

On-farm Demonstration of Homegarden Agroforestry Design and Its Role in Improving Livelihood of Small Holder Farmers at West Arsi Zone, Oromia, Ethiopia

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Abstract: Food shortage and security are the major livelihood challenges that have been facing developing countries. Homegarden agroforestry is one of the agroforestry options to overcome these challenges. The research was designed to evaluate the design role in improving the livelihood of smallholders, to see the farmers' perception of the design irrespective of their existing practice (Enset Monoculture), and to set a baseline for the improvement of the practice design for future at the area. Enset and coffee are major perennial crops in the experiment. Both crops lack appropriate management i.e. especially space and its monoculture system which lacks a mixture of annual and perennial crops gaining a high economic return. The experiment focused on spacing that can give the chance of integrating different crops within different arrangement regimes and behaving different layers of strata. The design was given the trial farmers the opportunity of growing a mixture of different annual and perennial crops under the arrangement. 2m spacing b/n coffee, 1m spacing b/n coffee and Enset as well as 2m distance between Enset were used in the arrangement. The result showed that the average maturity of Enset in the arrangement is 4 years while that of monoculture is 6 years. The productivity of the design was high as compared to the monoculture one that also got high acceptance among farmers. The growth pattern of perennial crop/ tree in the arrangement is increasing which can formulate different strata in the future as it is known in the complex homegarden agroforestry system (HAFs). Overall it has a greater advantage for ameliorating the microclimate of the area and also has greater value in conserving the biodiversity of the area.

Keywords: Coffee, Enset, Homegarden Agroforestry, Monoculture, On-farm Demonstration

1. Introduction

Homegarden agroforestry system is one of the most prevalent types of land use systems suitable to high rainfall areas in tropical conditions. Homegardens represent intimate, multistory combinations of various perennial and annual crops, sometimes in association with domestic animals, around the homestead which serves as a permanent or temporary. Traditional resource management adaptations such as homegardens in agroforestry systems may potentially provide options for improvement in livelihoods through simultaneous food production (either directly food grains, fruits, vegetables and root crops or indirectly improving soil conditions and there

by promoting understory crop productivity especially on degraded sites), fodder and firewood, high biodiversity, low use of external inputs, soil conservation potential, nutritional security, ecological benefits, socio-cultural as well as mitigation of the impact of climate change. By providing supportive and complementary roles with a flexible approach, homegardens offers specific social and environmental benefits across a range of landscapes and economies [1]. Homegardens to be very specialized systems adapted to subsistence land-use. It is structurally too complex to be suitable for manipulation and improvement [2]. By adoption of home garden agroforestry system farmers will have preferences for more valuable species.

Home gardening is widely practiced in the south and south-Western highlands of Ethiopia. At the altitudes of 1500-2200 meters above sea level, where moisture and temperature conditions are more favorable for agriculture, the gardens are complex in species composition and structure. These gardens are characterized by unique combination of two dominant perennial crops; enset and coffee. Other components of these multi-species agro ecosystems include, chat (*Khata edulis*) which is a mid-stimulant, root and tuber crops, fruits, vegetables, cereals, spices and other crops. Moreover, Livestock are kept in gardens and different tree species are grown to serve productive as well as protective function [2].

The presence of many tree species and shrubs of different uses contributes to the diversification of tree products and sustenance of agricultural systems [2]. According to the report of Abebe [3], the increase of cash crop production and financial income obtained more attention while declining food crop production and biodiversity of the system were given little attention by the farming households. The transition towards monoculture cultivation of crops has affected the rational of weighing and balancing economic gain and the socio-cultural and ecological benefits derived from the traditional homegardens agroforestry.

Homegardens have been supporting a very dense population of 367 to 562 persons per square kilometers. This figure is 6 to 10 times higher than the Ethiopian average of 55 persons per square kilometers [4]. The ability of the systems to support such a large population has been due to the integrated perennial crop base of the systems where crop diversity and high productivity of enset contributed to stability and food security. The share of enset in most of these gardens is still high but it does not well organized in the study areas. Both crops lack appropriate design i.e. especially space and it is monoculture system which lacks mixture of annual and perennial crops gaining high economic return. Research and extension efforts should aim at exploring possibilities to enhance sustainability in the areas. The share of enset in most of these gardens is still high but it does not well organize in the study areas. Both crops lack appropriate design i.e. especially space and it is a monoculture system that lacks a mixture of annual and perennial crops gaining a high economic return. Research and extension efforts should aim at exploring possibilities to enhance sustainability in the areas. The experiment focused on spacing that can give the chance of integrating different crops within different arrangement regimes and behaving different layers of strata. Therefore, the project was designed to *evaluate the design's role in improving the livelihood of smallholders, to see the farmers' perception of the design irrespective of their existing practice (Enset Monoculture), and to see farmers' perception toward practice as the whole.*

2. Research Methods

2.1. Description of the Study Area

The study was conducted in highlands of West Arsi Zone,

Arsi Nagele District where continuous transformation of landscapes from natural forest to cultivated lands exist. Arsi Nagele district is situated at latitude of 7°09' N to 7° 41' N and 38°25' E to 38°54' E and an altitude ranges from 1500 to 2300 meter above sea level (Negele Arsi Agriculture and rural development office, 2013). It is located at 225 km South of Addis Ababa the capital city of Ethiopia. The average of rain fall ranges from 800 to 1400 mm with the average minimum and maximum of temperature is 15°C and 20°C respectively. The rainfall is bimodal, the long rain occurs from June to September and the short rain fall is from March to April with highest usually recorded in July and August, respectively. Arsi Nagele district is divided in to three major climatic zones based on altitude including low, mid and high altitudes. Mixed crop-livestock system is the mode of agriculture in district.

Specifically to the study area enset is the major perennial crop found in the gardens of many farmers with monoculture systems. It is an adaptive crop and is used as a food reserve during the food shortage in the area. However no research data at our hand and not the concern of this experiment, coffee is an adaptable crop in both areas. But it is not found in the garden of many farmers as Enset.

2.2. Homegarden Establishment

Homegarden sites were established with the two dominant perennial crops; Enset and Coffee and with other annual crops included based on farmers' preference and need. The new spacing design introduced to the farmers includes; 2m distance between plants was used for both coffee and Enset, a 2m distance b/n row for coffee and Enset as well as 1m between the rows of coffee and enset. A total plot size of 160m² (8mx20m) was used for enset and coffee plots. Coffee started planting on its row 1m after enset. As the objective was to give farmers the chance of using different crops mixture types within the system, different crop mixture types exist based on the willingness and skill of the farmer. Except few of them, the majority of the farmers used different types of crop mixture types interchangeably in four years. So the types included in the arrangement by farmers were; Enset-Coffee-Maize-type, Enset-Coffee-Horticultural Crops type, Enset-Coffee-Spices type, and the sub-systems of these fours. Among the Fruit trees, Banana and Persia americana were included while other MPTs were also included in the arrangement plot as per farmer preference. The existing variety of Enset was used to avoid many criteria's important to evaluate new variety to the area and Coffee arabica from Sheshemene governmental nursery.

2.3. Data Collection

Economic data's were recorded yearly from the plots of the two practices. Other data's like list of the crops grown in the plot, Maturity year of enset per farms and per treatments to calculate average maturity year of enset and number of perennial trees in the arrangement plot were recorded. Farmer's field day was repeatedly organized for evaluating the perception of farmers on the practice.

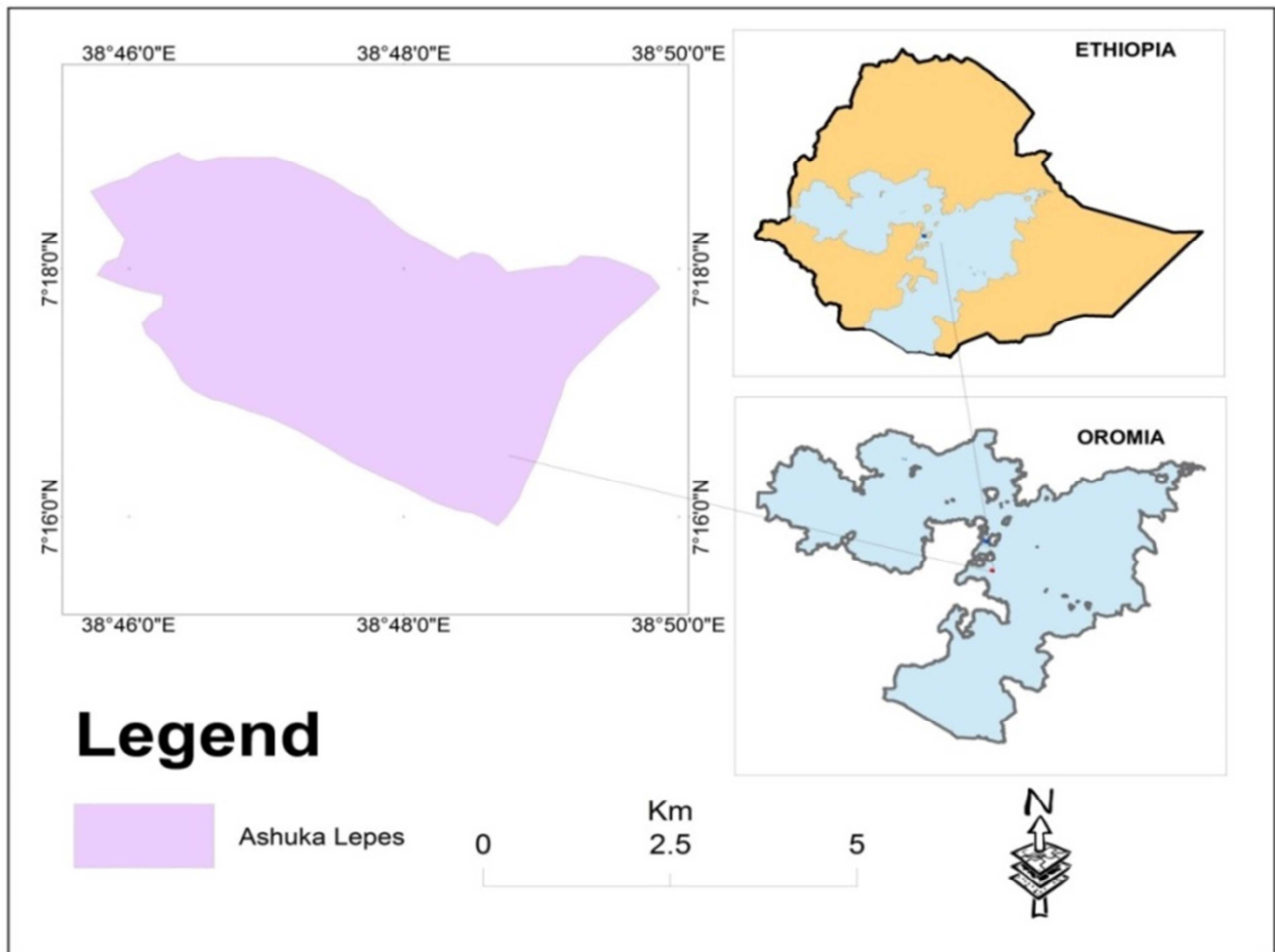


Figure 1. Map of Ashuka-Lephis Kebele Administration (PA).

2.4. Data Analysis

The collected data's were analyzed descriptive statistics like average, percentage and frequency. Profitability indicators like Total costs, Gross Income and Net Income were used to analysis the economics. Additionally Net Present Value (NPV) and Benefit Cost Ratio (B/C ratio) were included to evaluate the worthiness of the project by taking the time factor in to account (i.e involving discounting). Finally, the results were summarized using tables and graphs.

3. Results and Discussion

3.1. The Trend of Perennial Trees/Crops in the Design

The number of woody species in the arrangement plot is increasing with increasing awareness of the farmers on integrating multipurpose trees including fruit trees in the garden. Tolera *et al.* [5] and Abebe [2] reported, with increasing age and size of homegardens, the diversity of woody species in the garden plots increased. The trees growth pattern is increasing which can formulate different

strata in the future as known in the home garden as also described by Peyre *et al.* [6], Tesfaye *et al.* [7] and Almaz [8]. This has greater advantages for ameliorating micro climate of the area, and also has greater value in conserving the biodiversity of the area. This all are agroforestry payments for ecosystem services [9]. The increasing number of trees in the garden has a prominent role in ameliorating the micro climate of the areas and conserving the biodiversity of the area. According to Nyong *et al.* [10] the presence of trees in homegarden agroforestry also has a promising advantage to mitigate climate change and global warming through Carbon sequestration. The growth and Yield performance of perennial trees/crops in the arrangement Plot indicated in the following graph as follow;

The result (Table 1) showed that average maturity of Enset in the arrangement is 4 years while that of monoculture is 6 years. This shows the productivity of the introduced design is high as compared to the monoculture one. The maturity time of enset in mono culture practice is parallel with the result obtained by [11] reported 5-7 years. But the maturity time for the enset in the design is 4 year which is little bit less than the year range they stated.

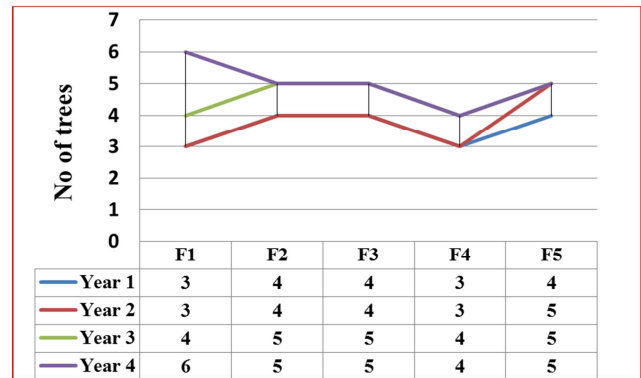
Table 1. Maturity year of enset per farmers per treatment plots.

No.	Type of practice	F1	F2	F3	F4	F5	Average
1	Enset Monoculture	7	6	6	N/A	6	6
2	Enset-Coffee	5	4	4	4	4	4

3.2. The Role of Design in Improving the Livelihood of Small Holders

Economic Analysis is used to evaluate the role of design in improving the livelihood of small holders. Four year Partial Budget analysis of the arrangement in hectare extrapolated from 160m² plots is calculated by using profitability indicators in the table below. From the result the spacing (design) to the area exceeds the monoculture or existing practice of the farmer at least in double economically. However, this is not to mean that the plots are fully utilized. Since the management practices are different among farmers the comparison is only between the practices (Enset-Coffee vs. Enset Monoculture) per a farmer. From the field reality the more the farmer utilized the spaces obtained in the arrangement, the more they benefited. Except farmer one the yield obtained from the design i.e. Enset-Coffee plot is sufficient under other four

farmers. B/C greater than one is acceptable and almost all treatments fulfill it. However, maximum and profitable return found under the evaluated design (Spacing).

**Figure 2.** Trend of perennial trees/crops in the design per farmer's field.**Table 2.** Partial budget analysis of the treatments.

Farmer	Type of Practice	Total costs HEC/yr.	Gross Income HEC/yr.	Net Income HEC/yr.	NPV10%	B/C ratio
F1	HG (Ens+Coff based)	4,427.66	10,127.31	5,699.65	1,051.23	1.3
	HG (Enset Monoculture)	5,853.17	17,361.11	11,507.94	4,673.36	2.0
F2	HG (Ens+Coff based)	10,129.70	148,032.20	137,902.50	105,597.35	13.6
	HG (Enset Monoculture)	2,275.80	99,566.18	97,290.38	78,524.45	42.7
F3	HG (Ens+Coff based)	7,708.33	82,375.00	74,666.67	55,337.47	9.7
	HG (Enset Monoculture)	6,081.08	23,648.65	17,567.57	9,492.96	1.5
F4	HG (Ens+Coff based)	11,912.68	136,081.56	124,168.88	92,773.71	10.4
	HG (Enset Monoculture)	N/A	N/A	N/A	N/A	N/A
F5	HG (Ens+Coff based)	22,443.61	95,864.66	73,421.05	42,130.12	3.3
	HG (Enset Monoculture)	9,000.00	45,937.50	36,937.50	23,088.84	4.1

Cost includes fixed (land) and all variable costs. The average cost of land for 0.025ha at Negele Arsi site is 1100 ETB (Ethiopian Birr) yr⁻¹ while 1400 ETB yr⁻¹ at Sheshemene site.

Gross income is not only from coffee and enset yields but also including different horticultural crops sown under arrangement because of the chance given by the arrangement unlike Mono Enset and Maize Yields. Fruits are other outputs that can be obtained from the arrangement in the future.

Net Income is the difference between Gross Income and Variable Cost.

3.3. Farmers' Perception toward the Design of the Practice

Farmers' perception was identified by the method used by [12]. Based on this, the field day participants (Trial farmers, selected farmers from the localities and team of experts from the district level to KA office) confirmed the importance of the practice in improving farm productivity (94.4%) and increase farm income in table 3 below. They also appreciated the design arrangement for growing a mixture of different annual and perennial crops, and the improved maturity time of the Enset. It also has been various payments for ecosystem

services (Carbon sequestration, Soil erosion control, water quality, and biodiversity) are often crucial for the widespread adoption of agroforestry systems [9]. These and other services were evident to the farmers for the adoption of the practice design arrangement. Participants almost fully accepted it during field day held at Ashoka – Lephis KA in Negele Arsi District.

Table 3. Farmers' perception toward the design of the practice.

No.	Farmers perception (30)	Freq.	%
1	As a new practice that is difficult and un compatible to local farming condition	1	3.3
2	As a practice that can improve farm productivity	28	94.4
3	As a practice not properly understood	0	0
4	As a common practice among local farmers	1	3.3
Total		30	100

4. Conclusion and Recommendations

4.1. Conclusion

Both coffee and enset are important perennial trees/crops that have a prominent role in the economy of the household

individually and the country as a whole. The combination of these two native perennial crops and their dominance in the systems, therefore, contribute to the socio-economic as well as ecological sustainability of the systems. The presence of crops with different functions fulfills the nutritional and monetary needs of the households. The management of multispecies agroecosystems, based on perennial crops fulfilling the subsistence and cash needs of households, enhances agricultural sustainability. The replacement of monoculture enset practice with multistory enset-coffee plots with this design and other appropriate arrangements/designs through research and extension effort; is likely to increase the ecological benefits derived from the integrated and complex systems, and enhance their long-term sustainability. During the field day, the participants claimed the supply problem of different spices, horticultural crops, and improved seedlings of fruit trees that have exerted pressure on the intensification of varying crops within the system.

4.2. Recommendations

- 1) By taking this spacing design as a base line, research is important to verify other spacing that could improve the performance of the system.
- 2) Close collaboration between research organizations and Zonal/ District offices help improve the problem of quality seed and seedlings whether it needs research or extension of existing technologies.
- 3) Finally, further research is also important to identify the most adapted coffee variety to the agro-ecology of the areas and resistant to Coffee Berry Disease (CBD) with compatible shade trees.

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