CARBON CONTENT SEQUESTERED IN THE NATURAL GRASSLANDS OF THE PROTECTED AREA "ICHUBAMBA YASEPAN", THROUGH GEOSTATISTICAL ANALYSIS.

Guicela Margoth Ati Cutiupala[1]* Víctor Adrián Caguana Siguencia[2], Maritza Lucia Vaca Cárdenas [3], Hernán Eriberto Chamorro Sevilla [1]Miguel Ángel Guallpa Calva [1,] Martha Marisol Vasco Lucio[2],Norma Ximena Lara Vásconez[2,] Diego Francisco Cushquicullma Colcha[4]

1 Facultad de Recursos Naturales, Escuela Superior Politécnica de Chimborazo, Panamericana Sur, Km 1 ½, Riobamba EC-060155, Ecuador; *Correspondencia guicela.ati@espoch.edu.ec , https://orcid.org/0000-0002-9779-2758;hernan.chamorro@espoch.edu.ec ; https://orcid.org/0000-0002-8531-7116 ;miguel.guallpa@espoch.edu.ec ; https://orcid.org/0000-0001-5392-036X

2 Investigador Independiente, Riobamba EC-060155, Ecuador;;caguana_adrian@outlook.com,https://orcid.org/0000-0002-7821-5904;martha1995vasco@hotmail.com , https://orcid.org/0000-0003-1377-7305, xnormalara@yahoo.com , https://orcid.org/0000-0001-8381-0401

3 Facultad de Ciencias Pecuarias, Escuela Superior Politécnica de Chimborazo, Panamericana Sur, Km 1 ½, Riobamba EC-060155;maritza.vaca@espoch.edu.ec ; https://orcid.org/0000-0003-4474-4354

4 Universidad de Granada, Avenida de Fuente Nueva, s/n, 18071-Granada-España; diegofc10@correo.ugr.es; https://orcid.org/0000-0001-6265-8164

Summary

Global warming as a result of the increase in greenhouse gases symbolizes a great threat to life on the planet, with the passage of time it has been reflected in the increase intemperatures causing major disasters and altering physical, biological and human systems, so it is sought mitigate its effects and preserve biodiversity. Therefore, the present research proposed to estimate the content of carbon sequestered in the natural grasslands of the Ichubamba Yasepan protected area, with the purpose of establishing the amount of carbon present in necro mass, biomass and soil stored in the high Andean natural grasslands to have real data for future negotiations of environmental compensations and thus contribute to the reduction of greenhouse gas emissions associated with deforestation and environmental degradation. In the grassland and shrub ecosystems 4 plots were established and sampling units of square shape with dimension of 10 x10 m were installed, two circular plots with a radius of 5 and 2.5 m were installed, 8 quadrants of 50 x 50 cm were formed according to the GLORIA methodology, where they were collected 18 necromass samples, 18 aerial biomass samples and 16 soil samples. These were processed in the laboratory of the Faculty of Natural Resources (FRN) of the Polytechnic School of Chimborazo (ESPOCh). For the statistical analysis, a database was built that was processed using the InfoStat statistical package, where values between 6.14 and 7.22 Ton C * ha-1 of biomass, 1.74 and 11.55 Ton C * ha-1 in necro mass and according to the depth of the soil of 30 to 60 cm the amount of 93.98 Ton C *$^{ha-1}$ was determined , obtaining as total results 170.8 Ton C * ha-1 in the shrub vegetation corresponding to 220,690.68 tons of total carbon in an area of 1292.1 hectares, while the grass vegetation registered 178.7 Ton C * ha-1 corresponding to 625,097.96 tons of total carbon distributed in 3498.03 hectares,which affirms that these ecosystems are huge carbon containers since vegetation cover absorbs CO2 from the environment, stores part of the carbon and returns oxygen to the atmosphere, all this through the process of photosynthesis, which prevents the destruction of the ozone layer and strengthens the mitigation of climate change worldwide.

Keywords: Carbon sequestration, shrub vegetation, grassland vegetation, aerial biomass, necro mass.

Introduction

Climate change threatens the environment, affects human health, food security, other natural resources and physical infrastructure. According to a report by the Intergovernmental Panel on Climate Change, scientists agree that increasing concentrations of anthropogenic greenhouse gases in the Earth's atmosphere are causing climate change (1). There is great interest in the management of forests to mitigate high concentrations of carbon and its repercussions on the global climate, but also some mitigation techniques may even clash with management strategies for objectives of maintenance and restoration of biodiversity worldwide, however, the use of forests shows clear reduction in carbon storage (2) . Therefore, it is essential to have information about carbon, through the establishment of field techniques to monitor and calculate its storage in forests (3) Grassland ecosystems have great potential in their soils because they store a large amount of carbon, in addition the presence of shrubs and trees contribute to the total reserve of the same (4) . The growing concern about the increase in CO2 caused by anthropic activities has caused people to become aware worldwide (5)

Generally, all areas covered by natural pastures in the country present different degrees of degradation, as a result of human intervention and the advance of livestock that breaks the balance in nature (6). In the southern Andes of Ecuador, the most important natural vegetation ecosystems are the páramos and the adjacent natural forests or grasslands due to their economic, social and ecological contribution (7). The moors are located at more than 3,000 meters above sea level and have a herbaceous vegetation dominated by grasses, shrubs or reeds (8). Ecologically, páramos perform environmental functions such as carbon storage and fixation (9). In Ecuador, páramos are known as important sinks because they contain a high percentage of carbon stocks. Mostof the páramos are one of the best options for carbon sequestration, since these ecosystems reduce the phenomenon of climate change generated by activities such as land use change, deforestation, biomass burning, among others. Similarly, the basic option for the conservation and storage of carbon through the paramo is identified: the conservation of native species of the place thus avoiding carbon emissions and promoting the protection and sustainable management of the natural ecosystem, which leads to recover degraded areas with actions such as the protection of watersheds, reforestation, etc.

Páramos are natural systems whose interactions contribute to balance and normal natural activity. In addition, it has a biodiversity that fulfills several functions such as social, cultural, economic, ecological, biological and hydrological, it is an important ecosystem service for the community. It is protected by parks and ecological reserves that cover the highlands of the Andes. In addition, Ecuador's páramo has approximately 1,835,834 hectares (10),reflecting its importance in mitigating climate change. Therefore, in addition to being a regulator of water resources, it has several qualities, among which stand out, the accumulation of organic matter and the storage and capture of carbon (11). Carbon is an essential chemical element in organic compounds, elements distributed between the ocean, atmosphere, land and subsoil in which carbon deposits, reservoirs or storage are formed (12). The Páramo of the Ichubamba Yasepan Cooperative being a private

property, on July 30, 2020, became part of the National System of Protected Areas of Ecuador (SNAP), it has great ecosystem services, one of them is the supply of the water resource generated in the páramos, on which the General Board of Chambo-Guano users depends with 11000 users who grow their agricultural products and carry out agricultural activities.
The processes of carbon capture and emission are part of a system of four reservoirs in: aerial and root vegetation, decaying matter, soils and forest products, with very different and closely interrelated associated residence times and flows. In the páramo, carbon is more concentrated due to the low temperature and the slow decomposition of plant residues in this ecosystem, which contributes to carbon fixation, so the present research focuses on the ecosystems present in the páramo of the Protected Area "Ichubamba Yasepan", which is an important space for the conservation and research of ecosystem goods and services, for the great biodiversity it possesses.

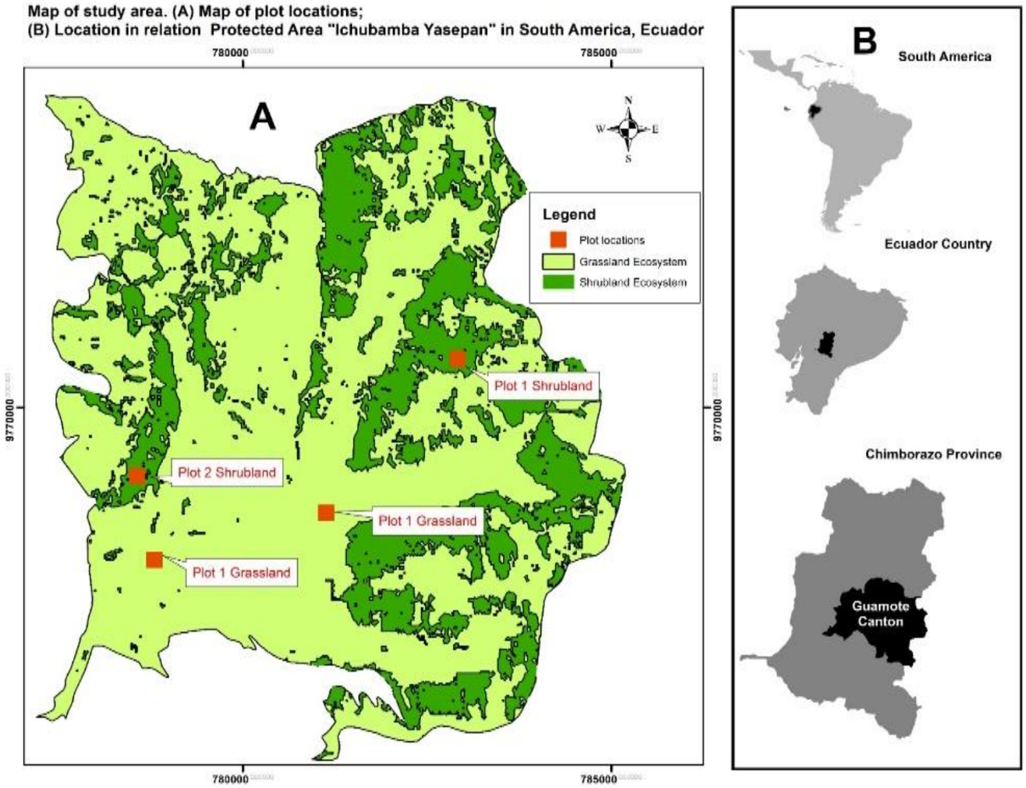
2. **Materials and methods**

The present research was constituted in a systematic process based on experimental sampling strategies for the direct collection of samples in situ, to continue with the research process in the soil laboratory of the Faculty of Natural Resources (FRN) of the Polytechnic School of Chimborazo (ESPOCH), in order to obtain the data. The study was carried out in the two ecosystems of the protected area which correspond to: Grassland Ecosystem of páramo that has an area of 3498.03 hectares (Ha.) and the Scrub Ecosystem of páramo with 1292.1 Ha; for which 2 plots were established in each of the ecosystems through the application of Geographic Information Systems and Q GIS software, considering accessibility and distance between plots (500 meters).

2.1. *Area of study*

The present research work was developed on the premises of the Agricultural Cooperative Ichubamba Yasepan, as shown in (figure 1) is located in the parish Cebadas, canton Guamote, province of Chimborazo; It is composed mainly of vegetation of Herbazal and Arbustal páramo in an altitudinal range between 3440 and 4320 m.a.s.l., Geographical location: latitude 9780678 UTM and longitude 0764938 UTM. Northern limits: Páramo de tres Cruces-Guargualla, South: Sangay National Park, West: Sangay National Park and east: Reten Milmahuanchi. The moors of the Ichubamba Yasepan Cooperative have a temperate – cold climate, and the temperature varies between 4 to 20 ° C with an annual average of 13.7 °C (Chambo Guano Irrigation Board, 2019; cited in Caranqui et al., 2021).

Figure 1. Location of the study area in the moors of the protected area "Ichubamba Yasepan", of the herbazal and shrub ecosystems 4 plots were installed.



2.2.1. Data collection

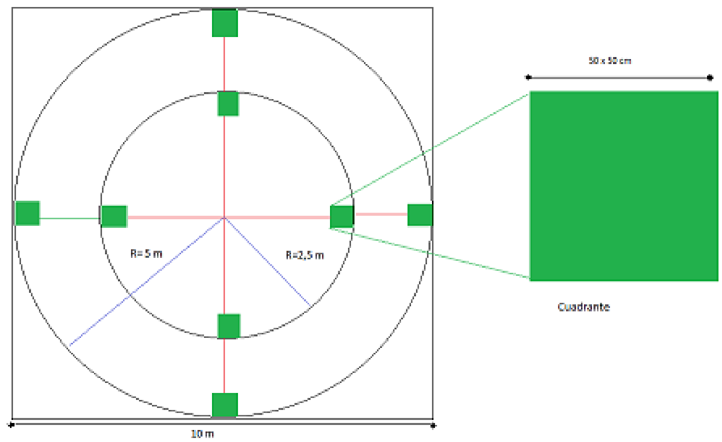
The following study factors were identified at the site, such as: altitude and depth. Subsequently, sampling units of square shape with the dimension of 10 x10 m were installed based on the methodology proposed by Calderón et al. (13),with a modification in the distribution of the quadrants since in each of the plots 8 was determined unlike 12 that is explained in the methodology, This is due to the difficulty of access to the plots and the type of vegetation. In the installation of the plot, subplot and quadrants for the collection of information, sampling was carried out according to the GLORIA methodology, which was designed specifically for studies in páramos, methodology proposed by Calderón et al. (13) For the installation of plots and after their layout, samples of biomass, necromass and soil were collected. The study of biomass is very useful to establish a complete knowledge about high altitude vegetation and therefore reduce the degradation of ecosystems through the use of native plant species (14), in the same way the intensive analysis of necromass is very important in studies to make estimates of carbon components, which cannot be known simply by satellite remote sensing (15).

For the collection we proceeded to cut with the pruning shears in the case of aerial biomass from the stem, for the necromass all the dead matter was taken by hand and for the soil the hole tool was used, then the samples were packed in hermetically sealed sheaths, each of them was weighed and the corresponding data were taken, and then be transported to the soil laboratory of the Faculty of Natural Resources of ESPOCH.

2.2.2. Carbon estimation of necromass and biomass of the grassland and shrub ecosystem

For the estimation of the carbon content in the necromass and the biomass of the grassland and shrub ecosystem in the general plot of 10 x 10 m two circular plots with a radius of 5 and 2.5 m were nested, the necromass and biomass were collected each in 4 quadrants of 50 x 50 cm, two in the circular subplot of 5 m radius and two in the subplot of 2.5 m radius in the form of a cross, which is shown in (Figure 2). The direction of the cross was defined at random. The collected necromass and biomass samples were weighed and taken to the laboratory for drying usually between 48 and 72 hours at 60 ° C in the stove, then the samples were reweighed, and then placed in the muffle at 450 ° C for one hour.

Figure 2. Plot design, subplots and quadrants for random cross data collection



To know the carbon content in the biomass and necro mass, the moisture content and the amount of dry biomass were established; These contents were obtained from the fresh weight determined in the laboratory stage. The moisture content is the amount of water contained in the biomass, and is calculated by the equation established by Serrato et. al. (16). For this the following equation was used:

Equation 1

$$CH = \frac{Pfs - Pss}{Pfs}$$

CH= moisture content
Pfs= fresh weight of subsample (g)
Pss= dry weight of the subsample (g)

To determine the biomass, all the vegetation present (aerial biomass) was harvested, cutting it flush with the ground with a pruning shears. On the other hand, for the conversion of biomass to carbon it has been shown in studies that the use of conversion coefficients is very necessary, which allows differentiating the carbon stored in aerial biomass (17). However, according to what Serrato et. al. (16). Biomass refers to the weight of organic matter that is free of moisture, so the following equation was used to determine biomass:

Equation 2

$$\mathrm{B(ton)} = \frac{(\mathrm{Pft}) - (\mathrm{Pft} * \mathrm{CH})}{1000000}$$

Where:

B=biomass (tonnes)

Pft=Peso fresco total (g)

CH=moisture content

1ton =1000000 g

According to Serrato et. al. (16), half of the dry biomass belongs to the amount of Carbon, therefore, once the dry biomass has been determined it is multiplied by 0.5 as indicated by the IPCC (IPCC 1996) according to the following equation:

$$CC\ (\mathrm{Ton\,C} * \mathrm{ha}^{-1}) = \frac{B\ *\ 0.5}{\mathrm{Tmm}}$$

Where:

CC= Carbon content (ton/ha)

B=Biomass (tonnes)

Tmm= Total metres sampled (ha)

0.5= IPCC Carbon Factor

2.2.3. Estimation of soil carbon in the grassland and shrub ecosystem

The soil is considered a great reservoir of carbon in nature, its content has been strongly studied in forest species, leaving aside important ecosystems such as the high Andean natural grasslands, whose vegetation cover is constituted by great diversity of species distributed in large areas of territory (18). In the 4 sampling units of 10 x 10 m, with the hole we proceeded to take 4 subsamples at two depths: 0-30 cm and 30-60 cm, the subsamples were taken in each corner of the plot; which were mixed forming a sample composed of each depth, hermetically packed and labeled with the plot number, the vegetation, depth, altitude, and responsible for sampling, were then sent to the soil laboratory, where they were dried at 60 ° C between 48 to 72 hours, in the stove, then proceeded to weigh each of the samples, and then placed in the muffle where they remained at 450 ° C for half an hour. With the results issued by the laboratory, the calculations corresponding to the carbon content were made.

2.2.4. Soil Organic Carbon (SOC)

Soil organic carbon (SOC) results from the balance between the incorporation of fresh organic material into the soil and the output of soil carbon in the form of CO2 into the atmosphere (19). The estimate of carbon content depends on land-use change, age and vegetation type (20). SOC is dynamic, however anthropogenic impacts on soil can make it a sink or net source of greenhouse gases (21). The organic carbon content of a soil is indicative of the percentage of its organic matter. The importance of determining organic carbon is that it provides an indication of the organic matter content of the soil. For its determination, the dry combustion method is used, useful for high precision purposes because absolute values are obtained (22).

From the value obtained for organic matter, the Van Bemmelen factor of (1.724) was used to calculate the percentage of soil organic carbon, which assumes that 58% of the MO is composed of C Eyherabide et, al. (23). The following equation was used for the calculation:

$$\%CO = \frac{\%MO}{1{,}724}$$

To know the CO content in the study area, an estimate was made by calculating the COS (in milligrams per hectare) in the sampling area according to each land use, for which the following equation was used:

$$\text{COS}\ ((\text{Ton C} * \text{ha}^{-1}))\ = \frac{\%\text{CO}}{100} * \text{Da} * \text{Prof} * 100$$

Where

COS (Ton C*$^{ha-1}$) = carbon content in soil

Da=Bulk density (g/cc)

D=Depth (cm)

100= Ratio between (1ha=100000000cm ^{2};1ton=1000000g)

2.2.5 Total carbon stored

To know the total carbon stored, the formula proposed by Ayala was used. *Et al.* (24) with modifications; the total carbon content stored in shrub and grassland vegetation is the sum of total soil carbon plus biomass and necromass in the units of Ton C*ha-1.

$$CT = COS + CCN + CCB$$

Where

COS (Ton C*$^{ha-1}$) = carbon content in soil

CCN (Ton C*$^{ha-1}$) = Carbon content in necromass

CCB (Ton C*$^{ha-1}$) = carbon content in biomass

2.3. Statistical analysis

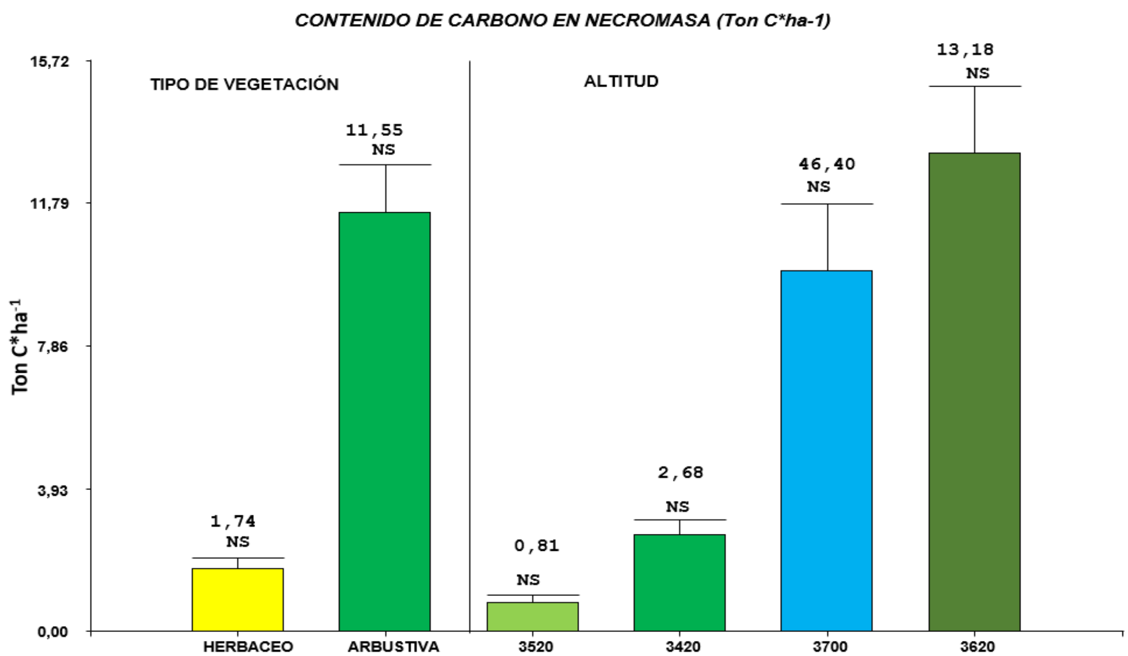
The data were analyzed with the statistical package InfoStat the Tukey test was performed in order to generate comparative tables between the species, performing the respective analyzes and establishing the amount of carbon stored in the protected area, in addition to check the assumptions of normality and homoscedasticity Shapiro Wilks – modified and the Levene test was applied, where, in the case of not complying with the assumptions, the means with the best result were visually identified (25).

3. Results

3.1. *Necromass analysis*

According to the tests of normality and homoscedasticity applied in the carbon content for the necro mass the data do not behave normally, however it can be observed that the means have visual difference between them. In (figure 3) it can be seen that shrub vegetation registers a higher average carbon content of 11.55 Ton C *$^{ha-1}$ than herbaceous vegetation, in the same way it is shown that at altitudes of 3620 to 3700 meters above sea level a higher carbon concentration was obtained. This coincides with the study carried out by Carrera (26) that indicates a positive relationship between altitude and carbon content in aerial biomass, that is, in the same way as in the present study at higher altitudes the carbon concentration is presented in an ascending way. In addition, in the study carried out by Páliz (27) in the Uyuca Biological Reserve in Honduras, he points out that the increase in altitude influences the carbon content, thus being at 1900 meters above sea level the contribution was the highest of 1.82 (g.cm-2), compared to 1.24 (g.cm-2) obtained at 1700 meters above sea level, however, It was also evident that land use over time has modified this result. On the other hand, the present research coincides with the study carried out by Pastor et al. (28), which recognises that the carbon content is higher at higher altitude sites.

Figure 3. Carbon content in necromass according to the type of herbaceous and shrubby vegetation, and altitude



According to (tabla 1) it is observed that the biomass does not present significant differences however a visual difference of means can be observed in which it indicates that the biomass of the herbaceous vegetation contains more carbon with 7.22 CC (TN / HA-BIOMASS), unlike the shrub vegetation that obtained a lower value of 6.14 CC (TN / HA-BIOMASS).

Table 1. Summary measures for the biomass of the shrub and herbaceous paramo vegetation type

TYPE OF VEGETATION	Variable	n	Media	D.E.	CV	My.	Max.
SHRUB	CC(TN/HA-BIOMASS)	24	6,14	1,76	28,65	3,71	9,24
HERBACEA	CC(TN/HA-BIOMASS)	24	7,22	2,61	36,17	3,57	12,89

For the normality test, absolute residuals are used to help determine if the assumptions of ordinary least squares and the behavior of the data are met.

3.2. Carbon stored in soil

As Cerri et al. (29) point out, soil is the most important reservoir of carbon in the biosphere because it contains three times more carbon than vegetation and the atmosphere. In addition, in the study prepared by Huaman et al. (18) It is concluded that as altitude increases, the soil has a greater capacity to store organic carbon. On the other hand, in the study conducted by Acosta et al. (30) It was evident that at greater soil depths the carbon concentration decreased by about 35%.

The shrub vegetation has a pH between 5.92 and 6.45; while the grassland area has a pH between 5.95 and 6.74 slightly more neutral than shrub vegetation. The data correspond to a normal distribution, which is why it was verified through the assumptions of normality and homoscedasticity according to the methodology of Balzarini et al. (25)

Table 2. Shapiro-Wilks Normality Test (modified*)*

VEGETATION TYPE	Variable	n	Media	D.E.	In*	P (Unilateral D)
ARBUSTAL	RDUO DC tn/ha	24	0	18,71	0,97	0,8861
HERBACEA	RDUO DC tn/ha	24	0	31,68	0,98	0,9595

According to (table 2) the p value > 0.05 so the null hypothesis is accepted that mentions that all values are similar. The hypotheses that were tested are: H0: residues have normal distribution versus H1: residues have no normal distribution. Additionally, the homoscedasticity test must be performed with the Levene test.

According to Balzarini*et al.* (25) The Levene test consists of performing an analysis of variance using the absolute value of the residuals as the dependent variable. If the p-value of the treatment factor of this ANAVA is less than the value of nominal significance, the hypothesis of homogeneous variances is rejected, otherwise the assumption of equality of variances can be sustained, as observed in (table 3) p value > 0.05 the null hypothesis that mentions the variances are equal is accepted. Once the assumptions were verified and being clear that the data are normal, the ANAVA and the comparison of Tukey's means at 5% were carried out.

Table 3. Analysis of Variance Table (Levene)

F.V.	SC	Gl	CM	F	p-value
Model	1164,37	1	1164,37	4,16	0,0573
Vegetation type	1164,37	1	1164,37	4,16	0,0573
Error	12887,41	46	280,16		
Total	14051,78	47			

In addition to the two-factor ANAVAL, an interaction was made between vegetation type and soil depth, if the p value is < 0.001 we can say that the statistical difference is highly significant (Table 4).

Table 4. Analysis of variance

Variable		N	R^2	R^2 I	CV
CC tn/ha		48	0,63	0,61	28,25
F.V.	**SC**	**Gl**	**CM**	**F**	**p-value**
Model	53288,15	3	17762,72	25,1	<0,0001*
Type vegetation	14882,56	1	14882,56	21,03	<0,0001*
Depth	34260,38	1	34260,38	48,42	<0,0001*
Type veget*depth	4145,2	1	4145,2	5,86	0,0197
Error	31135,8	44	707,63		

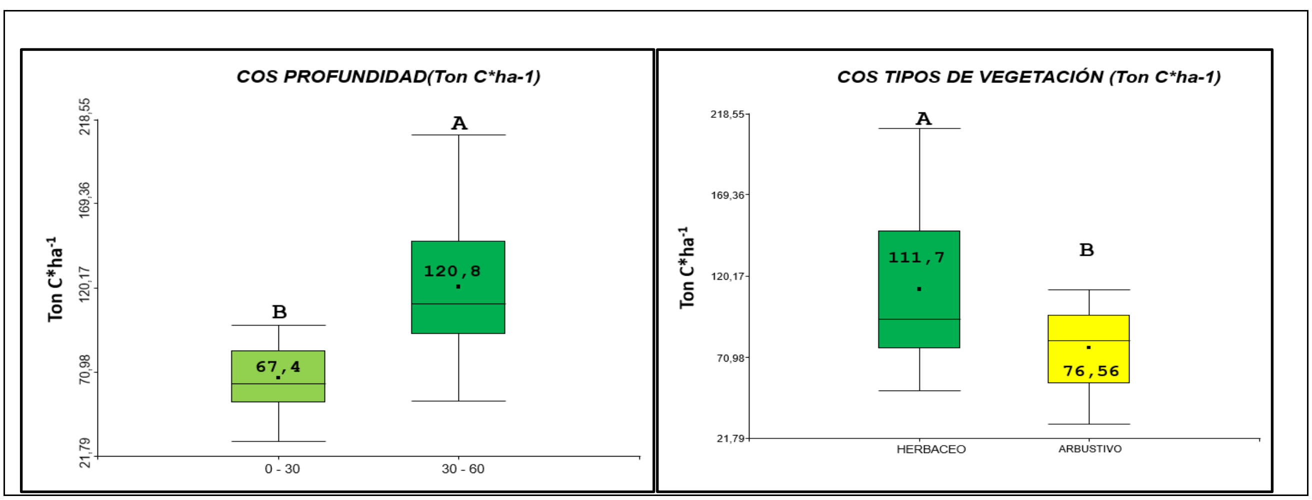
Total	84423,94	47

In addition to the two-factor ANAVAL, an interaction was made between soil type and depth, if the p value is < 0.001 we can say that the statistical difference is highly significant.

The organic carbon in the aerial biomass, necro mass and soil of the herbaceous and shrub vegetation was determined, the results showed that there are highly significant differences for the variable type of vegetation and soil depth. The (figure 6) shows that the deeper the soil carbon content (SOC) increases so it can be seen that from 30 to 60 cm depth of herbaceous vegetation presented the highest amount of stored carbon of 120.8 Ton C * ha-1, unlike the depth of 0 to 30 cm of shrub vegetation with 67.4 Ton C $*^{ha-1}$, which coincides with Castañeda et. al, (31) which proposes a comparison of the carbon content related to the depths of the soil where the similar trend maintains greater depth greater amount of carbon, as shown by the results obtained.

In addition, as can be seen in (figure 6) The herbaceous vegetation shows greater carbon sequestration with 111.7 Ton C * ha-1, while the shrub vegetation obtained 76.56 Ton C $*^{ha-1}$, this is very similar to what Guallpa et al mentions. (32), in its study, noting that the carbon stored 20 cm from the soil, the herbaceous vegetation obtained 111,84 Ton C*ha-1 and the shrub vegetation presented instead 122,45 Ton $C*^{ha-1}$ a value higher than the result of the present study.

Figure 6. Carbon content at soil depth and vegetation types



3.3. Total carbon present in grasslands

In (table 5) the total carbon is observed according to the type of vegetation and its relationship with the surface of each ecosystem, which is the result of the sum of the carbon registered in biomass, necromass and soil, so it was obtained as a result that the herbaceous vegetation reached the highest value of 178.7 Ton C $*^{ha-1}$ which according to its area of 3498.03 hectares corresponds to 625,097.96 tons of total carbon, while shrub vegetation showed 170.8 tons C $*^{ha-1}$ corresponding to 220,690.68 tons of total carbon in 1292.1 hectares.

Table 5. Total carbon present in grasslands according to the type of shrub and herbaceous vegetation with respect to biomass. necro mass and depth from 0 to 30 cm and 30 to 60 cm

VEGETATION TYPE	SHRUB (medium)	Total area (Ha)	HERBACEA (media)	Total area (Ha)
		1.292,1		**3.498,03**
BIOMASS	6,14	7933,49	7,22	25.255,78
NECRO MASS	11,55	14.923,76	1,74	6.086,57
0-30cm	59,13	76.401,87	75,76	265.010,75
30-60cm	93,98	121.431,56	93,98	328.744,86
TOTAL (Ton C$*^{ha-1}$)	170,8	220.690,68	178,7	625.097,96

4. Discussion

It is observed that at greater depth there is greater carbon content, since within the study at a depth greater than 30 to 60 cm in both types of vegetation was recorded 93.98 Ton C $*^{ha-1}$, this coincides with the study prepared by Guallpa et al. (33) within which it indicates that the carbon content was higher at greater depths, where 20 to 30 cm in grassland-type soil the highest values of 121,33 Ton C * ha-1 were observed, in addition they established that the amount of carbon depends on land use and environmental factors. In the research carried out by Aguirre (34) it is observed that the total coal obtained was 546.86 MgC*ha, which corresponds to 7070.9 MgC°C in an area of 12.93 hectares, a value lower than that obtained in the present study, which is not only due to the size of the area studied but also to the type of existing vegetation and even to the lack of a more complete study that contemplates carbon analysis in the soil depth.

For the estimation of the carbon content in the biomass and necromass of páramo was taken as a reference the protocol for monitoring carbon contents and fluxes in high Andean altitudinal gradients, as proposed in the methodology, Hofstede (1999), where it is recorded that the biomass of the grassland páramos store a maximum of 20 Ton C $*^{ha-1}$, values different from those reported in this research, since the figures were 170.8 Ton C * ha-1 for shrub vegetation and 178.7 Ton C $*^{ha-1}$ for grass vegetation, these data were obtained from the total sum of the carbon contents present in biomass, necro mass and at ground level.

In the study conducted in the Podocarpus National Park by Aguirre et al. (35) the herbaceous páramo obtained 4.27 Ton C*ha-1 and in the shrub 7.08 Ton C*ha-1 in the biomass, similar to the results obtained in the present investigation, which yielded the following results: 7.22 Ton C*ha-1 for grassland and 6.14 Ton C$*^{ha-1}$ for shrub vegetation,which is ratified in the study conducted by Ayala et al. (24) where the shrub vegetation obtained a value of 159.05 Ton C * ha-1 in biomass and necro mass, on the other hand the grass vegetation only obtained 116.18 Ton C $*^{ha-1}$; with which it can be observed that the shrub ecosystem obtained more carbon sequestered as the present study.

In similar studies on carbon sequestration stored in a *Tectona grandis* plantation in Mexico as García et al. (36), an estimated 66.41 Ton C*ha-1 was obtained in 4 years, a low value compared to the results of the present investigation where it can be evidenced that the páramos of the protected area presents in grassland vegetation 178.7 Ton C * ha-1 and 170.8 Ton C $*^{ha-1}$ in shrub vegetation. In another research carried out by Seppanen (37),on carbon sequestration through eucalyptus plantations in southeastern Mexico, it is evident that eucalyptus showed a high productivity of 40 m^3/ha/year which is estimated to generate between 320 and 610 Ton C $*^{ha-1}$ this in a cycle of 7 years.

The results obtained ratify what was stated by Palacios et al. (38), as regards the importance of nature reserves for the provision of ecosystem services, which has been little studied especially in terms of carbon storage, which undoubtedly plays an indispensable role in the mitigation of climate change. On the other hand, Bunning et al, (39) points out that the páramos house about 25% of all the diversity of the planet, thus occupying a fifth of the earth's surface, which supply drinking water for the global population, are considered vital for climate change due to their relationship with carbon capture and storage.

The study carried out by Martel et, al. (40) on the "Quantification of carbon stored in Amazonian plant formations in Peru" indicates that the levels of carbon storage in forests and any plant formation must be clearly identified, because this allows a more effective management and thus determine the potential conservation areas to protect the ecosystem services of the site.

5. Conclusions

The carbon content in the biomass compartment was 7.22 Ton C * ha-1 in grass vegetation and 6.14 Ton C * ha-1 for shrub vegetation, for necro mass was obtained 1.74 Ton C * ha-1 and 11.55 Ton C * ha-1 respectively, on the other hand, in the soil at 30 cm depth was reached 59.13 Ton C * ha-1 for shrub vegetation and 75.76Ton C * $^{ha-1}$ for grassland, and finally at 60 cm depth was obtained 93.98 Ton C *$^{ha-1}$ in both types of vegetation.

The total carbon stored in the moors of the Protected Area "Ichubamba Yasepan", for shrub vegetation was 220,690.68 tons of carbon distributed in 1292.1 hectares, while grass vegetation obtained a value of 625,097.96 tons of carbon distributed in 3498.03 hectares.

Research on carbon sequestration has generally focused on forest plantations due to the use made of this type of species, which are also potential to mitigate CO2 from the atmosphere, however, according to the results of the present research show that due to the diversity of species of natural grassland ecosystems show high figures of carbon sequestration, surpassing forest plantations.

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