-governmental organizations through improved research, and extension services to obtain optimum results. The species *Cordia africana*, *Mangifera indica*, *Melia azedarach*, and *Sesbania sesban* were the most preferred woody species to increase soil productivity of the parkland agroforestry systems in the study area. Further studies should examine the impacts of these woody species on the understory herbs and crop species of parkland agroforestry practice of the region, especially in the study area.

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