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Original Article

Socio-Economic Factors Influencing Agroforestry Tree and Shrub Species Diversity on Small-Scale Farms in Kisumu County, Kenya

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ABSTRACT

Kenya is one of the developing countries experiencing rise in demand for arable land and tree products. This has led to the scarcity of available land for productive agriculture. To improve this situation, agroforestry technologies have been assimilated in many regions in Kenya. However, at the local level in Kisumu County, agroforestry technologies are yet to be adopted effectively for agrobiodiversity improvement. This study therefore sought to determine the socio-economic factors influencing the diversity of tree and shrub species of agroforestry on the small-scale farms in Kisumu West Sub-county. Descriptive research was undertaken and respondents were selected through proportionate stratified random sampling. Use of questionnaire instruments together with Key Informant Interviews were employed to 404 household heads and forest officers respectively in Kisumu West Sub-county. Inventory data of tree species was conducted on each of the sampled farm plots and together with the questionnaire data; Microsoft Excel and SPSS software were used for exploratory statistics, tree diversity measurement, chi-square and regression analysis tests. Diversity of agroforestry tree species was analysed using Shannon-Wiener Index. The results showed that the most abundant tree species were *Eucalyptus spp* and *Grevillea robusta*. The overall Shannon-Wiener Index was 1.9311 which was regarded as very low. In the study, there was a significant positive relationship between gender, level of education completed by household head, household size and the species diversity. In addition, there was a significant positive relationship between farm size and species diversity. The study recommends that information on socio-cultural factors such as education and gender, in addition to economic factors such as the farm size, that influence diversity should be a priority to the development partners and even to the local communities.

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INTRODUCTION

From time immemorial, many farmers reserved or proactively involved woody species on their agricultural landscapes (Chirwa, 2016). It has been noted that over 1 billion hectares (approximately 46%) of agricultural land globally has more than 10% tree cover (Bhattarai, 2020). Specifically, in the tropical regions, trees and shrub species are crucial components of agriculture (Chirwa, 2016). Tree and shrub species that are retained on agricultural lands offer multiple uses, including shelter, shade, fodder, food, lumber and numerous other goods and services (Khadka *et al*., 2021). This enables the households involved in agroforestry activities to become food secure (Buyinza, 2015). Due to reliance on products of agriculture and forestry, the real challenge that occurs in tropical land management is to balance the ever-growing population and its subsequent demand for these products (Gomiero, 2016).

This predicament is predominantly severe in small-holder farming systems as a result of demographic, social and economic pressures. In addition, as a result of the increasing population, the size of farmland decreases, and the demand and exploitation of tree and shrub species for fodder, firewood and construction increases, leading to loss of the species diversity (Marris, 2010). Another cause for loss of the species diversity is the intensification of agricultural practices and the resultant simplification of agricultural landscape (Guenat, 2014). Nevertheless, the incorporation of agroforestry is still a needed solution in order to meet the households' needs from the available piece of land while in support of biodiversity conservation (Jose, 2009). Furthermore, practice of agroforestry offers more multiple uses from their diverse components than mono-cropping systems (Jose, 2009). Agroforestry also has abundant potential for lowering deforestation and forest degradation, improvement of rural livelihoods and habitations for perennial woody species outside the forest areas, and lessening resource-use pressure on conservation areas (Boffa, 2022). Recently, trends in conservation of plant species diversity are not only aiming at protected areas of natural vegetation but also on agricultural lands. These agricultural landscapes are thought to be of eminent significance in conserving woody species diversity via on-farm conservation leading to in-situ conservation and preservation of the mentioned species in the forests. Traditional management of agroforestry species, with less intensively managed systems by utilizing native woody species having perennial crops as an understory and less external inputs, leads to enhanced conservation and sustainable use of biodiversity resources (Smith *et al*., 2006). It has been noted that farmers have a wealth of indigenous knowledge for cultivating and managing these enormous woody species on their farms. Agroforestry species management systems are undertaken in order to improve and secure these species' functions for the present moment and in the future, in addition of being interdependent with the utilization of the species (Bongers, 2010).

One of the major challenges is the conservation of biodiversity on agricultural landscape, especially in the tropics whereby there is rapid population growth, unplanned settlement and fragmentation of land size, is the reduction of plant species

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diversity and abundance (Schroth *et al*., 2013). Current concerns to biological diversity management has led to the need of research on the environmental attributes of resource conservation to the human ecosystems in addition of protected areas (Tejeda-Cruz *et al*., 2010). It is only in the recent past decade, whereby scientists have become interested in the conservation of biodiversity and also in environmental services that agroforestry offers to the locals and even to the global society, rather than research activities only focusing on sustainable agricultural production, particularly food (Schroth *et al*., 2013).

In Sub-Saharan Africa, one of the regions in the developing world, presently incorporate agroforestry and obtain value from it (Bommarco *et al*., 2013). It has been known that agroforestry systems in different regions of Sub-Saharan Africa are diverse and complex in nature, even when the practice are done in similar biophysical conditions such as altitude (Zomer *et al*., 2014). This can be attributed to differing social and economic aspects of the households regarding tree and shrub species availability and their use (Hauck *et al*., 2013). In spite of the fact that Sub-Saharan Africa experiences degradation especially in the farmlands, there are promising trends arising from agroforestry practice if it is well incorporated (Khan *et al*., 2017).

A report by the Ministry of Environment and Forestry, in the year 2018, indicated that Kenya was categorized among the countries with low tree cover of less than 7.6% of the total land area (GoK, 2018). Major reason for this low tree cover is due to the conversion of natural forest land to agricultural land (Mueller & Mburu, 2017). Only about 20% of the land area in Kenya is classified as agriculturally viable and under forest and nature reserve, while majority (80%) is arid and semi-arid (Mwangi *et al*., 2018). It has been noted that deforestation is rapidly increasing especially in the western part of Kenya (FAO, 2013). Nonetheless, the prevailing conditions can be ameliorated by accelerating the practice of agroforestry trees and shrubs cultivation in the farms by households (Ndegwa *et al*., 2016). There is discrepancy in the information regarding how household characteristics influence the assimilation of agroforestry practice and the diversity of the tree and shrub species (Asse & Lassoie, 2011). Therefore, the objective of this study was to investigate the socio-cultural and economic factors influencing diversity of agroforestry tree and shrub species in Kisumu West Sub-county. Specific objectives included the following:

1. To investigate the agroforestry tree and shrub species adopted and their uses in the small-scale farms in Kisumu West Sub-county

2. To assess the diversity indices of agroforestry tree and shrub species in small-scale farms in Kisumu West Sub-county

3. To evaluate the socio-cultural factors influencing agroforestry tree and shrub species diversity in the small-scale farms in Kisumu West Sub-county

4. To determine the economic factors influencing agroforestry tree and shrub species diversity in the small-scale farms in Kisumu West Sub-county

METHODOLOGY

Study Area

The study was undertaken in Kisumu West Sub-county, which is one of the seven Sub-counties in Kisumu County. The Sub-county is located at 34°33''0'' and 34°48'0'' East, 0°0'0'' and 0°12'0'' South (Fig. 1). Total land area of the Sub-county is 358.7 km^2 (KCIDP, 2013). There are two divisions, five locations and twenty sub-locations in the Sub-county. The population is at 169,806 (KNBS, 2019). There is no gazetted forest in the Sub-county (KCIDP, 2018).

Kisumu County has tree cover of less than 10% as attested by a study by Amolloh (2022) undertaken in Kisumu County. The soils in the Sub-county are majorly clay, sandy and lake sediments. Some of the areas bordering the rivers in the Sub-county have riverine vegetation that is often marshy. The main agricultural crops grown in the region are

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maize, beans, cassava *and* sugarcane. Agriculture is mainly practiced in small scale with rainfall as the main source of water (KCIDP, 2018). The Sub-county has two rainfall seasons. The long rains normally occur from March to May with ranges of between 1000mm and 1800mm while the short rains from September to November with the ranges of 450mm and 600mm (KCIDP, 2018). The mean yearly minimum temperature varies from 9° C to 18° C while the mean annual maximum temperature spans from 25° C to 35° C (KCIDP, 2018).

Sample Size and Sampling Procedure

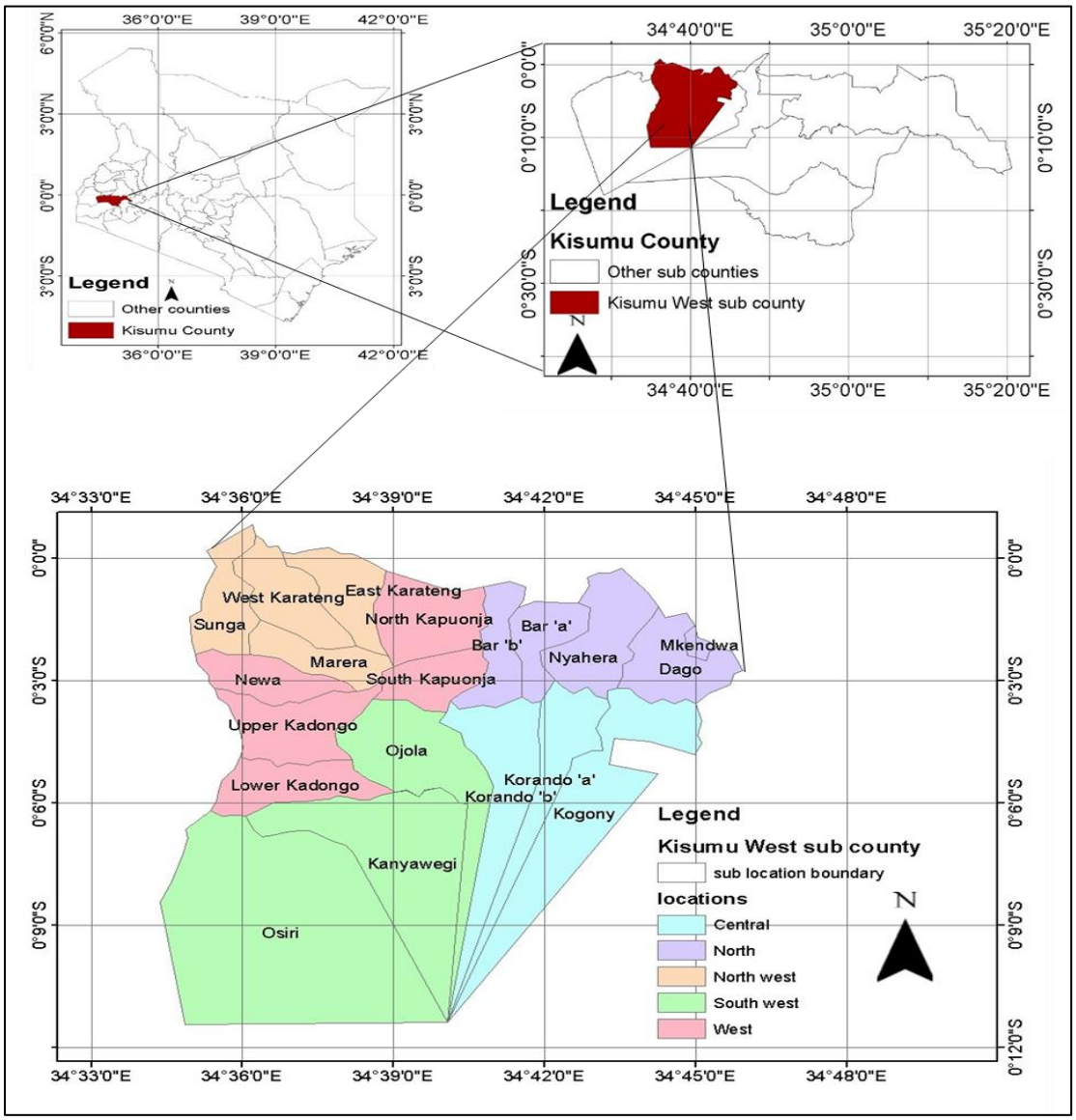
The target population was the household population in Kisumu West Sub-county that stood at 45,933 households (KNBS, 2019). The sample size was determined using the Fisher's formula at 95% confidence level, with the formula being:

Fisher's formula: $n=p \times q \times (z/d^2)$

Where: n=minimal sample size needed, p=proportion of category with positive response which is 0.5, q=proportion of category with negative response which is 0.5, z=value corresponding with level of confidence which is 1.96, d=standard error which is 0.05.

$n=0.5 \times 0.5 \times (1.96/0.05^2)$ giving 384 households.

Figure 1: Map of the study area



Source: KNBS (2019)

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Additional 20 households were included to cater for non-response sample, with the total sampling size equaling to 404 households. Two Key Informants were also interviewed who were Forest Officers in Kisumu Sub-county.

The sampling procedure involved multistage sampling at the location, sub-location and the household level. Proportionate stratified random sampling was employed, whereby the sample size in each sub-location was proportionate to the number of the households in each of the sub-location to the total number of households in the Sub-county.

Data Collection and Processing

The parameters of the socio-economic attributes included the frequencies of age of the household head, gender of the household head, marital status of the respondent, household size, main occupation of the household head, farm size and monthly income of the household head in relation to species diversity, particularly Shannon-Wiener Index of diversity. Frequencies of Shannon-Wiener Index was utilized as a parameter of diversity. Structured questionnaire was utilized to collect both quantitative and qualitative data. The questionnaire was used to collect data on the sociocultural and economic attributes together with the Key Informant Interviews. Key Informant Interviews was conducted on Forest Officers in Kisumu County. Inventory on the tree and shrub species was undertaken in each of the sampled farm plots in order to collect the data that will constitute the species diversity. A local guide was contracted to assist in the identification of the agroforestry tree and shrub species while in the field. Data was processed by use of SPSS software for error checking and any irregularity removed.

Data Analysis Methods

Tree and shrub species data was subjected to diversity analysis using the Shannon-Wiener Index. The Index was used as it focuses more on the diversity and richness of the species and less on the abundant species, thus it is sensitive to small diversity changes of the species. The formula for calculating Shannon-Wiener Index is as follows:

$$H = \sum (pi\ In\ pi)$$

Where, H is the Shannon-Wiener Index of diversity, pi = proportion of each species in the sample and *In* = natural log

Simpson's Index was used to indicate the dominance of the species over the others. High values indicated higher dominance and vice versa was true for lower values (Simpson, 1949). The formula for calculating Simpson's Index is as follows:

$$D = \sum n_i(n_i-1) / N(N-1)$$

Where n_i is the numbers of organisms that belong to species i, N = The total number of organisms

Evenness, as a measure of analysis, was also used to indicate how even the species were. Values close to 1 indicated more evenness and vice versa was true for low values close to zero. The formula for calculating Evenness is as follows:

$$E = H / In\ (k)$$

Where E = Evenness, H = Shannon-Wiener Index, *In* = Natural log and k = the number of species

Chi-square analysis tests were employed to test for significant relationships between the independent and the dependent variables. Regression analysis tests were also conducted between the variables.

The formula for multiple linear regression equation that was utilized is as follows:

$$y = \beta_0 + \beta_{1x1} + \beta_{2x2} + \beta_{3x3} + \varepsilon$$

Where y = dependent sample variable, β = regression coefficient, x = independent sample variables, ε = residual (error)

The independent variables were sociocultural and economic factors such as age, household size and monthly income levels. Dependent variable was agroforestry tree and shrub species diversity. Information from Key Informant Interviews was

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included to enhance study findings from the questionnaire data.

RESULTS AND DISCUSSION

Demographic Characteristics of Respondents and their Associated Relationships with Diversity

Age

Majority (36.6%) of the respondents were 51 years and above while only a small percentage (7%) were aged between 18-20 years. This meant that young people had little involvement in agroforestry activities in the study area. This could be due to lack of land, capital and having low interest in farming as established by FAO (2013). A similar study undertaken by Wangoi (2020) in Bungoma County, Kenya recorded a majority (32.9%) of the respondents being above 50 years. From the aforementioned results of the studies, it was the senior generation (people aged 50 years and above) that were majorly involved in agroforestry practice. Regarding the relationship of age with diversity, there was no significant association between age and diversity of agroforestry tree and shrub species (P value=0.257, P>0.05). The study findings produced a contrast when compared to findings in a study by Kinuthia (2020) conducted in Ethiopia, which indicated that age had significant effect on diversity of the agroforestry species. The reason for such a contrast could be that, in this study there was a significant proportion of the respondents aged 51 years and above when compared to a study by Kinuthia (2020).

Gender

Majority (72%) of the household heads in the study were males while the rest were females. This indicated a significant disparity between the genders as the male dominated. This could be attributed to the fact that among the communities inhabiting western Kenya, male is generally regarded as the household head. Gender was important as a factor in the study since it determines how roles are differentiated in the community and this determines how natural resources are utilized (Kiptot & Franzel, 2011). A study by Okioma (2008) conducted in Kakamega County indicated similar results whereby 79% of the household heads were males while the rest were females. Chi-square analysis test of independence indicated that there was a strong statistical significant association between gender and diversity as the P-value was 0.000 (P<0.05). Male headed households had higher diversity compared to the female headed ones. The male household heads were more involved in agroforestry practice than their female counterparts. This could be attributed to the fact that farming and tree growing is a labor intensive exercise that requires endurance. In contrast, study findings by Alufah *et al*. (2012) conducted in Kenya indicated no evidence of association from the Chi-square analysis.

Marital Status

Majority (63.5%) of the respondents in this study were married. The reason for this high percentage of married couples could be due to the fact that, in the community that the study was conducted, people marry when they are young. On the other hand, about 30% of the study population were widowed due to their partners being deceased because of old age or illness. The study findings corroborate those by Mugure (2013) conducted in Busia County where 93% of the respondents were married. From the Chi-square analysis test, the difference in marital status did not have any effect on the diversity of the agroforestry tree and shrub species, P = 0.219 (P>0.05). This finding of no significance support a study by Okioma (2008) undertaken in Kakamega County.

Level of Education

Regarding the level of education attained, majority (40.3%) of the respondents completed primary education while only 6.9% completed university education in the study area. From the interview findings, majority of the respondents in the study area completed primary education and did not continue with their education due to lack of enough resources. The education level of the household head is key in determining the adoptability and innovativeness of climate smart agriculture practices such as the agroforestry

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practice (Okuthe, 2018). These research findings corroborate those of Wanjira (2019) done in Siaya County where 60% of the respondents completed primary education while only 13% completed middle-level and university education. Chi-square test of analysis indicated that there was a strong significant association between education level completed by the household head and the diversity of the species P = 0.000 (P<0.05). Similarly, Spearman correlation gave a value of 0.234. This meant that an increase in the level of education corresponded to an increase in diversity of the agroforestry tree and shrub species. A study by Nyamweya (2017) undertaken in Nakuru County attested similar results.

Table 1: Socio-economic characteristics of respondents in Kisumu West Sub-county

Socio-economic characteristics		Frequencies	Percentages
Age of the Household Head (HH)	18-20	3	7%
	21-30	35	8.7%
	31-40	106	26.2%
	41-50	112	27.7%
	51 and above	148	36.6%
Marital status of HH	Married	257	63.5%
	Widowed	119	29.4%
	Single	21	5.2%
	Separated	2	0.5%
	Divorced	5	1.2%
Household size of respondents	1-3	45	11.14%
	4-6	186	46.04%
	7-8	101	25%
	>8	72	17.82%
Education level completed by HH	Pre-primary	55	13.6%
	Primary	163	40.3%
	Secondary	117	29%
	Middle-level college	41	10.1%
	University	28	6.9%
Main occupation of HH	Mixed farming	166	45.2%
	Crop farming	29	7.9%
	Informal employment	55	15%
	Formal employment	39	10.6%
	Small business enterprise	77	20%
	Commercial farmer	1	0.2%
Farm size of the respondents	<1	184	45.54%
	1-3	206	51.00%
	3.1 - 6	7	1.73%
	>6	7	1.73%
Monthly income of HH	<10,000	261	64.60%
	10,000 – 20,000	71	17.57%
	20,001 – 30,000	38	9.40%
	30,001 – 50,000	19	4.70%
	>50,000	15	3.71%

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Household Size

The study established that majority (46.04%) of the respondents had a household size of 4-6 members. This size was considered ideal for the households in the study area as ascribed by the 46.04% of respondents. The findings agree with those of Okuthe (2018) undertaken in Homabay County whereby majority of the family size was 6 members and below. Chi-square test of analysis between household size and agroforestry tree and shrub species diversity gave a P-value of 0.048 (P<0.05). This meant that there was a statistically significant association between the household size and the agroforestry tree species diversity. An increase or decrease of household size in the study, led to an increase or decrease in diversity respectively. This study finding support a study by Abebe and Sewnet (2014) undertaken in Ethiopia.

Taboos

Chi-square test of analysis between belief in taboos and tree and shrub species diversity gave a P value of 0.000 (P<0.05), meaning that in the study, the stronger the beliefs in taboos by the household members lead to higher diversity of the agroforestry tree and shrub species diversity or vice versa.

There was also significant association between traditional beliefs and diversity of the agroforestry species and also in totems and the diversity of the mentioned species. This meant that the stronger the beliefs in traditions led to higher diversity and vice versa is also true. Similar study by Mugure (2013) conducted in Busia County found similar results whereby traditions and taboos significantly affected diversity of agroforestry species positively.

Farm Size

Regarding the economic factors, majority (51%) of the respondents had farm size ranging from 1-3 acres. Land was scarce in the study area since the available land was continually subdivided among the subsequent generations. According to FAO (2013), land size is an essential factor that affects the extensiveness and intensity of various agricultural innovations by the communities. The study findings corroborate those of Andahi (2016) undertaken in Sabatia Sub-county where majority of the respondents had land size of 1-3 acres. Chi-square test of association indicated a strong significant association between the farm size and the diversity of the agroforestry species as the P-value was 0.000 (P<0.05). This meant that an increase or decrease in size of farm led to a significant increase or decrease in the diversity of the species respectively. This is functional as the bigger the farm size the more space there is to introduce different species. Studies by Mekonnen and Damte (2011) and Gebreegziabher and Mekonnen (2010) gave a similar finding of a statistical significant association between farm size and agroforestry diversity.

Main Occupation of the Household Head

Majority (45.2%) of the respondents practiced mixed farming that included agroforestry practices, 35% of them being in informal employment which included small businesses and only 10.6% were in formal employment. These finding agree with those by Nyamweya (2017) undertaken in Nakuru County where a majority of the respondents were small-scale farmers. The main occupation of the household head did not affect the diversity of the species P-value = 0.159 (P>0.05). The study finding was in contrast to a study by Iiyama *et al*. (2017) conducted in Ethiopia that showed that there was a statistically significant relationship between the main occupation of the household head and diversity. The reason for such a contrast is that there is a significant proportion of the respondents that were farmers.

Monthly Income of the Household Head

Regarding the monthly income, majority (64.60%) of the respondents earned a monthly income of less than 72 US Dollars. This could be attributed to the high poverty levels in the study area and also to minimal returns from farm yields when sold in the market. The minimal yield is ascribed to changes of the weather caused by climate change, whereby the rains have become majorly unpredictable and in shorter periods. These findings corroborate the findings by Oloo

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et al. (2013) conducted in Siaya County, where majority (47%) earned a monthly income of 57 US Dollars. Chi-square results between monthly income of the household head and agroforestry tree and shrub species diversity gave a P-value of 0.253 (P>0.05) pointing out that there was a non-significant relationship between the monthly income of the household head and agroforestry species diversity. Similar study by Kharal and Oli (2009) conducted in Nepal also gave a finding of no significant association between the main occupation of the household head and the agroforestry tree species diversity.

Regression Analysis of Socio-cultural and Economic factors with AF diversity in Kisumu West Sub-county

The analysis indicated that there were no statistical significant relationships between the socio-cultural factors with Shannon-Wiener Index. Study by Maluki *et al*. (2016) also indicated that from regression analysis conducted, there were no significant relationships between the parameters. The results of the regression analysis undertaken between the variables indicated that there was a statistically significant relationship between the farm size and Shannon-Wiener Index. Likewise, a research study by Mutuku *et al*. (2020) undertaken in Machakos County indicated a significant relationship between farm size and species diversity.

Table 2: Regression analysis of socio-cultural and economic factors and AF diversity in Kisumu West Sub-county

Model	Unstandardised Coefficient		Standardised Coefficients	t	Significance level
	B	S. Error	Beta		
1. (Constant)	0.653	0.299		2.182	0.030
Agelevel	-0.086	0.062	-0.065	-1.390	0.165
Educationlevel	0.088	0.056	0.070	1.584	0.114
Householdsizelevel	-0.002	0.070	-0.001	-0.028	0.978
Incomelevel	0.045	0.052	0.035	0.856	0.393
Farmsizelevel	1.373	0.097	0.590	14.147	0.000

Agroforestry Trees and Shrubs Composition and Abundance and their uses in the Farms

A total of thirty-five trees and shrub species were found and recorded in the farms and these represented 20 families of the species. Tree species in great abundance were *Eucalyptus spp* followed by *Grevillea robusta* (A.) Cunn. *Table 3* below presents the findings.

The least of the species in abundance was *Ficus sycomorus* (L.) at (0.19%) (*Table 3*). Eucalyptus and *Grevillea robusta* species constituted the majority in the study area because of their uses whereby they were being sold as timber. It was observed that Eucalyptus species mainly occurred in farm boundaries and in hedgerows while *Grevillea robusta* and other species were mainly found in the farms. These findings corroborate the findings by Oloo *et al*. (2013), in a study undertaken in Siaya County, where *Eucalyptus spp* and *Grevillea robusta* were the dominant species found in the woodlots and in the farms respectively. Study by Gachie *et al*. (2021) undertaken in Murang'a County, indicated that *Grevillea robusta* ranked the highest in the county and subsequently followed by *Eucalyptus spp*. The tree species were cultivated because of their effectiveness as fuelwood and timber. According to the study findings by Nduati (2015) undertaken in Makueni County, *Eucalyptus spp*, followed by *Grevillea robusta* then *Cupressus benthamii* Endl. were the most abundant agroforestry tree species planted by the respondents in Muooni Location.

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Table 3: Agroforestry trees and shrubs abundance

Species	Common/local name	Shrub or tree	f	%
Eucalyptus spp	Blue gum	Tree	8166	21.43
Grevillea robusta	Silky oak	Tree	7897	20.73
Cupressus benthamii	Cypress	Tree	6639	17.43
Mangifera indica	Mango	Tree	2005	5.26
Markhamia lutea	Siala	Tree	1820	4.77
Persea americana	Avocado	Tree	1697	4.45
Jacaranda mimosifolia	Jacaranda	Tree	1657	4.35
Psidium guajava	Guava	Tree	1631	4.28
Syzygium cumini	Java plum	Tree	1286	3.37
Carica papaya	Pawpaw	Tree	754	1.97
Casuarina equisetifolia	Whistling pine	Tree	669	1.75
Casimiroa edulis	White sapote	Tree	442	1.16
Thevetia peruviana	Yellow oleander	Tree	349	0.91
Azadirachta indica	Neem	Tree	251	0.65
Erythrina abyssinica	Abyssinian coral tree	Tree	229	0.60
Moringa oleifera	Moringa	Tree	215	0.56
Acacia senegal	Gum Arabic tree	Tree	211	0.55
Annona senegalensis	Wild custard apple	Tree	187	0.49
Blighia unijugata	Mwikuni	Tree	186	0.48
Melia azedarach	Persian lilac	Tree	174	0.45
Tithonia diversifolia	Tithonia	Shrub	156	0.41
Albizia coriaria	Ober	Tree	151	0.39
Leucaena leucocephala	Lead tree	Tree	127	0.33
Sesbanian sesban	River bean	Tree	118	0.31
Solanecio mannii	Solanecio	Tree	118	0.31
Dovyalis caffra	Kei apple	Shrub	114	0.29
Terminalia brownii	Mbarao	Tree	112	0.29
Acacia brevispica	Osiri	Tree	111	0.29
Vepris nobilis	Odar	Tree	103	0.27
Terminalia mollis	Opok	Tree	98	0.25
Combretum molle	Adugo	Tree	89	0.23
Kigelia africana	Sausage tree	Tree	85	0.22
Tamarindus indica	Tamarind	Tree	84	0.22
Dracaena steudneri	Steudner's dragon tree	Tree	81	0.21
Ficus sycomorus	Sycamore fig	Tree	76	0.19

Uses of Agroforestry Tree and Shrub Species

Economic Uses of Agroforestry Tree and Shrub Species

Grevillea robusta was among the most abundant species because of a number of benefits attributed to it. The main benefit was income generation when the tree species was sold for timber or firewood. The species was also reported to be friendly to the crops. *Cupressus benthamii* Endl. (Cypress tree) on the other hand was mentioned by some of the respondents (7%) as having economic use as it provided income when sold as poles. 85.3% of the respondents indicated that some parts of *Thevetia peruviana* Merr. (yellow oleander) were being fed to goats in form of fodder. 14.7% of the respondent indicated the same regarding *Persea americana* (L.) Williams (avocado). Fruits were obtained from trees such as *Mangifera indica* (L.) (Mango), *Syzygium indica* (L.) (red plum tree). The fruits were consumed by the households as mentioned by some of the respondents (60.2%) and the surplus sold in market for generating income. Basamba *et al*. (2012) noted that households would sell firewood and poles from agroforestry trees and shrubs such as *Markhamia lutea* Benth. and *Sesbania sesban* Linn. in the tropical regions of Africa.

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Socio-cultural Uses of Agroforestry Tree and Shrub Species

Some of the agroforestry tree and shrub species provided socio-cultural benefits. For example, *Mangifera indica* provided shade as noted by 77% of the respondents and so was *Grevillea robusta* (4.2%). The household members would sit under the trees to avoid heat of the day from the sun and even have discussions under the tree rather than in the house. Study findings by Mugure (2013) also indicated that *Grevillea robusta* was an important tree for provision of shade. From the study findings, *Markhamia lutea* was also an important socio-cultural tree as it was used for prayers and also as totems to resemble a landmark for a family. Twigs from trees such as *Tamarindus indica* L. were utilized for teeth cleaning as reported by some of the respondents (21%). Study by Basamba *et al*. (2012) also attested similar finding whereby Markhamia lutea was a sacred tree in Uganda.

Environmental Benefits of the Agroforestry Trees and Shrubs

Some of the other benefits comprised of improvement of soil fertility. Tree species such as *Sesbania sesban* were a favourable choice for such a case. In some (9%) of the farms, it was found that *Sesbania sesban* tree was intercropped with maize and this was reported to improve the yield of the maize crop. It was also noted that *Sesbania sesban* and *Acacia senegal* when left during the fallow period, their leaves droppings decomposed providing soil nutrients, thus improving the fertility of the soil. *Sesbania sesban* was also included in the farms for nitrogen fixation. 30.3% of the respondents mentioned that *Mangifera indica* species helped in reducing soil erosion. In 22% of the farm plots, *Grevillea robusta* was planted along the farm boundaries and this prevented the carrying away of the top soils when there was rain as the species held the soil together. Another study by Kiptot and Franzel (2011) attested similar findings whereby some of the species such as *Acacia senegal* were used for improving the fertility of the farms.

Table 4: Uses of AF tree species and shrubs in Kisumu West Sub-County

Uses/species		Percentage
Cash income	*Eucalyptus spp*	50%
	Grevillea robusta	32.7%
	Cupressus benthamii	7%
	Mangifera indica	4.2%
	Markhamia lutea	1.8%
	Syzygium cumini	1.8%
	Acacia senegal	1.3%
	Others	1.2%
Medicine	*Azadirachta indica*	46%
	Melia azedarach	18.2%
	Thevetia peruviana	10.2%
	Mangifera indica	8%
	Moringa oleifera	7.3%
	Tithonia diversifolia	5.2%
	Eucalyptus spp	5.1%
Furniture, Timber, Poles	*Eucalyptus spp*	58.4%
	Grevillea robusta	29.2%
	Markhamia lutea	7.8%
	Cupressus benthamii	4.6%
Fuel	*Mangifera indica*	24.9%
	Eucalyptus spp	21.1%
	Markhamia lutea	20%
	Psidium guajava	13.3%
	Thevetia peruviana	10.7%
	Grevillea robusta	10%

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Uses/species		Percentage
Fodder	*Thevetia peruviana*	85.3%
	Persia americana	14.7%
Shade	*Mangifera indica*	77%
	Syzygium indica	7.8%
	Jacaranda mimosifolia	6.5%
	Eucalyptus spp	4.5%
	Grevillea robusta	4.2%
Soil fertility, erosion control	*Mangifera indica*	30.3%
	Grevillea robusta	22%
	Sesbania sesban	9%
	Others	38.7%
Food (Fruits)	*Mangifera indica*	46.4%
	Persia americana	20.6%
	Psidium guajava	18.6%
	Syzygium indica	7.4%
	Carica papaya	6.4%
	Others	0.6%
Social uses	*Markhamia lutea*	55.2
	Erythrina abyssinica	32.8
	Tamarindus indica	10.4
	Others	1.6

Medicinal Uses of AF Tree and Shrubs

Azadirachta indica (A.) Juss. (Neem tree) was the major choice by the respondents (46%) in providing medicinal value. The bark and leaves of the tree were noted to cure malaria fever by boiling the mention parts and drinking the concoction. *Moringa oleifera* Lam. (Moringa tree) was also grown as a medicinal tree by some (7.3%) of the respondents. The leaves were consumed as vegetable by some of the respondent households and this was alleged to provide the essential nutrients when added to the diet. Study findings by Mugure (2013) conducted in Busia County also mentioned the medicinal use of the neem tree for malaria fever treatment.

Diversity of Agroforestry Tree and Shrub Species

A total of 38,088 individual trees and shrubs were recorded on 693.56 acres of farm lands giving an average density of 54 trees per acre. Most of the tree species were found scattered in the farms while Eucalyptus species were mainly found along the boundaries of the farms and as hedgerows. The overall Shannon-Wiener Index in the farms was 1.9311, a figure regarded to be very low based on category of values provided by Baliton *et al*. (2020). This meant that there were only a few species that were frequent in numbers while the majority of the species in the farm plots were less in number. A similar study conducted by Najma *et al*. (2016) in Machakos County gave a Shannon-Wiener Index value of 1.73. It can therefore be noted that both studies gave a result of low Shannon-Wiener Index as the species were not well distributed in diversity. Simpson Index was used to indicate the tree and shrub species that were dominant and this gave a value of 0.71. This meant that a few species in the farm plots were dominating in frequencies and this is clearly demonstrated in *Table 5*. A study by Wanjira (2019) undertaken in Siaya County recorded a value of 0.82 as the Simpson Index. The value in this research was lower than that of Wanjira (2019) indicating that there were fewer species that were dominant compared to that of Wanjira (2019). An analysis measure of evenness was also used to indicate how even in number the tree and shrub species were. This gave a value of 0.40 indicating that there was evenness among some tree and shrub species in the farms even though there were a few dominant ones. A similar study by Abebe *et al*. (2013) undertaken in Ethiopia

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gave a value of 0.50. It can therefore be noted that evenness was observed in the species diversity.

Table 5: Measures of diversity of AF species in Kisumu West County

Measure of diversity	Value
Density (individual tree per acre)	54
Overall Shannon-Weiner Index	1.9311
Evenness	0.40
Simpson Index	0.71

CONCLUSIONS AND RECOMMENDATION

From the study, Eucalyptus species, followed by Grevillea robusta then Cupressus benthamii were the most abundant agroforestry tree and shrub species found in the farm plots of the study area. Ficus sycomorus was the least species in the farm plots. There was very low diversity of agroforestry species with the overall Shannon-Wiener Index being 1.9311. This is due to the fact that there were few dominant agroforestry species in the study area, leaving other species being dismal in number. The reason for the low species diversity was due to the dynamics of socio-cultural and economic factors that came into play in the study area. For instance, gender, education level and household size were the socio-cultural factors that were found to be statistically significant in influencing the diversity of agroforestry species. Significant economic factor that influenced the diversity of the agroforestry species included the size of the farm of the households' respondents in the study area.

One of the recommendations is that information on socio-cultural factors such as education and gender, in addition to economic factors such as the farm size, that influence diversity should be a priority to the development partners and even to the local communities. In this case, the cultivation and diversification of the agroforestry tree and shrub species by the local people and the continuity of the agroforestry projects will be ensured. Another recommendation is that there is need to promote the practice of AF tree and shrub species in order to increase the diversity of the species for increased agrobiodiversity.

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