Research Open Access

dnivela@cfi.com.ec

Correspondence:

Determination of forest cover in 10 farms under traditional agroforestry systems in the Corotú area of El Empalme canton, Guayas.

Determinación de la cobertura forestal en 10 fincas bajo sistemas agroforestales tradicionales en el recinto Corotú del cantón El Empalme, del Guayas

Diana Elisseth Nivela Peralta
Master, Independent Forestry Consultant,
Quevedo, Ecuador, dnivela@cfi.com.ec
https://orcid.org/0000-0002-0886-1863

Cesar Alberto Cabrera Verdesoto
Master, Forestry Engineering Career,
Universidad Estatal del Sur de Manabí,
Jipijapa-Ecuador,
cesar.cabrera@unesumn.edu.ec,
https://orcid.org/0000-0001-5101-3520

Darwin Marcos Salvatierra Pilozo
Master, Forestry Engineering Career,
Universidad Estatal del Sur de Manabí,
Jipijapa-Ecuador,
darwin.salvatierra@unesum.edu.ec,
https://orcid.org/0000-0002-2659-4471

Abstract
The present research was aimed at determining the forest cover in ten farms with traditional agroforestry systems, based on the characterization of each of them (farms).A planimetric survey and zoning of the agricultural areas with vegetation cover was carried out, where the common name, diameters, commercial and total height of the trees greater than 10 cm DBH of the adult stand were recorded through a census, subsequently the data were separated into diameter classes with 10 cm intervals, determining the basal area and commercial volume, for the taxonomic identification of the species the Angiosperm Phylogenetic Group (APG) classification system was used. A total of 524 forest species associated with agroforestry systems were identified and classified into four different types according to their production components. The floristic diversity corresponds to 35 species, 33 genera, and 19 families, the most abundant species was Cordia alliodora (Ruiz & Pav.) Oken, being the Boraginaceae family the most abundant, the Ecological Importance Value Index (IVI) was shown to be most representative for Ceiba pentandra (L.) Gaertn, with 77.57%; the Shannon index determined a medium diversity in SAF1, SAF2 and SAF4, unlike SAF3 that showed low diversity, within the Jaccard analysis that 0.05% was obtained, indicating that there is little similarity of species among the SAF.

Keyword: Agroforestry; trees; crops; relationship.

Received July 22, 2021
Approved: December 18, 2021

Resumen
La presente investigación se encaminó en la determinación de la cobertura forestal en diez fincas con sistemas agroforestales tradicionales, con base en la caracterización de cada uno de ellos (fincas). Se efectuó un levantamiento planimétrico y zonificación de las áreas agrícolas con cobertura vegetal, donde se regist omercial y total de los árboles mayore se separaron en clases diamétricas co en comercial, para la identificación ación de Angiosperm Phylogenetic Group (APG). Se identificaron 524 especies forestales asociadas a los sistemas agroforestales, para ello se clasifico en cuatro tipos diferentes de acuerdo a sus componentes de producción. La diversidad florística corresponde a 35 especies, 33 géneros, y 19 familias, la especie más abundante fue Cordia alliodora (Ruiz & Pav.) Oken, siendo la familia Boraginaceae la más abundante, el Índice de Valor de Importancia Ecológica (IVI) se mostró más representativo para Ceiba pentandra (L.) Gaertn., con 77,57%; el índice de Shannon determinó una diversidad media en los SAF1, SAF2 y SAF4, a diferencia del SAF3 que presentó diversidad baja, dentro del análisis Jaccard que se obtuvo 0,05% esto indica que existe poca similitud de especies entre los SAF.

Palabras clave: Agroforesteria; árboles; cultivos; relación.

Introduction

The expansion of monocultures such as: banana, African palm, industrial plantations, cocoa CNN-51 and others have caused the reduction of native forest species, therefore, it was of great importance to conduct studies on forest cover in traditional agroforestry systems, to determine the types of agricultural associations with the management of the shade of tree species. Therefore, it was proposed to determine the forest cover in 10 farms, whose objective was to characterize the agrarian systems and their relationship with the trees.

The role of conservationist farmers of agricultural germplasm and associated woody plants is known within the science of agroforestry as traditional agroforestry systems, because it is the tradition of cultivating and maintaining agrarian spaces in combination with native species. The approach of traditional peasant agriculture makes it possible to diversify crops in small areas, maintaining rotation, soil conservation and local seeds. The scarce information of studies on traditional agroforestry systems has an impact on the sustainability of agroforestry production systems, so the social, ecological and economic benefits of FFS are unknown, in farms where there are no trees the negative effects of natural agents (rain, wind and sun) increase, water retention capacity decreases, soil leaching occurs, these effects may be greater in areas where short-cycle crops are grown, intensive soil use and absence of forest cover (Benavides, 2013, p.133).

Agroforestry techniques are used in various regions with diverse ecological, economic and social conditions. The environmental conditions favor vegetation, where there is moisture and the soils are fertile, agroforestry systems can be very productive and sustainable (Musálem, 2002, p. 98).

Ecuador is considered to have a high rate of biodiversity of flora and fauna, due to the ecological and geographic conditions where it is located. Despite its small territory, it is a mega-diverse country in terms of agricultural, livestock, aquaculture and forestry production associated with traditional agroforestry systems (CORPEI, 2012).

The canton of El Empalme has a land area of 1,139.22 km² where we find a great diversity of timber, agricultural, fruit, medicinal, and small livestock species; forming part of the traditional agroforestry systems that are options to reduce the risk of climate change. The combination of trees, crops and animals allows for sustainable agricultural production (PDOT, 2015).

The Guayas parish is one of the largest in the canton of El Empalme, 73.70% of the rural area has monocultures and crops such as rice, corn, cocoa, coffee, bananas, natural grasses and crops associated with traditional agroforestry systems.) Land use change in recent years has been drastic and traditional agroforestry systems are tending to disappear, affecting the food security of rural families (PDOT, 2015).

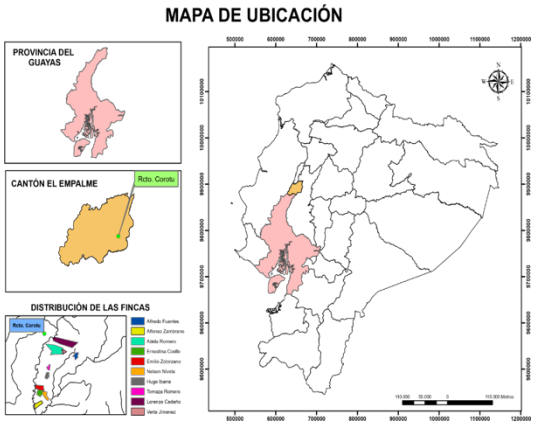
The study area does not have a work that collects all these traditional peasant experiences, it is considered agricultural production land where the owners encourage the cultivation of various forest species associated with dispersed agroforestry systems as a contribution of wood, shade, fruits, among other services.

Materials and methods

The present study was carried out in the Corotú precinct, La Guayas parish, El Empalme canton, Guayas province, 10 farms with traditional agroforestry systems were chosen, considering the methodology proposed by (Moreno et al., 2013), where a characterization of the different agrarian systems associated with timber species, fruit trees, perennial, annual and short-cycle crops was carried out to determine the types of FAS, so the planimetric surveys and zoning of the farms were carried out, through a forest census of the adult mass of trees and the various types of associations, where the typology that allowed differentiating the FAS was determined.

The dasometric parameters of the forest and fruit species were recorded to determine the richness and tree diversity of the systems by means of indices. The forest species were identified by scientific genus and family names, the formulas of absolute and relative abundance, absolute and relative frequency, absolute and relative dominance and the importance value index (IVI) were used to calculate the evaluation of the horizontal plant structure, while the vertical structure was calculated using the diametric classes, Shannon's index, Simpson's index, Sorensen's index and Jaccard's index.

Figure 1. Location of the agroforestry systems study area.



Selection of agroforestry systems and field registration

The criteria highlighted by (Navarro et al., 2012) are the structure-function, socioeconomic nature and ecological range of the system, the criteria by (Moreno et al., 2013), of a characterization of agroforestry systems in Mexico were also analyzed, as well as the criteria proposed by (Prado, 2009) on traditional agroforestry systems in Loja, Ecuador. Considering the studies of the previous authors, 10 farms were selected. In each productive unit, a planimetric survey and zoning was carried out. For the identification of forest species, the common name, commercial and total height, as well as the phytosanitary status of all trees greater than 10 cm DBH were recorded. All species were geo-referenced with GPS, using a field sheet for forest inventories. The Angiosperm classification system (APG, 2016) was used for species taxonomy.

Evaluation of horizontal plant structure

To calculate the vegetation structure within the farms with traditional agroforestry systems, data on height in m. and diameters in cm were recorded for individuals with DBH > 10 cm. These variables were used to determine Absolute Abundance (Aa), Relative Abundance (Ar), Absolute Frequency (Fa), Relative Frequency (Fr), Absolute Dominance (Da), Relative Dominance (Dr) and Importance Value Index (IVI). The diversity indices of a similar work proposed by (Poma, 2013) were taken as references.

a) **dasometric parameters**

- Basal area and volume

The following formula was used to calculate the basal area and volume per tree:

$$AB = \frac{\pi}{4} D^2$$

Where:

AB = basal area (m^2)

D = diameter (m)

π = constant

$$V = AB^2 \times H_C \times F_f$$

Where:

V = tree volume (m^3)

AB = basal area (m^2)

Hc = height (m)

Ff = form factor (0.7)

- Diameter classes

In order to provide a better representation of the forest cover on the farms, it was categorized in diameter classes with 10 cm intervals: C1 (10.00 - 20.00); C2 (20.01 - 30.00); C3 (30.01 - 40.00); C4 (40.01 - 50.00) and C5 (>50.01) cm of DBH, this allows us to know in which class is the highest frequency of flora diversity indexes in traditional agroforestry systems.

b.) Ecological parameters

- Absolute abundance (Aa)

For the calculation of absolute abundance, the number of individuals per species was taken as follows.

Aa = Number of individuals of a species

- Relative abundance

For relative abundance, we considered the number of individuals of the species divided by the sum of the absolute abundance of all species, multiplied by one hundred.

$$Ar = \frac{n^{o} \quad de \quad individuos \quad de \quad la \quad especie}{\sum \quad de \quad Aa \quad de \quad todas \quad las \quad especies} \text{ x } 100$$

Where:

Ar = Relative abundance (%)

Aa = Absolute Abundance

- Absolute frequency (Fa)

The following formula was used to calculate the absolute frequency:

Fa = No. of number of sampling units (farms) where a species occurs.

- Relative frequency

The absolute frequency of the species divided by the sum of the absolute frequency of all species, multiplied by one hundred, was considered.

$$Fr = \frac{Fa \quad de \quad la \quad especie \quad a}{\Sigma \quad Fa \quad de \quad todas \quad las \quad especies} \text{ x } 100$$

Where:

Fr = Relative frequency

Fa = Absolute frequency

- Absolute dominance (Da)

To determine absolute dominance, the basal area of the species was considered using the following expression:

Da = basal area of the species (Ab).

- Relative dominance

$$Dr\ (\%) = \frac{Da\ \ de\ \ la\ \ especie}{\Sigma\ \ Ab\ \ de\ \ todas\ \ las\ \ especies} \text{ x } 100$$

Where:

Dr = Relative dominance (%)

Da = Absolute dominance

AB = Basal area

- Importance value index

IVI = Ar + Fr + Dr

Where:

(IVI) = Importance Value Index (%)

Ar = Relative abundance

Fr = Relative frequency

Dr = Relative dominance

Indices for assessing vegetation diversity and similarity

To determine plant biodiversity within agroforestry systems, the Shannon and Weaver, Jaccard and Simpson indices were used (Finol, 1971).

- Shannon - Weaver indexes (H')

$$H` = -\sum_{i=1}^{S} pi\ log2\ pi$$

Being: $Pi = \frac{ni}{N}$

Where:

S = Number of species (riqueza de especies)

Pi = Proportion of individuals of species i with respect to the total number of individuals, i.e., the relative abundance of species i.

Ni = Number of individuals of species i

N = Number of all individuals of all species

- Simpson's Index (S)

S = 1/s (Pi)2

Where:

S = Simpson's Index

1/s = Probability that random individuals from a population come from the same species.

Pi = Proportion of individuals belonging to the same species.

- Sörensen's Index

Sörensen's index indicates the similarity of four samples.

$$Ia = \frac{2c}{a+b+c}\ x\ 100$$

Where:

Ia = Sörensen species association index (%).

a = Number of species appearing in the first plot.

b = Number of species occurring in the second plot.

c = Number of species occurring in both plots.

For the interpretation of the Simpson, Shannon and Wiener index, the values proposed by (Pla, 2006) were used.

Table 1. *Simpson, Shannon and Wiever's Index*

Values	Interpretation
0,0 - 1,6	Low diversity
1,7 - 2,89	Average diversity
> 2,90	High diversity

Source: (Pla Laura. 2006).

- Jaccard Index

The Jaccard index was used to determine if there are similarities or dissimilarities between the species that make up the vegetation structure within the traditional agroforestry systems to be evaluated.

$$IJ\ (\%) = \frac{\mathbf{C}}{\mathbf{A + B - C}} \mathbf{x\ 100}$$

Where:
IJ = Jaccard Index (%)
A = Number of species in community A
B = Number of species in the community B
C = Number of common species in both communities

Result

Table 2. *Table of areas of the owners of the 10 farms with traditional agroforestry systems.*

N°	Owners	Total Has.	N°	Owners	Total Has.
1	Adela Romero	14,24	6	Ernestina Coello	3,96
2	Alfredo Fuente	2,77	7	Hugo Ibarra	2,53
3	Alfonzo Zambrano	3,9	8	Lorenzo Cedeño	16,8
4	Bertha Jimenez	1,38	9	Nelson Nivela	3,96
5	Emilio Solórzano	4,79	10	Tomaza Romero	1,61

The farms where the research was conducted comprise an area of 55.94 hectares, which are relatively small, 20% are between 14 to 17 hectares and 80% are less than 5 hectares, so the agricultural systems must be diverse to have economic sustainability, they are also under pressure from large extensions of banana, African palm and industrial plantations, which would put in the future the disappearance of agroforestry systems.

Categorization of traditional agroforestry systems

The traditional agroforestry systems presented crops associated with banana area, coffee, national cocoa and CCNN-51 with timber and fruit species interspersed with annual cycles such as rice, corn, peanuts and beans, for a better classification the reference of (Mendieta el al., 2007) was taken, who propose as: SAF1 Trees in plots or dispersed in perennial crops; SAF2 Family orchard; SAF3 Crops in alleys and SAF4 Trees in line. Reference was made to (Moreno el al., 2013) who identified zones or sites with different types of land use and resource utilization on traditional agroforestry systems in Mexico, where 20 different names for PFS were identified with their spatial location, the intensity of management of the system and the ecological and biocultural context of the communities.

Floristic diversity in traditional agroforestry systems.

The farms are made up of valuable timber species and edible fruit trees, which have been cultivated through natural regeneration, trees planted in line and internal divisions of crops, where a total census was conducted for each farm, where 504 individuals, 19 families, 33 genera and 35 species were recorded. in the 10 farms with traditional agroforestry systems, which are sources of economic income at different times of the year obtaining a stable production of various crops and in its final turn the use of trees either by thinning or harvesting.

The total area of the ten farms corresponds to 55.94 ha, 50% of the farms are next to each other and the others are separated by other properties that do not have agroforestry systems. A total of 504 individuals were found, which represents 9 trees/ha.

Abundance of botanical families in agroforestry systems.

The abundance of individuals of the families found in the evaluated farms was for Boraginaceae with 126, Moraceae with 70, Lauraceae with 64 and Polygonaceae with 59 and with an uncommon notoriety for Bignoniaceae, Muntingiaceae and Myrthaceae with one species.

Absolute and relative abundance

The species with the highest number of individuals was *Cordia alliodora* (Ruiz & Pav.) Oken. With 126 and the species that showed the lowest number of individuals were *Ceiba pentandra* (L.) Gaertn, *Raphia taedigera* Mart., *Pouteria caimito* (Ruiz & Pav.) Radlk, *Tabebuia guayacán* (Seem.) Hemsl, *Artocarpus altilis* (Parkinson ex F.A. Zorn) Fosberg. With 1 individual respectively.

Absolute and relative frequency

The species found in the four types of agroforestry systems were *Cordia alliodora, Mangifera indica*, Pholidostachys dactyloides, as opposed to the trees *Artocarpus altilis, Artocarpus heterophyllus, Cecropia peltata, Ceiba pentandra, Chrysophyllum cainito, Erythrina poeppigiana, Ficus aculeata, Inga spectabilis, Muntingia calabura, Ochroma pyramidale, Ocotea sp, Otoba gordoniifolia, Pouteria caimito, Raphia taedigera, Schizolobium parahyba, Spondias dulcis , Syzygium malaccense, Tabebuia guayacan.*

Absolute and relative dominance

The species with the highest absolute and relative dominance within the agroforestry systems was *Cordia alliodora*. With 8.58 and 58.09; and the species with the lowest dominance were *Tabebuia guayacan* . With 0.01 and 0.04 followed by *Syzygium malaccense*. With 0.02 and 0.22, and *Raphia taedigera*. With 0.05 and 0.16 correspondingly.

Value and Importance Index (IVI)

The species with the highest percentage of Value and Importance Index within the agroforestry systems was: *Ceiba pentandra* with 77.57% because the value belongs to a single individual *Mangifera indica* with several individuals presented 81.55% and *Tectona grandis* with 79.02%, while the species with the lowest percentage of IVI are: *Tabebuia guayacan* with 3.45% followed by *Geonoma cuneata* with 3.51% and *Zanthoxylum riedelianum* with 3.53% comparatively.

Diversity and density of traditional agroforestry systems.

The diversity and density of traditional agroforestry systems is represented by the Boranginaceae, Moraceae, Polygonaceae, Lauraceae, Sapotaceae, Lamiaceae and Anacardaceae families, due to the fact that landowners still adopt to conserve the germplasm of valuable timber as a forest resource on their farms.

Figure 2. Diversity of families and species in the 4 types of agroforestry systems.

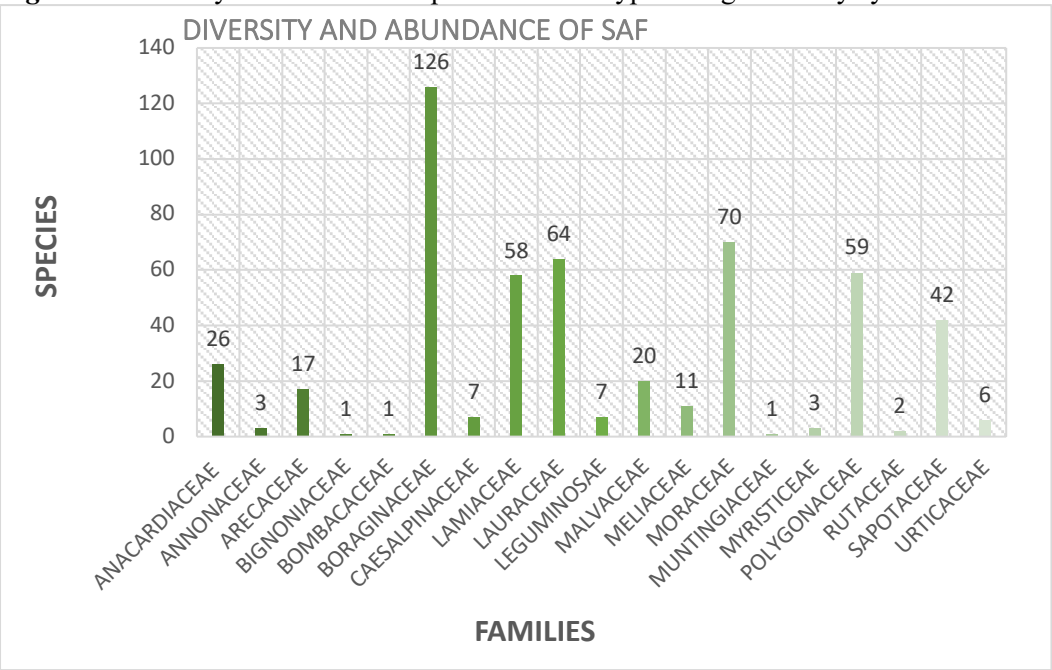


Table 3. *Diameter classes of wood in the ten farms.*

Diameter classes (cm)	Basal area (m^2)	Volume (m^3
10,0-20,0	2,49	9,75
20,01-30,0	9,24	45,80
30,01-40,0	11,20	57,40
40,01-50,0	7,91	42,41
> 50,01	17,06	160,63
Totals	**47,90**	**315,99**

Intervals of 10 cm were used as reference for the categorization of diameter classes and to determine the values of basal area $m^2$and volume m^3.

Shannon's and Simpson's index of agroforestry systems

The Shannon index showed values corresponding to medium diversity in SAF1, SAF2 and SAF3, while in SAF4 it showed a value corresponding to low diversity. Simpson's index in SAF1, SAF2, SAF3 and SAF4 represents an unequal distribution, so a very abundant species *Cordia alliodora* was found in all agroforestry systems.

Table 4. *Shannon and Simpson's index of the four types of agroforestry systems.*

Diversity	SAF1	SAF2	SAF3	SAF4
Shannon	2,46	2,14	1,73	1,58
Simpson	7,64	5,93	4,57	3,41

Sorensen's Index

Sorensen's index 0.01 indicates that the similarity and association indexes are low among agroforestry systems.

Jaccard Index

The Jaccard index is 0.05, which shows that there is little similarity of species among the agroforestry systems found in the ten farms.

Variables such as number of individuals, family, species and genus change from one zone to another due to the ecological and geographical conditions and the size of the agroforestry systems they present. This agrees with (Moreno *el al*., 2013) from a study conducted in traditional agroforestry systems in Mexico. Traditional agroforestry systems present crops associated with banana area, coffee, national cocoa and CCN-51 with timber and fruit species interspersed with annual cycles, which for (Torres *et al*., 2014) determines that through the integration of trees on farms improves the agricultural landscape, diversifies and sustains production to increase the social, economic and environmental benefits of farmers at all levels.

The most abundant family within the agroforestry systems was: Boraginaceae with 126 individuals followed by Moraceae with 70 individuals, data that does not agree with the research of (Zambrano, 2012) where the most dominant family was: Malvaceae followed by Arecaceae and the work done by (Chacón, 2017) the most abundant family was Leguminosae and Rutaceae.

Within the study area the agroforestry system of greater importance was for SAF 1 (trees in plots or dispersed in perennial crops), which does not agree with the research of (Zambrano, 2012) and (Chacón, 2017) conducted in the canton Valencia province of Los Ríos, where the most important agroforestry system was mixed orchards and trees associated with pastures.

The most predominant species in the agroforestry systems was *Cordia alliodora* followed by *Persea americana* and *Triplaris cumingiana*. This is partly consistent with the work done by (Martínez, 2011). The species with the highest frequency were *Cordia alliodora, Persea americana*, and *Mangifera indica*.

In the present study, the structure of diameter classes presented a greater number of individuals within the range 20.01 - 30 cm in diameter, which does not agree with the findings of (Zambrano, 2012) that obtained the highest number of individuals in the interval of 0 - 5 cm in diameter.

Conclusions

We reviewed the article by (Moreno et al., 2013) that refers to traditional agroforestry systems in Mexico, and with this reference the forest cover and its relationship with the agricultural systems of the ten farms of the Corotú precinct, canton El Empalme, through a characterization four types of agroforestry systems were defined which are: Trees in plots or dispersed in perennial crops (SAF1), family orchard (SAF2), crops in alleys (SAF3) and trees in line (SAF4).

A total of 504 individuals dispersed in 35 associated species in 19 families and 33 genera were recorded in combination with agricultural systems in the four types of agroforestry systems.

In the types of agroforestry systems found in the study area with the highest abundance of individuals was for SAF1 with 335, followed by SAF2 with 133 and the least abundant SAF3 with 13 and SAF4 with 23 individuals, this differs because they are agricultural crops associated with trees, where the shade factor affects the production of agricultural species, as shown in SAF3 and SAF4.

The species with the highest abundance, frequency, dominance within the agroforestry systems in the Corotú enclosure were: *Cordia alliodora* and *Persea americana, Triplaris cumingiana* and the species that were less abundant: *Ceiba pentandra, Raphia taedigera, Pouteria caimito, Tabebuia guayacan, Artocarpus altilis.*

More species predominated in the class (40.01-50.0) cm. The most ecologically important species exposed by the analysis of the Value and Importance Index "IVI" was *Ceiba pentandra* with 77.57% respectively. In the diameter classes of the agroforestry systems the most dominant was SAF1 followed by SAF2 and SAF4, which presented more individuals in the range of (20.01-30.0) cm. While in SAF3 > 50.01 cm.

References

The Angiosperm Phylogeny Group. (2016), M. W. Chase, M. J. M. M. Christenhusz, M. F. Fay, J. W. W. Byng, W. S. Judd, D. E. Soltis, D. J. Mabberley, A. N. Sennikov, P. S. Soltis, P. F. Stevens, An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV, Botanical Journal of the Linnean Society, Volume 181, Issue 1, May 2016, Pages 1-20, https://doi.org/10.1111/boj.12385

Benavides, A. (2013). Evaluation of agroforestry systems for the development of a management plan and sustainable use of resources in the Cepsa Eloy Alfaro parish. Thesis prior to obtaining the degree of environmental engineer. Technical University of Cotopaxi, Latacunga. Ecuador 133 p. repositorio.uteq.edu.ec/bitstream/43000/2848/1/T-UTEQ-0044.pdf.

Chacón, K. (2017) Floristic characterization of existing agroforestry systems in the Murocomba protective forest, valencia canton. Thesis prior to obtaining the degree in forestry engineering. State University of Quevedo. Ecuador. 112 p. https://www.bibliotecasdelecuador.com/Record/ir-:43000-1724. [Links]

Finol, U. (1971). "New parameters to be considered in the structural analysis of tropical virgin forests". Revista Forestal Venezolana, 14 (21): 29 - 42. www.scielo.br/scielo.php?script=sci_nlinks&ref=000131&pid. [Links]

Martínez, C. (2011). Determination of the contribution of agroforestry systems with cocoa to producer families in five municipalities in the departments of Cortés and Yoro. Thesis prior to obtaining the degree of forestry engineer). National School of Forestry Sciences ESNACIFOR. Siguatepeque. Comayagua. Honduras. 96 Repositorio.bibliotecaorton.catie.ac.cr/.../Martinez_Determinacion.pdf

Mendieta, M. & Rocha, L. (2007). Agroforestry Systems. National Agrarian University. Managua, Nicaragua 117 p. http://repositorio.una.edu.ni/id/eprint/2443. [Links]

Moreno, A., Víctor, M., & Casas, A. (2013). Traditional agroforestry systems in Mexico a biocultural approach. Botanical Sciences. 91 (4) 375-398 p.: https://www.researchgate.net/publication/274072240

Musálem, M. (2002). Agrosilvopastoral systems, a sustainable rural development alternative for the Mexican tropics. Revista Chapingo Serie Ciencias Forestales y del Ambiente. 8(2): 91-100. http://www.redalyc.org/articulo.oa?id=6298020.

Navarro, H., Santiago, A,. Musálem, M., Vibrans, H, & Pérez, A. (2012). Diversity of Useful Species and Agroforestry Systems. Diversity Of Useful Species And Agroforestry Systems. Revista Chapingo Serie Ciencias Forestales y del Ambiente. 18(1): 71-86. http://www.scielo.org.mx/pdf/rcscfa/v18n1/v18n1a7.pdf.

Poma, K; (2013). Floristic Composition, Structure and Endemism of an Amazonian Lowland Evergreen Forest in the Taisha canton, Morona Santiago. Thesis prior to obtaining the degree of forestry engineer. National University of Loja. Ecuador. 72 https://dspace.unl.edu.ec/jspui/bitstream/123456789/5213/1/COMPOSICI%C3%93N%20FLOR%C3%8DSTICA,%20ESTRUCTURA%20Y%20ENDEMISMO%20DE%20UN%20BOSQUE%20SIEMPREVERDE.pdf.

Pla, L. (2006). Biodiversity Inference Based on Shannon's Index and Richness. Caracas. Venezuela. 31(8) https://www.redalyc.org/pdf/339/33911906.pdf. [Links]

Prado, N. (2009) . Identification of traditional agroforestry systems and selection of the best practices to face desertification in the Macará canton. National University of Loja. Agricultural and

Renewable Natural Resources Area. Thesis prior to obtaining the degree of Forestry Engineer. P. 34-44. P. 110. Loja - Ecuador

Torres, B., Jadán, O., Aguirre, P., Hinojosa. L, & Günter, S. (2014). The Contribution of Traditional Agroforestry to Climate Change Adaptation in the Ecuadorian Amazon. The Chakra System. Handbook of Climate Change Adaptation. 19 https://www.researchgate.net/publication/270212436_The_Contribution_of_Traditional_Agroforestry_to_Climate_Change_Adaptation_in_the_Ecuadorian_Amazon_The_Chakra_System

Zambrano, C; (2012). Characterization of traditional agroforestry systems in the canton of Valencia. (Thesis prior to obtaining the degree of forestry engineer) State University of Quevedo. Ecuador. 152 repositorio.uteq.edu.ec/handle/43000/2093.