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Article

Carbon stored in an agroforestry plot under the Sowing Life Program in Huehuetán

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Abstract

Climate change today constitutes a substantial threat to living beings. Human activities such as the use of fossil fuels, burning, the use of chemicals, and mainly deforestation contribute to the emission of greenhouse gases. In response to this, in Mexico, governmental, national, and environmental programs have been implemented that establish schemes in conjunction with producers in which various social, economic, and environmental benefits are obtained, and whose main objective is to reduce the environmental impact, as is the case with the Sowing Life Program. Agroforestry systems are considered a relevant system to face climate change through the biomass and carbon content of the different plant strata in these agroecosystems. The research estimated the indirect carbon storage in the agroforestry system, with a total of 15 sites measuring 4 x 25 m; the plot is a participant in the Sowing Life Program in the locality of San José El Amate (Huehuetán, Chiapas); once these data have been collected, biomass, carbon, and carbon dioxide were obtained through allometric equations. The agroforestry plot studied has a reserve of 22.6 t ha^{-1} of aboveground biomass, 8.75 t ha^{-1} of carbon and 32.14 t ha^{-1} of carbon dioxide.

Keywords:

biomasa aérea, cambio climático, mitigación, modelos alométricos.

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Introduction

High concentrations of greenhouse gases, such as carbon dioxide (CO_2), have driven the search for strategies to mitigate them through natural absorption and storage mechanisms (González-Abrego *et al*., 2023). Agroforestry systems play an essential role in this process. The amount of carbon sequestered is linked to the characteristics of the agroforestry system present *in situ*, including tree species and system management (Podong *et al*., 2023).

Mexico is among the 15 countries with the highest greenhouse gas emissions worldwide, with approximately 444 million tons of net emissions per year, which represents 2% of global emissions (Casanova *et al*., 2011). In Mexico, a series of social and productive programs have been created to promote the development of small-scale producers; among them, the Sembrando Vida (Sowing Life) Program stands out, the purpose of which is to increase agroforestry productivity based on sustainability criteria, considering the mitigation of climate change and the reduction of greenhouse gases (Baca *et al*., 2021).

In the state of Chiapas, from 2001 to 2018, 327 753 ha were deforested, equivalent to 18 209 ha year^{-1} of deforested land; in 2023, 10 694 ha were deforested (CONAFOR 2022). Due to the loss of cover and soil degradation, the Sowing Life Program has been implemented, with the primary objective of reducing environmental degradation.

The plots established under this production scheme meet conditions that allow their carbon sequestration potential to be evaluated from the early stages, because it incorporates forest species (cedars and mahogany), fruit species (citrus), and traditional crops (coffee and cocoa) in various agroforestry arrangements (INECC, 2021). Despite the program's socioenvironmental importance, most research has focused on social and economic aspects (Tapia-Alba and Chiatchoua, 2025), and studies on ecological impacts are limited, leaving an important gap to investigate the carbon dynamics in these agroecosystems (Cortez *et al*., 2022).

Therefore, this study aims to estimate the carbon content stored in the aboveground biomass of forest species in plots under the Sowing Life agroforestry scheme in Huehuetán, Chiapas.

Materials and methods

Study area

The research was conducted in the locality of San José El Amate, in the municipality of Huehuetán, Chiapas. The UTM coordinates are 1 657 449 on the Y-axis and 559 120 on the X-axis, located in zone 15, with an altitude of 50 m. The study plot has an area of 2.5 ha enrolled in the Sowing Life Program (Figure 1).

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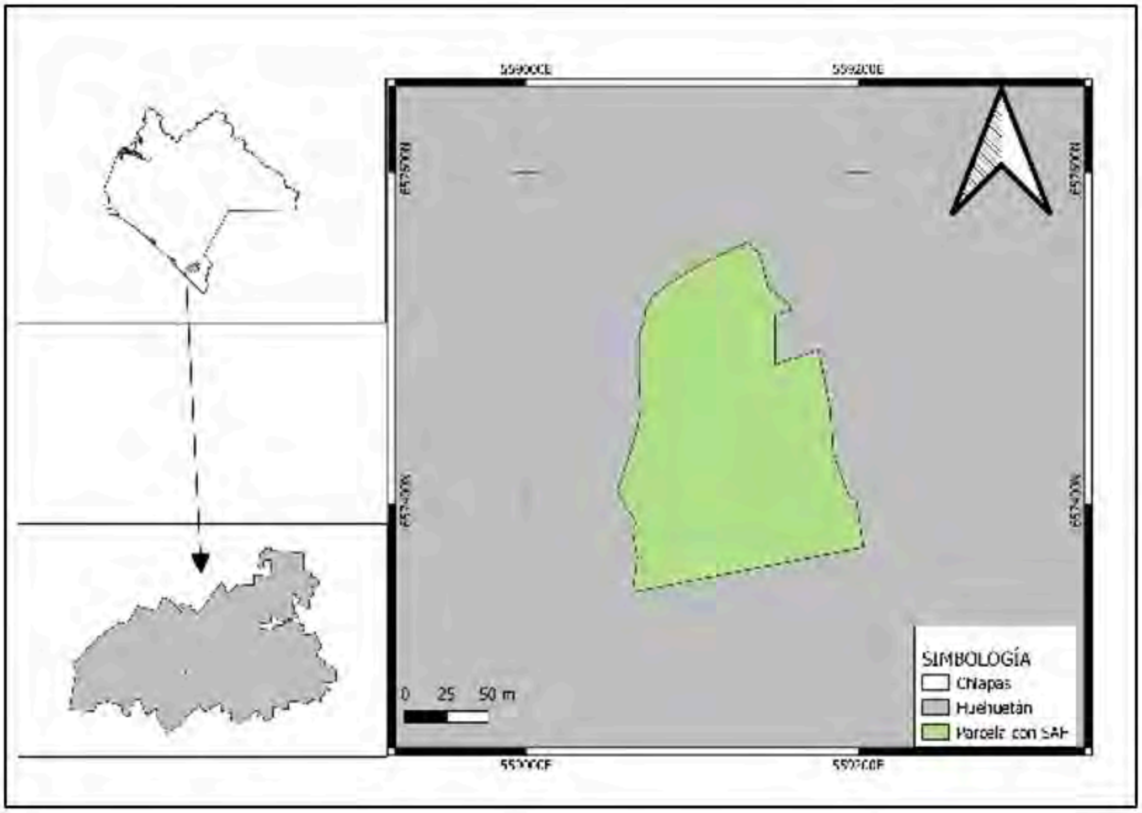
Figure 1. Location of the study area within the locality of San José El Amate in Huehuetán, Chiapas.



The plot was established in 2019 within the Sowing Life Program and was evaluated in the fourth year. The plantation design consists of a mixed agroforestry system that combines agricultural and forestry activities with the association of seven species. Agricultural species include *Musa paradisiaca* L. and *Theobroma cacao* L., with average diameters at breast height (DBH) of 12.36 cm and 4.79 cm (2 m high), respectively. The main forest species (fruit and timber) are: *Annona muricata* L., *Bixa orellana* L., *Cedrela odorata* L., *Tabebuia rosea* L., and *Cocos nucifera* L.; these have an average DBH of 3.5 cm, 5.57 cm, 5.56 cm, 6.76 cm and 0.95 cm, respectively, with a mean height of 1.7 m.

Experimental design

The research was conducted under a simple random design, primarily using 15 sites, each with an area of 100 m^2 (4 x 25 m). For data collection, plant species were stratified; small-sized species were recorded first, followed by the inventory of forest species. In each plot, the species present were identified and quantified, and the variables diameter at breast height (DBH) and total height (h) were measured.

Aboveground biomass

To estimate aboveground biomass, the indirect method was employed, using allometric equations specific to each species or functional group (Table 1).

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Table 1. Allometric equations for each species recorded in the experimental area.

Model	Species	Equation	Author
1	*Annona muricata* L.	LogBA= -1.716+2.413*Log(DBH)	Nogueira *et al*. (2008)
2	*Bixa orellana* L.	LogBA= -1.716+2.413*Log(DBH)	Nogueira *et al*. (2008)
3	*Cedrela odorata* L.	B= 0.00341*DBH$^{3.38248}$	Benavides-Solorio *et al*. (2021)
4	*Cocos nucifera* L.	B= 4.5+7.7*H	Frangí and Lugo (1985)
5	*Musa paradisiaca* L.	B= 0.0303*DBH$^{2.1345}$	Danarto and Hapsari (2016)
6	*Tabebuia rosea* L.	B= 0.1959*D$^{2.1206}$	Sáenz-Reyes *et al*. (2021)
7	*Theobroma cacao* L.	LnB= -4.2+1.19*Ln(DBH)+2.34*Ln(H)	Morán-Villa *et al*. (2024)

B= biomass; Ln= natural logarithm; D= diameter; H= height and DBH= diameter at breast height.

From these equations, individual biomass values were calculated and then integrated to obtain the total biomass by site. Each model was applied to a specific species according to its suitability and previous validation in studies related to its physiology and growth.

Carbon concentration

The carbon concentration of the plant species recorded in the study area was obtained from the average factors reported in the literature (Table 2).

Table 2. Carbon concentration by species.

Species	Carbon concentration	Author
Annona muricata L.	0.5	Elías and Potvin (2003)
Bixa orellana L.	0.5	Elías and Potvin (2003)
Cedrela odorata L.	0.45	Mendizábal-Hernández *et al*. (2011)
Cocos nucifera L.	0.5	IPCC (2003)
Musa paradisiaca L.	0.37	Arias *et al*. (2014)
Tabebuia rosea L.	0.5	Hamburg (2000)
Theobroma cacao L.	0.47	Hernández-Núñez (2021)

Carbon content

To obtain the carbon content, the total aboveground biomass of each individual was quantified through allometric models. Subsequently, the biomass value was multiplied by the corresponding carbon concentration factor to convert the results into tonnes per hectare (t ha^{-1}).

Carbon dioxide equivalent

To estimate carbon dioxide equivalent (CO_2e), a stoichiometric factor was used to convert the mass of carbon (C) into its equivalent in CO_2. Therefore, the CO_2e content was calculated using the following expression: CO_2e = net C content × 3.67.

Statistical analysis

To assess differences in carbon dioxide (CO_2) concentrations between study sites, data were grouped with location as a factor. First, the assumption of normality was verified by the Shapiro-Wilk test (Shapiro and Wilk, 1965). When normality was rejected ($p < 0.05$), the nonparametric Kruskal-Wallis test (Kruskal and Wallis, 1952) was used to compare the groups. Subsequently, Dunn's test was applied to determine significant differences ($p < 0.05$). All analyses were run in R Studio (version 4.3.0; R Core Team, 2023).

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Results and discussion

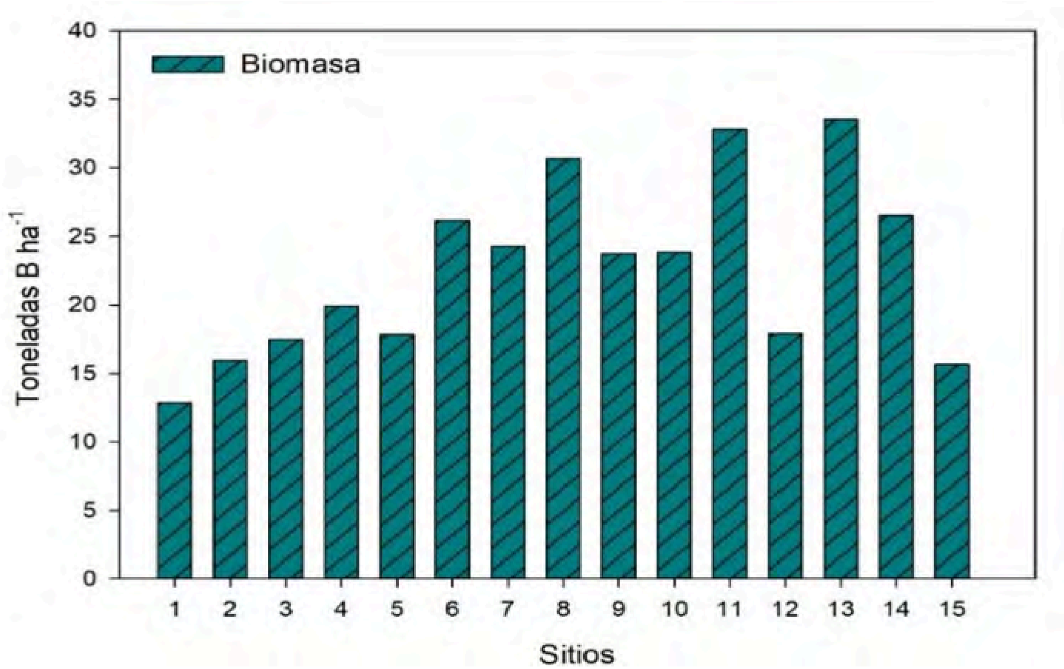
Recorded species

The species present in the 15 sites established in the Sowing Life plot were *Annona muricata* L. (soursop), *Bixa orellana* L. (achiote), *Cedrela odorata* L. (Spanish cedar), *Cocos nucifera* L. (coconut), *Musa* x *paradisiaca* L. (banana), *Tabebuia rosea* (Bertol.) D.C. (pink poui), and *Theobroma cacao* L. (cocoa). Within the plot, the plantation is designed in rows alternating agricultural crops and forest crops.

Estimated biomass

The estimated biomass (B) had its maximum value at site 13 (33.2 t ha^{-1}) and its minimum value at site 1 (12.5 t ha^{-1}); the average value was 22.6 t ha^{-1} (Figure 2).

Figure 2. Estimated biomass at the study sites.



Some studies demonstrate greater biomass in cocoa agroforestry systems, such as the case of Pocomucha *et al*. (2016), who recorded a biomass of 65.62 t ha^{-1}. For their part, Andrade *et al*. (2013) calculated an average biomass of 28.8 and 33.6 t ha^{-1}, which is also higher than that found in this research.

Carbon stored in agricultural activities

The carbon stored by agricultural activity (cocoa-banana) was 8.4 t C ha^{-1}; specifically at the species level, *Musa paradisiaca* (banana) obtained more carbon stored in the present sites than *Theobroma cacao* (cocoa); these accumulations were low compared to those provided by *M. paradisiaca*. This is attributed to the higher density of *M. paradisiaca* plants at the sites, whereas *T. cacao* has a lower presence, so C capture was minimal (Figure 3).

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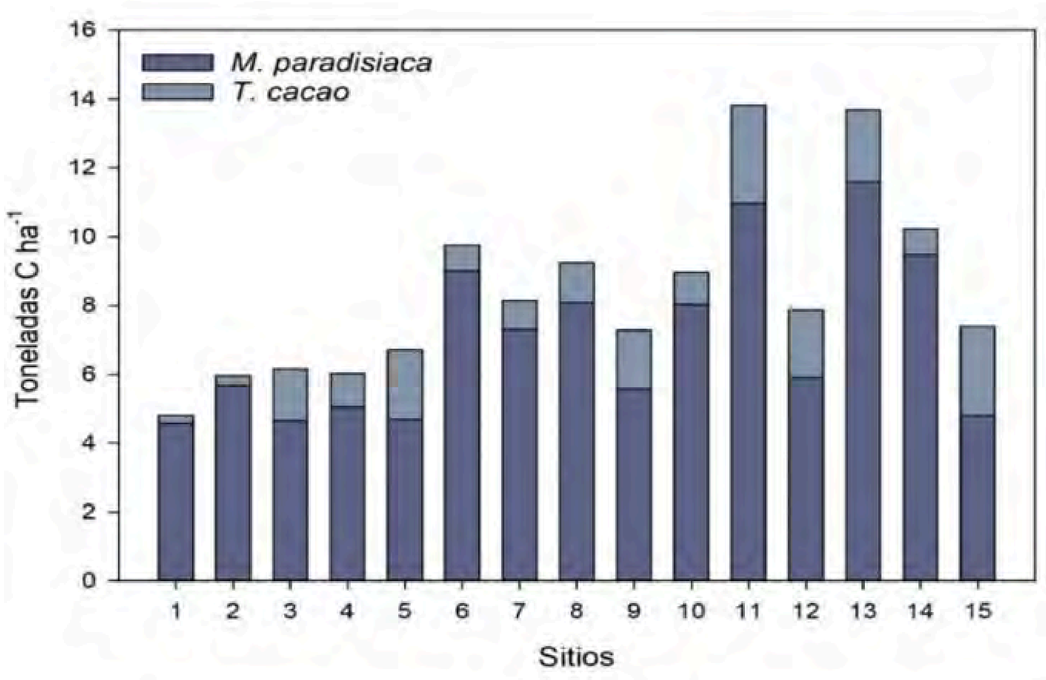
Figure 3. Carbon stored by site in agricultural activity.



The study by Ganeshamurthy (2023) estimated that the carbon stocks of the banana plant contribute between 2.573 and 6.407 t ha^{-1}; in contrast, the cocoa plant, according to Bermello *et al*. (2024), has an average aboveground biomass ranging from 0.056 t C ha^{-1} to no more than 4.064 t C ha^{-1} per tree. For their part, Avellán *et al*. (2020) report stocks of 2.95 t C ha^{-1} with the same species of *T. cacao*, stating that it is the number of individuals that determines the result.

Carbon stored in forestry activity

Carbon stocks include the shade perennials *Annona muricata* (soursop), *Bixa orellana* (achiote), *Cedrela odorata* (Spanish cedar), *Cocos nucifera* (coconut), and *Tabebuia rosea* (pink poui). Some sites showed no presence of any of the perennial species, and only in some sites were one or a few individuals of one or more species recorded.

More specifically, at sites 1 and 2, no timber or woody trees were found; at site 3, 0.841 t C ha^{-1} was quantified, with *C. nucifera* being the only forest species inventoried. Site 4 shows the presence of *B. orellana* (1.148 t C ha^{-1}) and *T. rosea* (1.508 t C ha^{-1}). At site 5, only *A. muricata* is distributed with 0.436 t C ha^{-1}. Site 6 (0.101 t C ha^{-1}), site 7 (1.239 t C ha^{-1}), and site 8 (2.859 t C ha^{-1}) have only one forest species: *C. odorata*. Site 9 reports *T. rosea* with 0.796 t C ha^{-1}; at site 10, *A. muricata* is again distributed with 0.528 t C ha^{-1}. At sites 11 to 14, no timber species were found; only at site 15, with *C. odorata* (0.080 t C ha^{-1}) being the species present. These results are shown in the same order in Figure 4.

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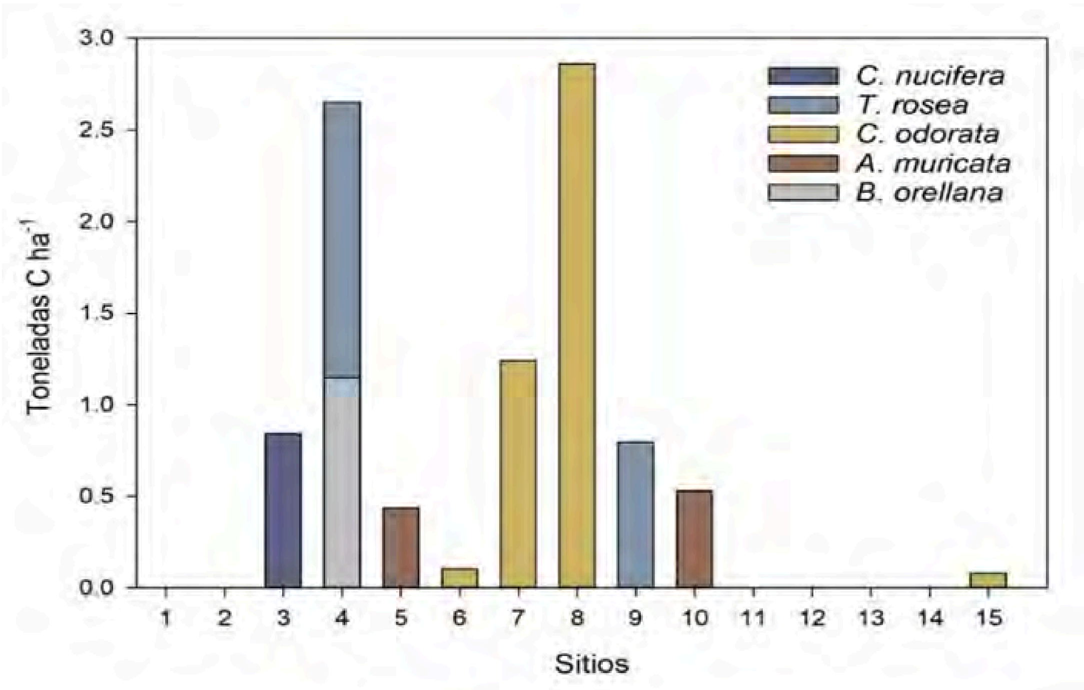
Figure 4. Carbon in forestry activity with timber species.



Some studies, such as that of Mendizábal-Hernández *et al*. (2012), report captures of up to 3.11 t C ha^{-1} for the species *C. odorata*, which is slightly higher than the value calculated for this species in the present research.

Total carbon stored

As a general result for all the species inventoried, regardless of activity, the average carbon is 8.75 t C ha^{-1}; therefore, the total carbon estimated for 2.5 ha will be 21.87 t C ha^{-1} (considering that this is the area required within the Sowing Life Program). The average value obtained is within the parameters of what a model Sowing Life plot can store in an agroforestry system, given that agroforestry systems generally store approximately 9, 21, 50 and 63 t C ha^{-1} in aboveground biomass (Espinoza *et al*., 2012).

Similar studies, such as the one carried out by Ortiz *et al*. (2008), found that a laurel-cacao system stored between 43 and 62 t C ha^{-1}, which are much higher values than those obtained in the present research, which may be due to the type of species and associations present in that system. For their part, Espinoza *et al*. (2012) found stores of 12 to 228 t C ha^{-1} in an agroforestry system, which is still higher than the 8.75 t C ha^{-1} found in the present research; however, compared to the study by Ortiz *et al*. (2008), it obtained higher carbon sequestration results. Although both studies have results with greater C capture, they align and agree with the carbon sequestration standard for an agroforestry system, which, according to Andrade *et al*. (2013), is 28.8 and 33.6 t C ha^{-1}.

Estimated carbon dioxide (CO_2)

The analyzed carbon dioxide data did not follow a normal distribution, registering a *p*-value < 0.001. Since the data are not normally distributed, when using the nonparametric Kruskal-Wallis test, a *p*-value < 0.001 was obtained, indicating significant differences between the sites. Therefore, when applying Dunn's test, it is observed that the pairs of sites 1-13, 1-14, 14-2, 1-5 and 2-5 present differences in their carbon dioxide (CO_2) values between these sites (Table 3). The remaining comparisons do not show significant differences between the sites.

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Table 3. Dunn's test results at sites with significant differences.

Comparison	Z	P. adj.	t C ha^{-1}
1-13	-3.523509	0.0447166	4.8-12.6
1-14	-3.927671	0.0090061	4.8-9.8
14-2	3.68284	0.0242182	9.8-5.9
1-5	-3.800792	0.0151446	4.8-7.1
2-5	-3.554287	0.0397956	5.9-7.1

In the design of an economic valuation model for agroforestry systems in cocoa, Fernández and Mora (2016) quantified CO_2 removal up to their fourth year, obtaining 24.42 t ha^{-1} of CO_2; in another sampling in their ninth year, they found up to 65.32 t ha^{-1} of CO_2. In this regard, in their research titled Carbon storage and fixation, and valuation of environmental services in agroforestry systems in Costa Rica, Ávila *et al*. (2001) determined an average value of 8.9 t C ha^{-1} as the highest capture of the agroforestry system; that same result, when analyzed with the carbon dioxide factor, results in an average of 32.66 t ha^{-1} of CO_2.

For their part, Zavala *et al*. (2018), when estimating the biomass and carbon stored in a coffee plantation agroforestry system, obtained 33.59 t C ha^{-1}, equivalent to 123.27 t ha^{-1} of CO_2, in a research that determines the age of the crop as a factor that influences carbon sequestration and storage, where the agroforestry system stores the most significant amount of CO_2 during the 8-16 year age range.

Conclusions

The biomass estimate for the Sowing Life plot in the locality of San José El Amate was 22.6 t ha^{-1}; the total carbon corresponds to 8.75 t ha^{-1}. Regarding CO_2 emissions, there are differences between some evaluated sites. The data obtained are dissimilar to those reported in other agroforestry systems in which the number of individuals and their associations have an impact.

Nevertheless, it should be noted that AFSs are part of a fundamental strategy to mitigate climate change; unlike monoculture, this environmental service is of higher quality in an agroecosystem. Sowing Life plots are an option to increase carbon storage and reduce climate change; therefore, it is important that agroforestry systems are considered as a strategy to buffer CO_2.

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Bibliography

1 Andrade, H. J.; Figueroa, J. M. y Silva, D. P. 2013. Almacenamiento de carbono en cacaotales (*Theobroma cacao*) en Armero-Guayabal (Tolima, Colombia). Revista Scientia Agroalimentaria. Ibagué. Universidad del Tolima. http://repository.ut.edu.co/handle/001/1318.

2 Arias, H. J. J.; Riaño, H. N. M. y Aristizábal, L. M. 2014. Dinámica de la acumulación de materia seca en dos especies de sombrío usadas en cafetales de Colombia. Cenicafé. 65(1):7-17. https://biblioteca.cenicafe.org/bitstream/10778/544/1/arc065%2802%297-17.pdf.

3 Avellán, A. R.; Barreto, E. D. y Peralta, E. J. 2020. Carbono en biomasa aérea, sistema agroforestal de *Theobroma cacao* L. laboratorio natural, los laureles 2018. Revista Universitaria del Caribe. 24(01):98-106. Doi:10.5377/ruc.v24i01.9914.

DOI: https://doi.org/10.29312/remexca.v17i1.3999

4 Ávila, G. V.; Jiménez-Otárola, F.; Ibrahim, M. A. y Beer, J. W. 2001. Almacenamiento, fijación de carbono y valoración de servicios ambientales en sistemas agroforestales en Costa Rica. Agroforestería en las Américas (CATIE). 8(30):32-35.

5 Baca, J. M.; Cuevas-Reyes, V. y Barradas-Miranda, P. 2021. De la dispersión a la centralización de las políticas públicas en el sector rural de México. Nóesis. Revista de Ciencias Sociales. 30(59):4-19. Doi:10.20983/noesis.2021.1.1.

6 Báez-Bringas, M.; Verdugo-Araujo, L. M. y Tereso-Ramírez, L. 2024. La participación de las mujeres en el programa sembrando vida en la comunidad de Nuevo San Miguel, Ahome, Sinaloa. Comunitaria. Revista internacional de trabajo y ciencias sociales. 28(2):89-109.

7 Benavides-Solorio, J. D.; Torres-García, O.; Flores-Garnica, J. G.; Acosta-Mireles, M. y Rueda-Sánchez, A. 2021. Ecuaciones alométricas para estimar biomasa y carbono aéreos de *Cedrela odorata* L. en plantaciones forestales. Revista Mexicana de Ciencias Forestales. 12(65):89-111. Doi:10.29298/rmcf.v12i65.791.

8 Bermello, Á. D.; Briones-Intriago, L. L. y Vivas, H. T. 2024. Captura de carbono en cacao (*Theobroma cacao* L.): una estrategia de adaptación al cambio climático. Revista Científica Ciencias Naturales y Ambientales. 18(2):591-598. Doi:10.53591/cna.v18i2.1925.

9 Casanova-Lugo, F.; Petit-aldama, J. y Soloria-Sánchez, J. 2011. Los sistemas agroforestales como alternativa a la captura de carbono en el trópico mexicano. Revista Chapingo Serie Ciencias Forestales y del Ambiente. 17(1):133-143. Doi:10.5154/r.rchscfa.2010.08.047.

10 CONAFOR. 2024. Comisión Nacional Forestal. Deforestación bruta a nivel estatal del Sistema Nacional de Monitoreo Forestal. SIAP. Datos Abiertos. https://snmf.cnf.gob.mx/deforestacion/.

11 Cortez, J. G.; Baca-Moral, J.; Uribe- Gómez, M.; Gómez-Hernández, T. y Valdés-Velarde, E. 2022. La multifuncionalidad de la agricultura como herramienta de análisis de políticas agrarias: el caso del programa sembrando vida en Chahuites, Oaxaca. Acta universitaria. 32:1-18. Doi:10.15174/au.2022.3339.

12 Danarto, S. A. and Hapsari, L. 2016. Biomass and carbon stock estimation inventory of indonesian bananas (*Musa* spp.) and its potential role for land rehabilitation. Biotropia The Southeast Asian Journal of Tropical Biology. 22(2):102-108. Doi:10.11598/btb.2015.22.2.376.

13 Elías, M. y Potvin, C. 2003. Assessing inter-and intra-specific variation in trunk carbon concentration for 32 Neotropical tree species. Canadian Journal of Forest Research. 33(6):1039-1045.

14 Espinoza-Domínguez, W.; Krishnamurthy, L. R.; Vásquez-Alarcón, A. y Torres-Rivera, A. 2012. Almacén de carbono en sistemas agroforestales con café. Revista Chapingo Serie Ciencias Forestales y del Ambiente. 18(1):57-70. Doi:10.5154/r.rchscfa.2011.04.030.

15 Fernández, L. J. y Mora, A. X. 2016. Diseño de un modelo de valoración económica para sistemas agroforestales basados en cacao y laurel de la región Caribe de Costa Rica. Universidad Earth, Provincia Limón, Costa Rica. 79 p.

16 Frangí, J. L. and Lugo, A. E. 1985. Ecosystem dynamics of a subtropical floodplain forest. Ecological Monographs. 55(3):351-369. Doi:10.2307/1942582.

17 Ganeshamurthy, A. N. 2023. Potencial anual de captura de carbono en huertos bananeros de la India. Biotropia. 30(3):374-383. Doi:10.11598/btb.2023.30.3.2005.

18 González-Abrego, D. O.; Rojo-Gómez, E. G.; Ochoa-Garfias, Á. F. y Trejo-Bautista, R. 2023. Captura, almacenamiento y conversión de CO2: nuevas técnicas de reducción. Pädi boletín científico de ciencias básicas e Ingenierías del ICBI. 11(22):20-27. https://repository.uaeh.edu.mx/revistas/index.php/icbi/article/view/11056.

19 Hamburg, S. P. 2000. Simple rules for measuring changes in carbon ecosystem in forestry-offset projects. Mitigation and adaptation strategies for global change. 5(1):25-37.

DOI: https://doi.org/10.29312/remexca.v17i1.3999

20 Hernández-Núñez, H. E.; Andrade, H. J.; Suárez, S. J. C.; Gutiérrez, G. G. A.; Trujillo, T. E. y Casanoves, B. F. 2021. Almacenamiento de carbono en sistemas agroforestales en los Llanos Orientales de Colombia. Revista de Biología Tropical. 69(1):352-368.

21 INECC. 2021. Instituto Nacional de Ecología y Cambio Climático. Potencial de mitigación para el programa sembrando vida: nota técnica. Gobierno de México. https://www.gob.mx/inecc/articulos/potencialdemitigacionparaelprogramasembrandovidanotatecnica.

22 IPCC. 2003. Intergovernmental Panel on Climate Change. Good practice guidance for Land Use, Special Report: Land-Use Change and Forestry. SNT. 590 p.

23 Kruskal, W. H. and Wallis, W. A. 1952. Use of ranks in one criterion variance analysis. Journal of the American Statistical Association. 47(260):583-621.

24 Mendizábal-Hernández, L. C.; Alba-Landa, J.; Márquez-Ramírez, J.; Cruz-Jiménez, H. y Ramírez-García, E. O. 2019. Captura de carbono por *Cedrela Odorata* L. en una prueba genética. Revista Mexicana de Ciencias Forestales. 2(4):107-114. Doi:10.29298/rmcf.v2i4.612.

25 Morán-Villa, V. L.; Monterroso, R. A. I.; Mata-González, R.; Marquez, B. S. R.; Abdallah, M.; Valdés, V. E. y Hernández, S. R. 2024. Estimación de la biomasa aérea mediante el desarrollo de ecuaciones alométricas para *Theobroma cacao* en Tabasco, México. Agroforestry Systems. 98(3):537-549. Doi: 10.1007/s10457-023-00928-x.

26 Nogueira, E. M.; Fearnside, P. M.; Nelson, B. W.; Barbosa, R. I. and Keizer, E. W. H. 2008. Estimates of forest biomass in the Brazilian Amazon: new allometric equations and adjustments to biomass from wood-volume inventories. Forest Ecology and Management. 256(11):1853-1867. Doi:10.1016/j.foreco.2008.07.022.

27 Ortiz, Á.; Riascos, L. y Somarriba, E. 2008. Almacenamiento y tasas de fijación de biomasa y carbono en sistemas agroforestales de cacao (*Theobroma cacao*) y laurel (*Cordia alliodora*). Agroforestería en las Américas. 46:26-29. https://repositorio.catie.ac.cr/bitstream/handle/11554/5764/Almacenamientoytasasdefijaciondebiomasa.pdf?sequence=1&isAllowed=y.

28 Pocomucha, V. S.; Alegre, O. J. y Abregú, T. L. 2016. Análisis socio económico y carbono almacenado en sistemas agroforestales de cacao (*Theobroma cacao* L.) en Huánuco. Ecología Aplicada. 15(2):107-114. Doi:10.21704/rea.v15i2.750.

29 Podong, C.; Khamfong, K.; Noinamsai, S. and Mhon-ing, S. 2023. Carbon sequestration in agrosilviculture agroforestry systems: preliminary results from three villages in Uttaradit Province, Northern Thailand. The Southeast Asian Journal of Tropical Biology. 31(2):134-145. Doi:10.11598/btb.2024.31.2.1741.

30 R Core Team. 2023. R: a language and environment for statistical computing. R foundation for statistical computing. Vienna, Austria. https://www.Rproject.org/.

31 Sáenz-Reyes, J.; Rueda-Sánchez, A.; Benavides-Solorio, J. D. D.; Muñoz-Flores, H. J.; Castillo-Quiroz, D. y Sáenz-Ceja, J. E. 2021. Ecuaciones alométricas, biomasa y carbono en plantaciones forestales tropicales en la costa de Jalisco. Revista Mexicana de Ciencias Forestales. 12(65):26-44. Doi:10.29298/rmcf.v12i65.856.

32 Shapiro, S. S. and Wilk, M. B. 1965. An analysis of variance test for normality. Biometrika. 52(3-4):591-611.

33 Tapia-Alba, J. A. y Chiatchoua, C. 2025. Contribución del programa sembrando vida en la reducción de la pobreza en México. Investigación y Ciencia de la Universidad Autónoma de Aguascalientes. 33(94):1-22. Doi:10.33064/iycuaa2025945054.

34 Zavala, S. J. W.; Zavala, G. S. L. y Mansilla, M. L. G. 2018. Estimación de la biomasa y carbono almacenado en un sistema agroforestal del cafetal de la Universidad Nacional Agraria de la Selva. Revista de Investigación y Amazonia. 8(5):1-8.

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