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ORIGINAL ARTICLE

Plant species composition and diversity of Mango-Based Agroforestry systems (MBAs) in the Gamo Zone, Southern Ethiopia

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Agroforestry is an ecologically based natural resource management system in woody grown with an annual crop or livestock on the same unit of land. The fruit tree-based agroforestry system is one of the Agroforest classification were woody components are mainly fruit trees or shrubs. *Mangifera indica* is the largest tropical fruit produced that account large area coverage and farmers have been increasingly integrating with other plant species in the Gamo zone. Therefore, the current study was aimed to investigate the composition of the species of plants species composition and the diversity of mango based agroforestry in Gamo zones in southern Ethiopia. Three kebeles were purposively selected on the basis of the extensive presence of Mango-based production in the Gamo zone: Lante, Chano mile, and Kola Shelle. Totally, sixty 50 m × 20 m sample plots were laid. All plant species were counted and recorded as standard procedures. Forty plant species, belonging to 34 genera and 26 families, were recorded. From the identified species, trees constituted 52.5%, shrubs 27.5%, herbs 17.5%, and lianas account 2.5%. Fabacea and Rutaceae were the most diverse families. Lante (H'=1.9) is more diverse followed by kola Shelle (H'=1.71) and Chano mile (H'=1.66). A study on the carbon sequestration potential, factors determining the mango-based Agroforestry system, and the role to ecology and farmer's livelihoods are recommended.

Keywords: Agroforestry, Gamo zone, *Mangifera indica,* Species diversity.

Introduction

Agroforestry is a dynamic, ecologically based natural resource management system in which trees and/or shrubs are grown in association with agricultural crops, pastures, or livestock either simultaneously or sequentially on the same unit of land (Nair, 1993; ICRAF, 2002).

In this system, there is ecological and economic interaction between the components (Nair, 1993; ICRAF, 2002; Alao and Shuaibu, 2013; Atangana *et al*., 2014). In addition to its potential to improve agricultural land productivity, economic and social benefits of the system for farmers, agroforestry is also known to play an important role in the conservation biodiversity (Terborgh and van Schaik, 2002; Berkes, 2009; Negawo and Beyene, 2017; Derero, 2020).

The fruit tree-based agroforestry system integrates the cultivation of agronomic crops, vegetable crops, fruit trees, and woody component. This system is highly popular among resource-limited producers worldwide due to its relative preproduction phase of fruit trees, the high market value of their products and the contribution of fruits to household dietary needs (Bellow, 2004; DO et al., 2020; Manga, 2021).

Mango, due to its attractive appearance and its very pleasant taste, is claimed to be the most important fruit in the tropics and has been touted as 'king of all fruits'. The fruit contains almost all known vitamins and many essential minerals. Farmers in different parts of the tropics, including Ethiopia traditionally integrate this fruit tree with other components of the so-called mango-based agroforestry system (Mesele, 2013; Alemu, 2016). This system (e.g., alley cultivation) is an important component of agroforestry systems and widely followed in many parts of the world (Nair, 1989; Rahman et al., 2008; Singh, 2018).

Conserving biodiversity in a wide variety of these ecosystems has become a major environmental and natural resource management issue of the country and has been reported by different scholars in Ethiopia. For instance, Mesele (2013) studied four agroforestry systems namely; enset based, enset-coffee based and fruit-coffee-based and chat based. The other author, Adane (2019), reported about the contribution of a fruit tree-based agroforestry system to household income in Sidama zone. However, there is still no previous study about specific fruit species.

Mango is the most produced tropical fruit that accounts for a large area coverage and farmers have been growing mango increasingly on their farm land since introduction of the species to Gamo zone (Alemu, 2016; GZANRDO, 2020).

Today, farmers integrate different species of plants into the mango farm as agroforestry for different purposes. However, there is a lack of suitable information on fruit-based agroforestry in general and mango based agroforestry system in particular. Therefore,

this study was carried out to quantify floristic composition and the diversity of the species of mango (*Mangifera indica L.)* based agroforestry system in the study area.

Materials and Methods

Description of the study area

The study was carried out in the purportedly selected mango growing areas of the Gamo zone in the Southern Nations, Nationalities and Peoples' Region of Ethiopia. According to the former Gamo Zone Agriculture and natural resource development office (2020) the top mango fruit producing potential areas in the Gamo zone were *Chano Mile*, *Lante* and *Kola Shelle*. These potential areas are shown in the map below (Fig. 1). Chano Mille and Lante are 505 km away from Addis Ababa and 285 km away from Hawasa, as well as and 20 Km north of Arba Minch at 06° 14′ 57″ N latitude and 037° 34‵ 35′ E longitude. Kola Shelle is located 520 km away from Addis Ababa and 300 km away from Hawasa, as well as 20 Km south of Arba Minch at 06° 05′ N latitude and 37° 38 East longitude. The areas lie within the lowland agro-ecological zone at altitude ranges between 1200 m to 1285 m.a.s.l. The maximum mean annual rainfall of Chano Mille, Lante, and Kola Shelle are 1000 mm and minimum mean annual rainfall is 300mm. The maximum and minimum mean annual temperatures are 38°C and 14°C respectively (Arba Minch meteorology service, 2020).

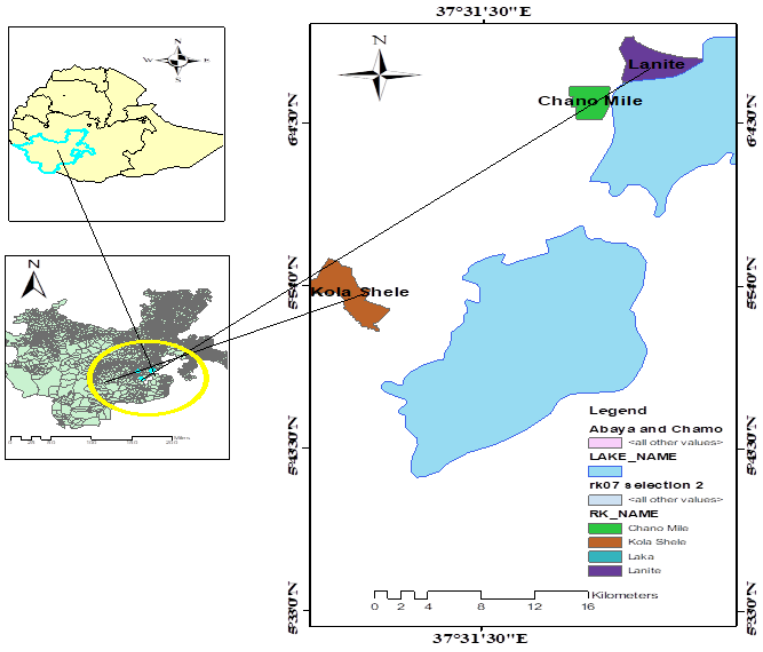

Fig. 1. Map of the study area.

Sampling techniques and data collection method

Sampling techniques

Three kebeles were purportedly selected based on the extensive presence of Mango-based agroforestry practices in the Gamo zone. Namely: *Lante, Chano mile, and Kola Shelle.* The data on species diversity and composition species were collected through field observation, semi-structured interview, and quadrant analysis prepared for the purpose.

Data collection method

To evaluate the diversity and composition of plant species in the mango based agroforestry system (*Mangifera indica L.)* based agroforestry system (50 m × 20 m=1000 m^2) sample square plot was considered in each mango based agroforestry practice. The first plot was randomly selected, and subsequent plots were systematically selected. In total, 60 sample pilots (20 of each kebele) were considered. The species identifications are based on vernacular names in the local language. Species identification for common species was performed in the field using different plant identification keys as references.

Data analysis

Floristic data and percentage of plant species, genera, and habit composition were analyzed in Microsoft excel sheet. The species diversity of the mango-based agroforestry was analyzed according to the Shannon index (Krebs 1985). This is a very widely used index for diversity analysis in various habitats. The Shannon diversity index is calculated as follows.

$H' = -\sum_{i=1}^{S} PilnPi$ ..... (1)

Where,

H′=Shannon-Wiener index of species diversity.

s=number of species in the community

Pi=proportion of the total abundance represented by the i-th species

The true diversity was calculated as $e^{H'}$ and expressed in terms of numbers. After analysis, the Shannon index value was converted into the effective number of species/true diversity.

Results and Discussion

Floristic composition of mango-based agroforestry systems (MBA)

A total of 40 plant species were recorded in the mango-based agroforestry system of the study area. The identified species belong to 34 genera and 26 families (Table 1). The species also distributed among different families in different proportions. Consequently, *Fabacea* and *Rutaceae* were represented by 5 species (13% of identified species*). Boraginaceae, Euphorbiaceae, Meliaceae, Poaceae, Solanaceae* represented by 2 species, and the rest of the families were represented by 1 species each (Table 1). The dominance of species in Fabacea and Rutaceae could be because for farmer's preference of the species for compatibility with mango, soil fertility improvement, palatability as animal feed. This is in line with the finding of Bucagu et al. (2013) and Megabit et al. (2018) on the farmers' interest and preference of farmers. Tadesse et al. (2019) of Ethiopian Sub-Humid Lowlands Home Gardens and Traditional Parkland Agroforestry Systems also reported that the most dominant family of identified species belong Fabaceae.

The dominance of *Rutaceae* might be due to the farmer's experience of integrating other fruit trees with mango. This could be confirmed as the family contains several economically important fruit trees as well as several ornamental species (Britannica, 2016). Another researcher Alemu (2016) also reported that farmers at Lante kebele ingrate fruits such as mango, papaya, lemon, false banana ('Enset'), orange, avocado and banana as sources of supplementary food and income generation opportunities. Some species are rarely available in mango-based agroforestry. It could be the species nature of not sustaining in dense shed of mango tree, as stated in Elevitch, (2006).

The plant species were also identified in terms of their habit. Accordingly, the species were grouped in four habit; 52.5% trees, 27.5% Shrubs, Herbs 17.5% and 2.5% (Fig. 2). In terms of gene composition, Fabacea represented 4 genera and *Rutaceae, Boraginaceae, Meliaceae, Poaceae, and Solanaceae* represented 2 genera each and the rest of other represented 1 genera (Table 1). Woody species (trees and shrubs) were dominant components in mango-based agroforestry of the study areas. This could be due to farmer knowledge and experience in integrating compatible woody species (trees and shrubs) than herbs and lianas. Different researchers from different agroforestry practices revealed that the integral component of agroforestry practices is woody species. For example, Mekonnen et al., (2014) reported 44 woody species from 69 identified plant species Homegarden agroforestry from Jabithenan District, north-western Ethiopia. Among the 59 plant species by Legesse and Negash, (2021) from the Kachabira district, southern Ethiopia, 69% of the species 42% were trees 27% shrubs 29% and climber 2%. The result of having dominant woody species is in line with that of Melese and Daniel (2015); Chaminda and Rasika (2014); Mulgeta (2018).

Table 1. Family, genera and species distribution identified species.

S.No	Family	No. of species	%	No. genera	%
1.	*Fabaceae*	5	13	4	12
2.	*Rutaceae*	5	13	2	6
3.	*Annonaceae*	2	5	1	3
4.	*Boraginaceae*	2	5	2	6
5.	*Euphorbiaceae*	2	5	1	3
6.	*Meliaceae*	2	5	2	6
7.	*Poaceae*	2	5	2	6
8.	*Solanaceae*	2	5	2	6
9.	*Anacardiaceae*	1	3	1	3
10.	*Araceae*	1	3	1	3
11.	*Asteraceae*	1	3	1	3
12.	*Balanitaceae*	1	3	1	3
13.	*Bignoniaceae*	1	3	1	3
14.	*Caricaceae*	1	3	1	3
15.	*Celastraceae*	1	3	1	3
16.	*Convolvulaceae*	1	3	1	3
17.	*Cucurbitaceae*	1	3	1	3
18.	*Lauraceae*	1	3	1	3
19.	*Malvaceae*	1	3	1	3
20.	*Moraceae*	1	3	1	3
21.	*Moringaceae*	1	3	1	3
22.	*Musaceae*	1	3	1	3
23.	*Myrtaceae*	1	3	1	3
24.	*Rhamnaceae*	1	3	1	3
25.	*Rubiaceae*	1	3	1	3
26.	*Proteaceae*	1	3	1	3
Total		**40**	**100**	**34**	**100**

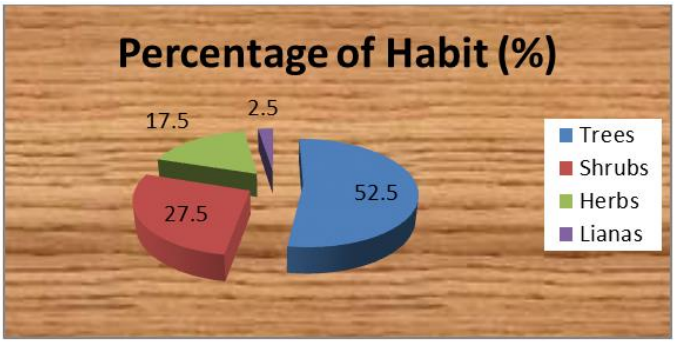

Fig. 2. Habit (life form) of identified plant species.

Plant species richness and diversity of Mango based agroforestry systems

The species richness was relatively higher in Lante (25) followed by Chano Mile (23) and less for kola Shelle (21) as indicated in (Table 2). According to the Shannon diversity index MBAs in Lante Kebele had the highest species diversity (H'=1.9, 7 effective species) followed by MBAs in *Kola Shelle* Kebele (H'=1.71, 6 effective species). The MBAs at *Chano mile* have relatively low species diversity (H'=1.66, 5 effective species) compared to two mango producing kebeles (Table 1). The difference in relative diversity could be due to the farmer's experience in the management of integrated different woody and non-woody components in mango farms. The higher diversity in Lante followed by kola Shelle kebele due to the farmers practice of planting and managing the species in the mango farm. This is also stated in the research reported by Tazebew and Asfaw, 2018; Daba et al. (2020) as the variation in diversity was due to the farmers' management strategy of farmers. On the variation in other hand, the diversity variation might be due to the preference of the farmer, the socioeconomic background of the households, perception and culture, shortage of seedling and pest problems, availability and proximity to irrigation water may influence the extent of integration of different plant species in the agroforestry setting (Talemos et al., 2013; abebe 2005; Agidie 2013; Lemessa and Legesse, 2018).

Table 2. Richness and diversity of plant species in Mango-based agroforestry systems.

		Diversity parameters	
Study kebeles	***Species richness***	***Shannon diversity (H')***	***True diversity($e^{H'}$)***
Lante	25	1.9	7
Chano mile	23	1.66	5
Kola shelle	21	1.71	6
Total	40		

Conclusion

Forty plant species were recorded in the mango-based agroforestry system of the study site. The identified species belong to 26 families and 34 genera. *Fabacea* and *Rutaceae* were the dominant family represented by five species each and *Boraginaceae, Euphorbiaceae, Meliaceae, Poaceae, Solanaceae* represented by two species, and the rest of the families were represented by one species. The identified species were classified into three habits, Trees (52.5%), Shrubs (27.5%), Herbs (17.5%), and Lianas (2.5%). The species richness was higher in the mango-based Agroforestry system of Lante followed by the kola Shelle and Chano mile. The highest diversity of species was recorded in Lante (H'=1.9) followed by Kola Shelle (H'=1.71) and Chano mile (H'=1.66). A further detailed study is needed on the carbon sequestration potential, socio-economic and ecological factors determining in the mango-based Agroforestry system and the contribution of the system to livelihood.

Conflict of Interest

There is no declared conflict of interest.

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