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Research Article

Biodiversity Management within the Agroecosystem of the West Arsi Zone, Southeast Ethiopia

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ABSTRACT

There is a growing realization worldwide that biodiversity is fundamental to agricultural production and food security. The main objective of this study was, therefore, to assess biodiversity management practices within the agroecosystem of the West Arsi Zone of Southeastern Ethiopia. Four Woredas namely, Wondo, Adaba, Kokossa and Nensebo were purposively selected based on their conservation and diversification practices. The Primary data collection methods like questionnaires, Focus group discussion, and key informant interview and field observation were used to identify the biodiversity conservation practices, especially, the vegetation diversity and the livestock management practices within the agroecosystem. Books, reports and articles were used as secondary sources of information to support the study. Diversity indices, Shannon diversity index and Evenness index were used to identify the vegetation diversity based on the three dominant land use practices homegarden, field crops and grazing land. To sum up, Least significance Difference (LSD) test at 0.05 was used to identify the vegetation diversity per land uses and households and also to check significant level among the household respondents. Therefore, SPSS (version 21) (Statistical Package for Social Science) was implemented to assess the diversity of plants and animals within the agroecosystem of the study areas. The result of the study indicates that there was significant different among the Woredas ($P<0.05$) regarding vegetation diversity per land uses and households. Based on the field experiments, homegarden is the most land use category having different diversity of vegetation ($H'=4.77$) followed by field crops ($H'=4.06$).From equity perspective, the homegarden vegetation of the agroecosystem is also the most evenly distributed ($J'=0.99$) followed by grazing land ($J'=0.98$). From the four Woredas, the highest vegetation diversity was recorded in Wondo Woreda, particularly, in homegarden (20.86 ± 3.85), while the lowest vegetation diversity was recorded in the homegarden of the Nensebo Woreda (7.38 ± 0.644). However, the Kokossa Woreda is the best in terms of vegetation diversity within the grazing land (13.774 ± 1.54) followed by the Nensebo Woreda (9.8723 ± 1.115). There is also significant variation ($P<0.005$) among the Woredas regarding the livestock holding per households. For instance, Kokossa Woreda is the best in terms of cattle population per households (12.495 ± 4.633) followed by the Adaba Woreda (8.043 ± 2.86). Since the agroecosystem of the West Arsi Zone is full of animal and vegetation diversity, all concerned stakeholders should give due attention for the area to get greater output of production.

Keywords: Biodiversity; Management; Agroecosystem; Land uses; West Arsi Zone

INTRODUCTION

There is a growing realization worldwide that biodiversity is fundamental to agricultural production and food security, as well as a valuable ingredient of environmental conservation. Throughout centuries, generations of farmers have developed complex, diverse and locally adapted agricultural systems, managed with time tested ingenious practices that often lead to community food security and the conservation of biodiversity [1]. A decline in agricultural productivity due in large extent to resource degradation and increasing public awareness has led the countries to consider biodiversity conservation in agricultural planning [2]. Yet, predominant patterns of agricultural growth have eroded biodiversity in, for example, plant genetic resources, livestock, insects and soil organisms. This erosion has caused economic loss, jeopardizing productivity and food security, and leading to broader

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social costs. Equally alarming is the loss of biodiversity in natural habitats from the expansion of agricultural production to frontier areas. Agricultural management systems are highly dependent on interactions with their surrounding ecosystems. Thus, sustainable use of plant and animal genetic resources should involve the conservation of agricultural biodiversity as an integral component of sustainable management practice [3].

Innovative biodiversity-rich farming systems can potentially be high-yielding and sustainable, and thus, support persistence of biodiversity by limiting the adverse effects of modern mono-cropping agriculture. Adoption of sustainable farming practices that utilize and conserve biodiversity may ultimately improve environmental quality and limit agricultural expansion into natural forests as well as the negative impacts of agriculture on biodiversity [4]. Hence, there is a compelling case for advocating conservation that is in tandem with livelihood needs of the people affected. In this regard, the systems have been advocated as a suitable pathway for improved livelihoods as it also impinges on biodiversity in working landscapes through incorporation of additional species in to agriculture.

Agro-ecosystems are communities of plants and animals interacting with their physical and chemical environments [5], that have been modified by people to produce food, fibres, fuel and other products for human consumption and processing [6]. The conservation of biodiversity across different land uses including homegarden, agricultural field and grassing land are currently getting due attention in tropical areas [7]. Homegarden is home for different trees and shrubs, vegetables, fruits, tubers and cereals. Agricultural fields also harbor the variety of cereals, vegetables and trees and shrubs too. In addition to cultivation of crops, farmers also prefer to manage certain plants species in their farmlands [3,8]. Grassing land, on the other hand, is the source of different grass species, trees and shrubs help maintain biodiversity [9,10]. Practices that conserve, sustainably use and enhance biodiversity are necessary at all levels in farming systems, and are of critical importance for food production, livelihood security, health and the maintenance of ecosystems [11,12]. Many people say that local knowledge and culture are also integral parts of agricultural biodiversity, because it is the human activity of agriculture which conserves biodiversity through sustainable use [13].

Ethiopia is also known as one of the home of agroecosystem [14-16]. The country is rich in faunal and floral diversity [17,18]. The flora of Ethiopia is estimated to be between 6,500 and 7,000 species, of which 10-12 percent is considered to be endemic [14]. According to CSA, Ethiopia is the first by endowing large number of livestock population and diversity in Africa [19]. The country has about 55 million cattle, 28 million goats, 27 million sheep, 1.1 million camels, 2 million horses, 7 million donkeys and 51 million chickens. The livestock population is almost entirely composed of indigenous animal species. The existence of diverse farming systems, socio-economics, cultures and agro-ecologies has endowed Ethiopia with a diverse biological wealth of plants, animals, and microbial species, especially crop diversity [14,20].

The country is one of the Centers of crop origin and diversity and harbors globally importance crops like sorghum, *Guizotia abyssinica*, millet, Arabica coffee, durum wheat and teff are among others [14-16,18,20]. The country harbors important gene pools of crop wild relatives for at least over 120 species of crops, including grains, pulses, oil seeds, vegetables, tubers, fruits, spices, stimulants, fibers, dyes and medicinal plants. In addition, several crops that were domesticated outside of East Africa exhibit high secondary diversification in Ethiopia, as evidenced in farmer varieties of wheat, barley, and several pulses [21]. For coffee genetic resources distribution, Taye as cited in Ethiopian Panel on Climate Change reported that there are about 21,407 coffee germplasm (10,573 arabica, 8,000 robusta, 1,282 mascaro and 1,552 arabica or robusta in Cameroon) in the different field gene banks of some African countries, of which around 89.85% is found in Ethiopia. Ethiopia alone possesses around 99.8% of total Arabica coffee genetic diversity. In the same way, the west Arsi zone is one of the conducive areas of production and has long years of experiences of farming systems. The zone is known by cultivation of different varieties of crops, diversity of vegetation species and small scale production of animals. The dominant land uses of the zone within the agroecosystem are homegarden, field crops and grazing land. The zone has several years of experiences in conservation of biodiversity, particularly, plants and animals, in each land use category. The objective of the study is, therefore, to understand biodiversity management practices within the agroecosystem of the Zone.

MATERIALS AND METHODS

Description of the study area

Use Location: West Arsi zone is located in Oromia National Regional state and shares boundary with east Shewa zone to the north, SNNSRS to the west and south, Arsi to the northeast, Guji to the Southeast and Bale Zone to the East. Shashemene town is the administrative center of the zone. It is located at 250 km from Addis Ababa and the total area of the zone is 12,556 km2. West Arsi zone is located in the Rift Valley Region. The zone lies between 60º12'29" to 70º42'55" latitude and 38º004'04" to 39º046'08" longitude. The zone has 12 districts, 4 urban administrative, 332 peasant associations. The zone is home for three lakes (Langano, Lake Shalla and Abjata) and Kaka Mountain is one of the largest mountains in Oromia next to Tullu Dimtu and Chilalo. It is the best ecosystem of Afro alpine vegetation (Figure 1).

Population: According to the Agricultural Office of the West Arsi Zone, the total population of the zone is estimated to be 1,964,038 that mean 973,743 are men and 990,295 women. The Oromo (88.52%) and the Amhara (3.98%) are the two largest ethnic groups in the zone; while all other ethnic groups consist of 7.5% of the population. Afan Oromo is spoken as a first language by 87.34% of the population and 6.46% spoke Amharic; the remaining 6.2% spoke all other their primary languages. The majority of the inhabitants are Muslim, with 80.34% of the population, while 11.04% of the population is followers of the Ethiopian Orthodox Christianity and 7.02% of the population are categorized under Protestantism.

Agro-ecology: The West Arsi zone has the three common traditional agro-ecology zones namely, highland (2300 masl-3200 masl), midland (150 masl to 2300 masl) and lowland (500 masl to 1500 masl) areas. The altitude of the zone generally ranges from 500 meters above sea level (masl) to 3200 masl. Attitudinally, the highland areas (locally known as Dega or Bidaai) covers 45.5% of the zone, whereas 39.6% of the zone midland (Woinadega or Badadaree) and the remaining 14.9% the zone is categorized under lowland hot and arid climate (Kola or Gamojjii). Most parts of the zone have elevations of ranging from 1500 m to over 3200 m. The annual average temperature of the zone ranges from 15°C to 20°C [22].

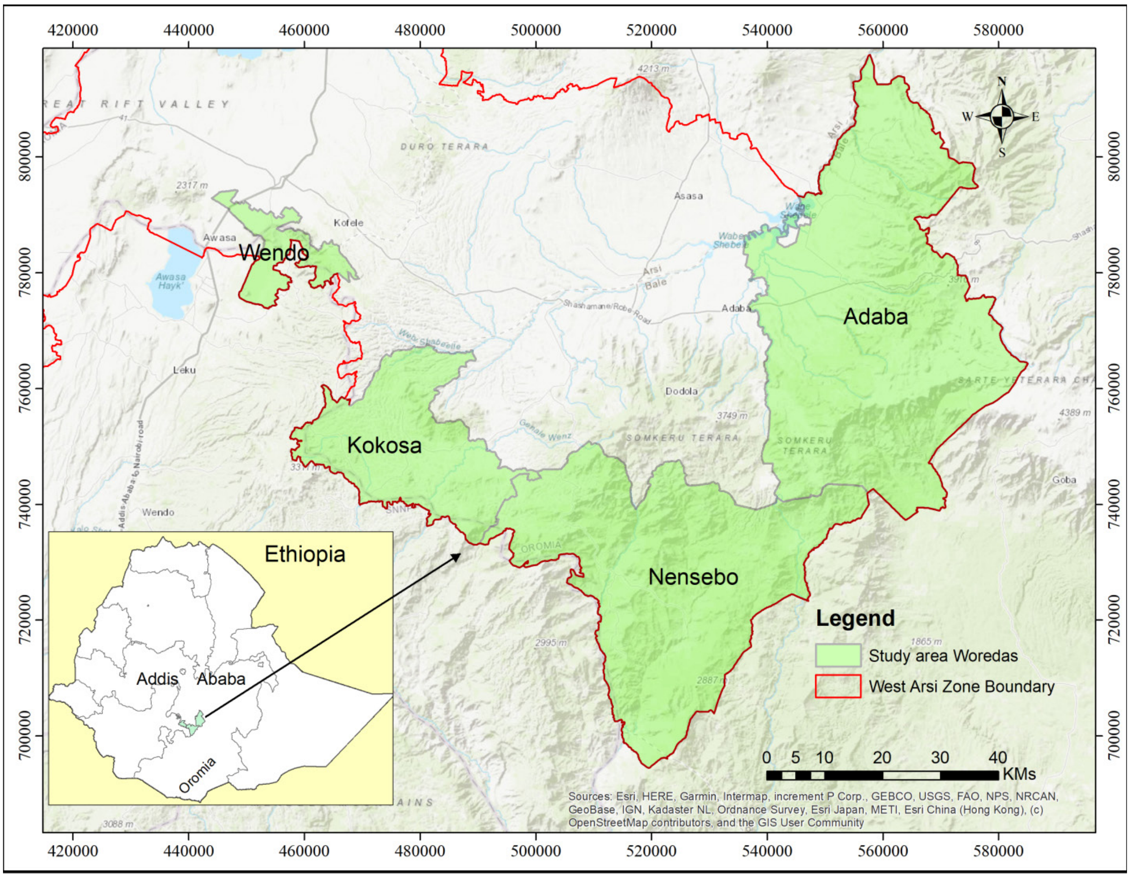

Figure 1: Location Map of the study area- ( ) Study area Woredas; ( ) West Arsi zone Boundary.

The zone has three distinct seasons. Meher season (ganna), which contributes major rainfall from June to mid of September. The Meher mean annual rainfall ranges from 800 mm to 1400 mm. Belg season (Arfaasaa) is the small rainy season of the zone from February to May. 31% and 56% of the zone's rain fall amount is from Belg and Meher respectively. Meher is the main production season in the country and in the zone in particular. The Bega season (Bona) is the dry season of the year from October to January.

Socio-economic activities: The major economic activities of the rural area are mixed farming in which cultivation of crops and animal production is practiced side by side. The most commonly produced crops in the zone include barley, wheat, sorghum, teff, maize, haricot beans, horse bean, field peas, linseeds, tomatoes, cabbage, potato, pepper, root crops, tuber crops, and coffee and enset. The zone is also known by the rearing of animals including cattle, equines (donkey, horse, and mule) and small ruminants, particularly, the production of sheep is the most common activities in the highland areas of the zone. The zone has also different woody species, trees and shrubs.

Research design: The west Arsi zone is full of different ethnic groups who occupied the area from different regions of the country. The communities live together and share different experiences with regard to agricultural practices and management of natural resources. Besides, the local peoples, there are also other communities who occupied the rural areas of the zone as migrant from other areas of the country, particularly from, Sidama and Walaita zones, Eastern and Western Haraghe and some are also from Amhara Regional National state, specifically from Wollo, Gojjam and Gonder. The whole communities are generally engaged in three land use practices namely, agricultural field (field crops), homegarden and grazing lands are prominent. Meher (ganna) is the major rainfall and production season. Belg season (Arfaasaa) is the small rainy season of the zone. Even if there are many religions, majority of the communities are the followers of Muslim.

In this study, both household based cross-sectional design and field based cross sectional design were used to gather reliable data pertaining to timeframe work. Household based cross-sectional design was used to investigate the plant and animal diversity managed based on the three lands uses (Homegarden, Field crops and Grazing Land) in the agroecosystem of the study areas. Field based cross sectional design was implemented to identify and quantify the type of plant and animal species that the different communities manage within the agroecosystem of the zone. Furthermore, descriptive research design was implemented to describe the state of management of biodiversity within the agroecosystem.

Sample size determination: If populations are large, it is important to implement a representative sample for proportions for the study under consideration. To meet the appropriate sample size, the model developed by Cochran was implemented [23].

$$n = \frac{Z^2 pq}{e^2}$$

Which is valid where n is the sample size, Z2 is the value of the standard variate at a given confidence level (confidence level, e.g., 95%) table showing area under normal curve, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1-p. The value for Z is found in statistical tables which contain the area under the normal curve.

Therefore,

$$n = \frac{(1.96)^2(0.5).(0.5)}{(0.5)^2} = 384\,households$$

Household respondents were proportionally selected from each kebele based on the decided sample size (Table 1).

Table 1: Proportionally sampled household respondents

Study woredas	Kebeles	Total HHs	Proportionally sampled HHs
Wondo	Gotu Onama	1500	71
	Shasha	1250	59
Kokossa	Gutu	1050	50
	Garbarufa	920	43
Adaba	Ejersa	1390	65
	Furuna	1033	49
Nensebo	Gemechu	550	26
	Garambamo	440	21
Total HHs		8133	384

Sampling techniques: In order to select the determined sample of the households, the researcher used multistage sampling techniques. First, the researcher used the purposive sampling techniques to select the woredas that clearly own the three dominant land uses namely homegarden, field crops and grazing land from the agroecosystem of the West Arsi zone. Accordingly, the Kokossa, Adaba, Wondo and Nensebo woredas were purposively selected. To sum up, simple random sampling technique was used to select the study kebeles from each woreda. Then after, systematic sampling technique was used to select the nth household based on the proportionally decided sample of the respondents per kebele.

Data collection instruments

Generally, the researcher used both primary and secondary data collection tools to generate facts about the study. Both primary and secondary data collection tools were implemented.

Primary data collection: In this section, the primary data collection techniques such as questionnaires, observation, focus group discussion, key informant interview and field based data collection was used to identify the diversity of plant and animal species that the different communities manage within the agroecosystem. Both the close-ended and open-ended forms of questionnaires were used to investigate the species that the different communities manage in the agro-ecosystems of west Arsi zone. Sixteen focus group discussion sessions, that means two focus group discussion sessions per each kebele which include six to eight members was held to identify the plant and animal species of the agroecosystem. Key informant interview was also held to examine the species that the different communities manage. Furthermore, field observation was used to clarify the plant and animal species of the agroecosystem.

Secondary data collection: Different published journals and books, manuals, reports and documents from the Woredas administrative offices were referred to generate secondary data pertaining to the management of biodiversity within the agro-ecosystems of the study areas.

Assessments of vegetation diversity: The different communities of the agroecosystem of the West Arsi zone generally engage in three land use practices namely field crops, homegarden and grazing. All vegetation diversity including woody species, shrubs and crops was assessed through the following procedures. Vegetation data from the three land use practices was collected based on some procedures from the four woredas. Two kebeles which are full of different ethnic groups from each woreda and totally eight kebeles were considered to assess vegetation species. Therefore, considering the land use systems, the researcher aligned four transect lines having 500 m intervals in eight kebeles namely Gotu Onama and Shasha kebeles from Wondo Woreda; Gutu and Garbarufa from Kokossa Woreda; Ejersa and Furuna from Adaba Woreda and Gemechu and Garambamo from Nensebo Woreda. Four quadrats were laid at an interval of 200 m. Hence, 16 quadrats in each selected Kebele that means, 5 quadrats in field crops and 5 quadrats in grazing land and 6 quadrats in homegarden and an entire of 128 quadrats were laid to assess vegetation diversity. First, samples of vegetation species were collected and recorded in their local names. Then, the name of vegetation species was changed in to scientific name through considering different references like tree species reference and selection, useful trees and shrubs of Ethiopia and Flora of Ethiopia and Eritrea [24]. Field based expert was assigned in case of challenges to identify some species.

Diameters at breast height (DBH) for all woody species ≥ 5 cm was measured using a caliper or diameter tape and that of coffee was exceptionally measured at 15 cm aboveground. A quadrat size of 20 m × 20 m (400 m2) was used to assess woody species having diameter ≥ 5 cm [25]. Within this plot five subplots of quadrat size 5 m × 5 m, at four corners and in the center, was aligned to assess sapling having diameter of 1 cm-5 cm. Within each subplot, again a small five plot of 2 m × 2 m was aligned in each corner and center for seedling assessment for diameter <1 cm [25].

Methods of data analysis

Descriptive statistics such as means and standard deviation was implemented to analyze quantitative data, particularly, the vegetation diversity and livestock ownership per household respondents within the agro-ecosystems. The qualitative data was also analyzed through content analysis in which the contents of questionnaires, interviews and focus group discussion were carefully described and interpreted. Furthermore, Least Significant Difference (LSD) test at 0.05 significant level was used to compare if any significant difference among households pertaining to the vegetation diversity within the agroecosystem and the number of livestock per households. Therefore, SPSS (version 21) was implemented to assess the diversity of plants and animals within the agroecosystem of the study areas. To sum up, different diversity indices were used to identify the diversity of vegetation species within the agroecosystem of the Zone.

Shannon-wiener diversity index (H'): It computes species evenness and abundance. The number of species and evenness portion of individuals among the species are the basic components of diversity here. The value is high when the relative abundance of the different species in the sample become even and low when few species are more abundant. The Shannon diversity index is computed as:

$$H' = -\sum_{i=1}^{s} p_i \, l_n \, p_i$$

Where, H' is Shannon diversity index and pi is proportion of individuals found in the i^{th} species

The value lies between 1.5 and 3.5, although, in exceptional cases, the value can exceed 4.5. The larger the H'value, the higher the diversity is.

Equitability index (J'): It was calculated to estimate the homogeneous distribution of vegetation species based on the three land use categories namely homegarden, field crop and grazing land. It was calculated as:

$$J' = \frac{H'}{\ln S}$$

Where, H′ is the Shannon diversity index, lnS is the natural log of the total number of Species (S) sampled in study area. J` assumes a value b/n 0 and 1, with 1 being complete evenness. The value of J' ranges between 0 and 1, with 1 being complete evenness.

RESULTS AND DISCUSSIONS

Increasingly, researchers are showing that it is possible to provide a balanced environment, sustained yields, biodiversity management through the design of diversified agroecosystem and the use of low-input technologies [1,7,26]. Smale et al. also concluded that in agroecosystem all the biological diversity, particularly species of plants and animals are well conserved. Supporting the maintenance of diversity on farms is one strategy for genetic diversity conservation [1,8,27]. On-farm conservation is viewed as a complementary strategy to *ex situ* conservation strategies. Through on-farm conservation not only are materials conserved, but so also are the processes of evolution and adaptation of crops to their environment. Likewise, the agroecosystem of the West Arsi zone is one of the best production areas of Ethiopia and practicing the production of cereal crops, fruits, vegetables and plantation of different tree species [28,29]. Besides the production of plant species, small-scale animal husbandry is the other activity that the communities are engaged in to improve their livelihoods.

Plant species of the agroecosystem of the West Arsi Zone

The dominant land use of the agroecosystem of the west Arsi Zone is categorized under three classes namely, Home garden, field crops, and grazing land [29-31]. There was significant different among the Woredas (P<0.05) regarding vegetation diversity per land uses and households (Table 2). This is because, the West Arsi Zone is full of different ethnic groups who were resettled there from different regions and zones of the country, specifically, from Amhara Regional National State, Southern Nations, Nationalities and Peoples Regional State, particularly, from, Kambata, Sidama and Wolayta Zones and Hararghe and Shewa zones of Oromia National Regional state. These different ethnic groups prefer their choices of production in each land classes. For instance, the communities of Southern Ethiopia are famous in conserving high vegetation diversity in their homegarden areas. This is also confirmed by different authors within the country, for instance. In contrast, those who resettled from Amhara Regional National State in the agroecosystem of the Zone engaged in diversification in their field crops.

Table 2: pecies diversity per land uses and households in the study areas

Woredas	Land uses (Mean ± SD)			
	Homegarden Species	Field Crop Species	Species of Grazing land	P-values
Wondo	20.86 ± 3.85	9.03 ± 1.187	5.70 ± 1.185	0
Adaba	12.38 ± 2.07	13.737 ± 1.877	8.64 ± 0.58	0
Kokossa	8.98 ± 0.69	5.88 ± 1.09	13.774 ± 1.54	0
Nensabo	7.38 ± 0.644	8.83 ± 0.60	9.8723 ± 1.115	0

Notice: SD- Standard Deviation, the different supper script letter indicated that, there is significant difference within the column at (p<0.05).

From the four Woredas, the highest vegetation diversity was recorded in Wondo Woreda, particularly, in homegarden (20.86 ± 3.85), while the lowest vegetation diversity was recorded in the homegarden of the Nensebo Woreda (7.38 ± 0.644). The Adaba Woreda has the highest vegetation diversity in the field crop (13.737 ± 1.877) whereas the lowest was recorded in the Kokossa Woreda (5.88 ± 1.09). However, the Kokossa Woreda is the best in terms of vegetation diversity in the grazing land (13.774 ± 1.54) followed by the Nensebo Woreda (9.8723 ± 1.115).

Therefore, this study concentrates on the biodiversity management practices, particularly, the plant and animal species conserved by the communities based on their land use categories within the agroecosystem. Based on the field experiments, homegarden is the most land use category having different diversity of vegetation (H′=4.77) followed by field crops (H′=4.06) (Table 1). From equity perspective, the homegarden vegetation of the agroecosystem is also the most evenly distributed (J′=0.99) followed by grazing land (J′=0.98) (Table 3).

Table 3: Diversity indices of the three land use classes

Land uses	Diversity Indices		
	Species Richness	Shannon Diversity Index (H′)	Evenness Index
Homegarden	125	4.77	0.99
Field Crop	67	4.06	0.96
Grazing Land	42	3.65	0.98

Vegetation species of home-garden

Home gardens host a significant portion of plant biodiversity and could be regarded as live models of sustainable utilization of biodiversity [7,32]. Homegarden is known to be ecologically sustainable and diversifies livelihood of local community [33,34]. Commonly home garden encompasses multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably livestock managed by family labour. Homegarden agroforestry play key roles in providing more diverse services for household and facilitate conditions for ecological and economic benefits [35]. As it is confirmed the homegarden of the community is full of vegetation diversity such fruits, spices, vegetables, root crops, cereal crops and tree species which are important for timber production, fuel wood, fodder, shade and medicines compared to the two other land uses (Table 2). The highest mean number of vegetation diversity from homegarden (20.86 ± 3.85) and the greater value of Shannon diversity index (H′=4.77) confirm that homegarden harbor different vegetation diversity than other land uses. The study conducted by Bonsa et al. in the West Arsi Zone also ratified that homegarden has greater vegetation diversity and play pivotal roles in conserving biodiversity in the agroecosystem of the zone. It is also in line with the study conducted by Tefera et al. about the role of homegarden in biodiversity conservation in the Shashemene District of the West Arsi zone.

The major fruits of the homegardens of the study Woredas include avocado (*Persia americana*), Mango (*Mangifera indica*), Banana (*Musa* *paradisiaca*), zeytune (*Psidium guajava L.*), Papaya (*Carica papaya L.*), Orange (*Citrus sinensis* (*L.*) *Osb.*), *Limes* (*Citrus aurantifolia* (*Christm.*) *Swingle*), and Kishta (*Annona squamosa L.*) are considered as main sources of food and income for the communities. The communities also produce small scale cereal crops in their garden areas such as Maize and small scale Sorghum in their homegarden areas. As the respondents revealed, Zea mays is the major cereal crop cultivated by the communities in the homegarden. According to the respondents the different types of vegetables commonly known in the homegarden of the community include cabbage (*Brassica carinata A.Br.*), tomatoes (*Lycopersicon esculentum Mill.*), Tiklegomen (*Brassica oleracea L.*), Keysir (*Beta vulgaris L.*), Karot (*Dacus carota L.*), potatoes (*Solanum tuberosum L.*), mustard (*Lactuca sativa L.*), kosta (*Beta vulgaris L.*), Pumpkin (*Cucurbita pepo L.*) and pepper (*Capsicum annuum L.*) are commonly produced (*Appendix I*). A total of 126 species representing 99 genera and 51 families were recorded in the homegarden of the study areas. As identified, Fabaceae has the highest number of genera (n=21) from the recoded families (Figure 2).

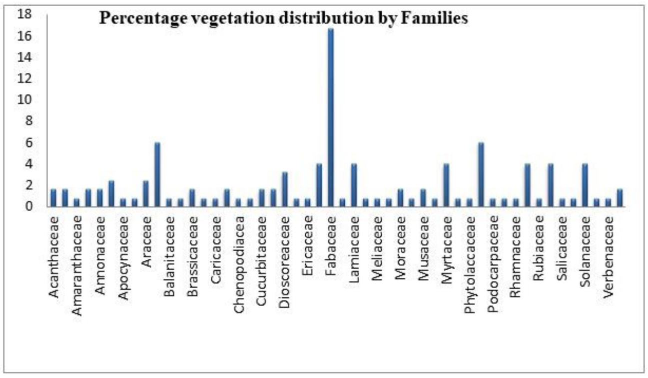

Figure 2: Comparison of Hazard Quotients for adults consuming cabbages from Mbare Musika and Mutoko.

Enset is one of the most important food crops that ensure food security in the country [36]. Ensete ventricosum play a central role in providing household food needs in the country. The other root crops of the garden areas including Keysir (*Beta vulgaris L.*), Dinich (*Solanum tuberosum L.*), Godare (*Colocasia esculeta* (*L.*) Schott), Karot (*Dacus carota L.*), Boyna (Dioscorea alata L.), Sikuar Dinich (*Ipomoea batatas* (*L.*) *Lam.*), Keyi bohina (*Dioscorea sagittifolia Pax.*), Nechi bohina (*Dioscorea praehenslis Benth*), and Tikur godare (*Xanthosoma sagittifolium* (*L.*)*Schott*) are dominantly produced by the communities to improve their livelihoods. Similar conclusions were also given by Mekonnen et al, and Reta, based on the research they conducted on the contributions of homegardens in the Holeta and Hawassa towns respectively.

Vegetation species of field crops

Wale et al, noted that farmers produce crop diversity to the extent that it meets their private needs. Of the different *in situ* conservation options, conservation on farmers' fields, also called on-farm conservation, has recently received considerable attention by the international community [37]. On-farm conservation, a subset of *in situ*, is also becoming a new conservation paradigm. Its dynamic features, its capacity to maintain crop diversity and the indigenous knowledge associated with it and the opportunity it opens up to link conservation and rural development are the typical desirable features of on-farm conservation. Biodiversity and agriculture are strongly interrelated, because while biodiversity is critical for agriculture, agriculture can also contribute to conservation and sustainable use of biodiversity [25].

In fact, a salient feature of traditional farming systems is their degree of plant diversity in the form of polyculture and/or agroforestry patterns that paves the way for the conservation of biodiversity. In fact, the species richness of all biotic components of traditional agro-ecosystems is comparable with that of many natural ecosystems. Throughout centuries, generations of farmers have developed complex, diverse and locally adapted agricultural systems, managed with time tested ingenious practices that often lead to community food security and the conservation of biodiversity. This peasant strategy of minimizing risk, stabilizes yields over the long term, promotes diet diversity, and maximizes returns under low levels of technology and limited resources.

A total of 73 species representing 62 genera and 34 families were recorded in the field crops of the study areas. In addition to cultivation of different crops, farmers also traditionally manage different trees and shrubs on their farmlands. The major crop species diversity identified as annual crops in their farm fields include Wheat (*Triticum sativum L.*), Barley (*Hordeum vulgare L.*), Maize (*Zea mays L.*), Gomen (*Brassica integrifolia* (*West*) *O.E.Schulz*), Teff (*Eragrostis teff* (*Zucc*)*Trotter*), Haricot bean (*Phaseoulus vulgarisL.*), Potato (*Solanum tubersum L.*), Pea (*Pisum sativum L.*), Horse beans (*Vicia faba L.*), Sweet potato (*Dioscorea abyssinica Hochst.ex.kunth*), Sugarcane (*Saccharum officinarum L.*), Keysir (*Beta vulgaris L.*), Garlic (*Allium sativum L.*), Onion (*Allium cepa L.*) and Yam (*Colocasia esculenta* (*L.*) *Schoot*) are the common crops produced in the four woredas of the agroecosystem of the West Arsi zone (Appendix II).

Vegetation species within grazing land

Parallel to the cropping system is the livestock system, defined as a land-use unit comprising pastures and herds and auxiliary feed sources transforming plant biomass into animal products. Important characteristics are the sequence of grazing on a given piece of land [38]. High biomass output and optimal nutrient recycling can be achieved through crop-animal integration. Animal production that integrates fodder shrubs planted at high densities, intercropped with improved, highly productive pastures and timber trees all combined in a system that can be directly grazed by livestock, enhances total productivity and facilitates the conservation of biodiversity. Grazing land plays a number of important and useful roles in mixed farming systems that enhance sustainability, increase productivity, diversify the products and services produced and help maintain biodiversity. Livestock can convert low-value waste materials, such as crop residues, and natural resources collected from or available on public land, such as grass and other wild plants, and turn them into high-value products [38]. Keeping livestock encourages farmers to plant perennial fodder crops, such as Napier grass and forage legume trees and shrubs.

As it can be understood from the household survey and field observation some legume species such as *Desmodium uncinatum* (Silver leaf Desmodium), *Stylosanthes spp* (Stylo), *Macroptilium atropurpureum* (Siratro), *Desmodium intortum* (Green leaf Desmodium), *Vigna unguiculata* (Cowpea), *Lablab purpureus* (Lablab), *Medicago sativa* (Lucerne, Alfalfa), Lotus maizeiculatus (Birdsfoot trefoil), *Melilotus altisimus*, *Trifolium spp*, (annuals&perennials clovers) and *Vicia dasycarpa* (Vetch) are also the best sources of animal food. As the communities revealed they also plant and manage some tree species that serve for many purposes including fodder, fuel, construction, medicine, shade for human and livestock, and erosion control (both wild and domesticated fruits) (Appendix III).

A total of 39 species representing 24 genera and 8 families were recorded in the grazing land of the study areas. Some of the most commonly produced browse tree species include *Sesbania sesban* (Sesbania), *Leucaena leucocephala* (Leucaena), *Calliandra callothyrsus* (Calliandra), *Cajanus cajan* (Pigeon pea), *Gliricidia sepium* (Gliricidia) and *Chamaecytisis palmensis* (Tagasaste, Tree Lucerne). Furthermore, some root crops like *Beta vulgaris* (Fodder beet) and *Ensete ventricosum* are also used as better fodder supply in addition to providing food for humans.

Livestock resources of the agroecosystem of the west arsi zone

Indigenous (or traditional, local) breeds of livestock are the thousands of locally distinct types of domestic animals–including cattle, camels, sheep, goats, pigs and poultry-that have for hundreds of years been developed and kept by livestock keepers throughout the world. In addition to crop production, Ethiopia is endowed with different livestock diversity. The country is believed to have the largest livestock population in Africa [39]. This livestock sector has been contributing considerable portion to the economy of the country, and still promising to rally round the economic development of the country [40]. It is eminent that livestock products and by-products in the form of meat, milk, honey, eggs, cheese, and butter supply etc. provide the needed animal protein that contributes to the improvement of the nutritional status of the people.

The study also revealed that the communities of the study Woredas produce the diversity of animals besides crop cultivation to improve their livelihoods. In the study woredas, Kokossa, Adaba, Wondo and Nensebo, there are the production of different animal diversity cattle, sheep, goat, donkey, horse and mules [41]. Poultry production is also practiced by the communities since the areas are better for agricultural production due to conducive climate and maximum rainfall [41].

There is significant variation (P<0.005) among the Woredas regarding the livestock holding per households. For instance, Kokossa Woreda is the best in terms of cattle population per households (12.495 ± 4.633) followed by the Adaba Woreda (8.043 ± 2.86). To sum up, Adaba Woreda is the most commonly known by having better number of oxen per households (3.18 ± 0.770) from the study areas as oxen play pivotal role in traditional farming system within the agroecosystem of the West Arsi Zone. Furthermore, Nensabo Woreda is the best from the four Districts by having large number of small ruminants per households as described 7.170 ± 1.307 and 9.021 ± 2.608 for sheep and Goat respectively. The District has also better distribution of equines (2.596 ± 0.712) and chicken (4.979 ± 1.170) among the household respondents (Table 4)

Table 4: Livestock population per household in the study areas

Variables	Woredas (Mean ± SD)				P-values
	Wondo	Adaba	Kokossa	Nensabo	
Cattle	2.400 ± 1.33	8.043 ± 2.86	12.495 ± 4.633	7.085 ± 1.705	0
Oxen	1.300 ± 0.618	3.18 ± 0.770	3.139 ± 0.760	2.212 ± 0.463	0
Sheep	1.75 ± 1.123	3.246 ± 1.514	4.537 ± 1.833	7.170 ± 1.307	0
Goats	1.153 ± 1.015	0.965 ± 0.819	1.527 ± 2.394	9.021 ± 2.608	0
Equines	0.83 ± 0.563	1.377 ± 0.954	1.763 ± 0.758	2.596 ± 0.712	0
Chicken	3.023 ± 1.088	3.851 ± 1.199	4.097 ± 1.104	4.979 ± 1.170	0

Note: SD- standard deviation, the different superscript letter can represent the significant difference (p<0.05) between column.

CONCLUSION

The agroecosystem of the West Arsi Zone is full of many biological diversity, particularly, animal and plant species. All vegetation diversity of the agroecosystem was assessed based on the dominant land use of the area, namely, homegarden, field crops and grazing land. The highest mean number of vegetation diversity from homegarden and the greater value of Shannon diversity index confirm that homegarden harbor different vegetation diversity than other land uses followed by field crops. The Adaba Woreda is the best in conservation of species diversity within the field crops while Kokossa Woreda is the best in terms of species conservation within grazing land. The agroecosystem of the West Arsi Zone is also prominent in animal production. There is also significant variation among the Woredas regarding the livestock holding per households. Kokossa Woreda is the best in terms of cattle population per households. To sum up, Adaba Woreda is better in oxen production per households. Furthermore, there is large number of small ruminants per households in Nensabo Woreda. The District has also better distribution of equines and chicken among the household respondents. Therefore, as the West Arsi zone is conducive and known by different biological diversity, all concerned bodies should consider the agroecosystem of the zone to enhance conservation strategies.

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AUTHORS' CONTRIBUTIONS

Adugna Babu is the corresponding author. He designed and drafted the manuscript. Kitessa Hundera and Tibebu Alemu contributed to the arranging the data and revision of first draft. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

CONFLICT OF INTEREST

The authors declare that they have no financial and nonfinancial competing interests.

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