Sustainable management of native flora at a Higher Education Institution

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Abstract

The promotion of environmental care is essential in the education of higher education students. Globally, the United Nations guarantees the right to a healthy environment, which promotes environmental education and sustainability. This project is aligned with SDG 15 of the 2030 Agenda, which seeks the conservation and restoration of terrestrial ecosystems, contributing to biodiversity protection and sustainable management of natural resources. The main objective is to promote and conserve green areas within the TecNM Campus Comalcalco, involving the technological community in creating a plant nursery. The study was carried out at the Institute, where a botanical garden was implemented and dasometric measurements were taken of 144 trees in the green areas of the institution. Students from different careers were involved in the installation of the botanical garden and the propagation of 89 plant species, using techniques such as cuttings, seeds, and seedlings. The creation of the botanical garden involved the entire community of the Institute, and its impact transcended the institution with workshops and plant donations to the local community. Plants were donated to the community at academic events and fairs, promoting environmental awareness beyond the Institute. In terms of the trees sampled, five species of major ecological importance were identified: Tabebuia rosea, Samanea samán, Ceiba pentandra, Persea americana, and Cedrela odorata. The largest trees, such as Samanea samán and Ceiba pentandra, showed the highest amount of biomass and carbon stored, with an average of 12,565.23 Mg. ha^{-1} of biomass and 6,282.61 $MgC.ha^{-1}$ of carbon for Samanea samán. The botanical garden is projected as an educational and conservation resource that can be replicated in other educational settings and homes, extending its impact in time and space.

Keywords: sustainable development, climate change, trees, plants.

Gerenciamento sustentável da flora nativa em uma instituição de ensino superior

Resumo

A promoção do cuidado com o meio ambiente é essencial na educação dos alunos do ensino superior. Globalmente, o direito a um ambiente saudável é garantido pelas Nações Unidas, que promovem a educação ambiental e a sustentabilidade. Esse projeto está alinhado com o SDG 15 da Agenda 2030, que busca a conservação e a restauração dos ecossistemas terrestres, contribuindo para a proteção da biodiversidade e a gestão sustentável dos recursos naturais. O principal objetivo é promover e conservar áreas verdes dentro do TecNM Campus Comalcalco, envolvendo a comunidade tecnológica na criação de um viveiro de plantas. O estudo foi realizado no Instituto, onde foi implementado um jardim botânico e foram feitas medições dasométricas de 144 árvores nas áreas verdes da instituição. Alunos de diferentes carreiras participaram da instalação do jardim botânico e da propagação de 89 espécies de plantas, usando técnicas como estacas, sementes e mudas. A criação do jardim botânico envolveu toda a comunidade do Instituto, e seu impacto transcendeu a instituição com oficinas e doações de plantas para a comunidade local. As plantas foram doadas à comunidade em eventos e feiras acadêmicas, promovendo a conscientização ambiental além do Instituto. Com relação às árvores amostradas, foram identificadas cinco espécies de grande importância ecológica: Tabebuia

rosea, Samanea samán, Ceiba pentandra, Persea americana e Cedrela odorata. As árvores maiores, como Samanea samán e Ceiba pentandra, apresentaram a maior quantidade de biomassa e carbono armazenado, com uma média de 12.565,23 Mg. ha^{-1} de biomassa e 6.282,61 $MgC.ha^{-1}$ de carbono para Samanea samán. O jardim botânico é projetado como um recurso educacional e de conservação que pode ser replicado em outros ambientes educacionais e residências, ampliando seu impacto no tempo e no espaço.

Palavras-chave: desenvolvimento sustentável, mudança climática, árvores, plantas.

1. Introduction

The promotion of environmental care is of vital importance in the development of human activities, including the training process of students at different educational levels and, particularly, its reinforcement at the higher education level. In Mexico, the Constitución Política de los Estados Unidos Mexicanos establishes the right of people to have a healthy environment for their development and well-being, and the State must guarantee this right (Congreso de la Unión, 1917: article 4°, paragraph 5). That is why in Mexico a broader legal framework has been generated (laws, regulations, standards) that, in turn, promotes the development of policies and mechanisms for the care and conservation, among other things, of the native flora.

Thus, the universities in which research work is carried out play an important role in this issue. An example of this is the Ley General de Educación Superior which indicates that the integral human development of the student must be fostered based, among other things, on respect and care for the environment, thus promoting sustainability (Congreso de la Unión, 2021: article 7, section VII).

According to the provisions of the Ley de Educación del Estado de Tabasco (Congreso del Estado de Tabasco, 1997), the development of activities in the different educational institutions, including higher education institutions, must take into account environmental education to raise awareness about the different current environmental problems (article 96-A, section III), as well as to engage society in the development of actions to improve the environment (article 9, section XV). Thus, the various stakeholders in higher educational institutions can manage spaces for the cultivation of plant species, and promote their conservation through the active participation of the student, teaching, administrative, and support community. This may lead to the development of plant nurseries.

The Sustainable Development Goals (SDGs) seek a sustainable future for all and incorporate, among other aspects, global challenges such as environmental degradation. Taking the 2030 agenda as a basis, to be more specific on SDG 15 “Life of terrestrial ecosystems”, this research project can be closely aligned with the following targets (Naciones Unidas, s.f.):

15.1: Conservation, restoration, and sustainable use of terrestrial and inland freshwater ecosystems and their services.

15.2: Sustainable management of all types of forests, ending deforestation and increasing reforestation efforts.

15.3: Combat desertification, restore degraded land and soils, and strive for a land degradation-neutral world.

15.5: Take urgent measures to reduce the degradation of natural habitats, halt the loss of biodiversity, and protect endangered species.

Green spaces tend to somehow reduce certain pollutants in the atmosphere which improves air quality. Trees absorb carbon dioxide and produce oxygen, so it is important to increase the number and quality of green spaces within educational institutions (Röbbel, 2016). The implementation and maintenance of these spaces not only benefits the environment but also improves the well-being of students, staff, and the community in general. The presence of vegetation can reduce stress, improve concentration, and increase motivation for learning (Huaman-Gutierrez, 2019). The establishment of plant nurseries as practical environmental activities in educational institutions plays an essential role in instilling fundamental values in students, such as respect and conservation of the environment. This pedagogical approach underlines the relevance of green areas, allowing for more effective monitoring and evaluation within the educational environment. Likewise, the nursery provides a practical space where students can acquire knowledge about biodiversity and sustainability, thus promoting ecological awareness and a greater appreciation for natural resources (Bermúdez-Campo, 2018).

Due to the above, the objective of this project is to promote and conserve green areas within a higher education institution, aligning with SDG 15. It is worth mentioning that the participation of students and academics in this project not only contributes to the restoration and care of green areas but also fosters a culture of sustainability and environmental responsibility in the educational community and promotes small-scale agricultural

productivity. This generates a lasting and positive impact, both on the local environment and on the formation of a citizenry that is aware of and committed to environmental conservation (Tarazona, 2020).

2. Materials and Methods

2.1 Study Site

The study was carried out in the municipality of Comalcalco, Tabasco, Mexico, in the green area of the TecNM Campus Comalcalco, Tabasco, Mexico, with an area of 80,897 m2; warm humid climate, an average annual temperature between 24 and 28 ºC and an average annual rainfall between 1500 and 3000 mm (INEGI, 2006).

In addition to its size, the green area hosts abundant biodiversity typical of the humid tropics, including tree species such as Tabebuia rosea (maculís), Swietenia macrophylla (mahogany), Cedrela odorata (Spanish cedar), Cocos nucifera (coconut palm), Mimosa orthocarpa var. berlandieri, and Psidium sp., (Córdova-Córdova et al., 2013). As well as associated fauna, such as migratory birds and key pollinators like bees and butterflies. These characteristics make the site ideal for the implementation of a botanical garden focused on conservation, research, and environmental awareness.

The selected location for the study area is (2022835.22 N and 476786.45 E), chosen for its representativeness of the humid tropical conditions of the region and its potential as a space for research and learning. Its proximity to the infrastructure of the TecNM Campus Comalcalco facilitates access to educational activities and the management of the botanical garden, ensuring the long-term sustainability of the project.

In which a botanical garden was implemented and measurements and identification of all the trees in the green areas of the institution were carried out (Figure 1).

Figure 1. Geographic location of the Institute. Source: Authors, 2024.

2.2 Creation of the botanical garden of medicinal plants

In collaboration with the student community of different educational programs of the Institution, such as Environmental Engineering, Food Industry Engineering, Mechatronics Engineering, Industrial Engineering, Logistics Engineering, Business Management Engineering, bachelor's degree in public accounting, and bachelor's degree in Gastronomy, work began on-site preparation and installation of the main structure of the botanical garden. This collaboration has had an impact on subjects such as Sustainable Development, Environmental Economics, Ecology, Biology, Research Fundamentals, Research workshops I and II, Ethics workshops, Fruit and Vegetable Technology, and related subjects.

The purpose of this project is the creation of a nursery of medicinal plants in the region to rescue and promote the cultural richness in this area and direct the actions around Sustainable Development. To achieve this, a series of activities were carried out to encourage students and the school community to value and contribute to the care and protection of the environment through the exploration, knowledge, and care of plants and the construction of a nursery, to learn about and disseminate the strategies that people implement for the use of plants for medicinal purposes, and to consolidate in a repetition of these actions by society. For the installation of the medicinal plant nursery at ITSC, we worked with students from professional residency projects, projects for the Integral Degree, and other projects that arose from this initiative. The technological community involved also took and implemented practices learned in the process to their family and social circle. This project faced challenges such as the lack of resources, so we used resources from the region such as pieces of logs, pallets, and compost to fertilize the soil for the creation of the project we used poles donated by teachers and students, as well as a roll of shade netting donated by "Sembrando Vida".

Procedure

a) To fulfill the objectives of the study, a survey will be applied to the population, accompanied by a clarification of questions and doubts through simple and clear language by the surveyors.

Suggestive data will be obtained that will be of help for the bibliographic review on the use of plants with medicinal properties.

b) The land will be adapted, and the dimensions, and materials will be used for the leveling of the land with shovels, rakes, machetes, and other tools.

c) Selection of the work site, the activities carried out were based on expositions of different biological groups, as well as field activities, sowing of seeds, and sampling of plants for medicinal use, these activities will be carried out with students.

d) This type of research is quantitative and experimental, the variables are the size refers to the height of the plant, which will be quantified with a simple instrument such as a flexometer, giving a quantitative result expressed in units of length.

e) We will also obtain the yield, which will depend on the place, the symbiosis with other plants, the population density of these, and the growth rate will be given according to time, it is worth mentioning that each plant has its characteristics of growth and multiplication, expansion of the leaf area in this refers to the increase in leaf area.

2.3 Tree Information Gathering and Analysis

The database was constructed from the information of 144 sampled trees whose normal diameter and total height were measured, and the species of everyone was recorded. A quantitative correlational design was used to calculate the aerial biomass of the species identified within the Institute's green areas. The quantitative approach focuses on the collection and analysis of numerical data. In this case, quantifiable variables such as diameter at breast height (DBH) and tree height are measured and used to calculate biomass using allometric equations. This approach is appropriate when the objective is to obtain accurate and objective measurements. The correlational design is used to explore or confirm the relationship between two or more variables.

In this context, it is assumed that there is a relationship between the independent variables (such as DBH and height) and the dependent variable (aboveground biomass). Correlation allows an understanding of how biomass varies as a function of DBH and tree height (Reserve, 2020). For each of the species, the average biomass was determined using the CALCBOSK equation database of the Forestry Protocol for Mexico-PFM (CAR, 2023), which is used to estimate the biomass of the main tree species in Instituto Tecnológico Superior de Comalcalco (Table 1). To determine the carbon content, the biomass value was multiplied by the factor 0.5 (Graciano-Ávila et al., 2019).

Table 1. Equations for estimating the aerial biomass of the Institute's most ecologically and culturally important trees

Specie	Equation	Equation No.	Source
Tabebuia rosea	$Biomass = 0.1959 \cdot (DBH)^{2.1206}$	(1)	Saenz et al., (2021)
Samanea samán	$Biomass = 0.1245 \cdot (DBH)^{2.4163}$	(2)	Hung et al., (2012)
Ceiba pentandra	$Biomass = 0.0842 \cdot (DBH)^{2.4100}$	(3)	Navarro, 2009
Persea americana	$Biomass = 0.1138 \cdot (DBH)^{2.3513}$	(4)	Hung et al., (2012)
Cedrela odorata	$Biomass = 0.4125 + 0.0421(DBH)^2$	(5)	Cairns et al., (2003)

Note: Biomass, in Mg. ha-1; DBH = diameter at breast height, in cm; height, in m.

2.4 Biodiversity conservation workshops

Different workshops such as ReforestaTec and Conservation of Plants of the region were carried out, both in the Institution and in different High Schools, such as CECyTE #9, CECyTE #21, Telebachillerato Comunitario #5 and CONALEP #291. The workshops were aimed at the installation of botanical gardens and plant propagation.

2.5 Propagation of plants

The need to collect different species of native flora was disseminated to the student, teaching, administrative, and support communities, starting with 48 different species and reaching a total of 89 different species including medicinal, ornamental, timber, fruit, and ancestral plants. Once the site was ready, propagation activities were carried out through cuttings, seeds, and seedlings. Table 2 details the diversity of species propagated with additional categories

Table 2. Endangered or endemic species classification

Endangered (EN)			
Arabica coffee	*Coffea arabica*	Mother of thousands	*Kalanchoe daigremontiana*
Vulnerable (VU)			
Cotton	*Gossypium hirsutum*		
Last concern (LC)			
Anatto	*Bixa orellana*	Mexican pepperleaf	*Piper auritum*
Avocado leaf	*Persea americana*	Mountain arnica	*Arnica montana*
Bay laurel	*Laurus nobilis*	Pennyroyal	*Mentha pulegium*
Beach morning glory	*Convolvulus pes-caprae*	Pink trumpet	*Tabebuia rosea*
Bell pepper	*Capsicum annuum*	Pochote	*Ceiba aesculifolia*
Blue mahoe	*Hibiscus elatus*	Sage	*Salvia officinalis*
Bougainvillea	*Bougainvillea glabra*	Sensitive plant	*Mimosa pudica*
Broadleaf plantain	*Plantago major*	Soursop	*Annona muricata*
Cashew	*Anacardium occidentale*	Southern sandbur	*Cenchrus echinatus*
Chinaberry	*Melia azedarach*	Spearmint	*Mentha spicata*
Common nettle	*Urtica dioica*	Tamarind	*Tamarindus indica*
Drumstick tree	*Moringa oleifera*	West indian birch	*Bursera simaruba*
Elder	*Sambucus nigra*	West indian elm	*Guazuma ulmifolia*
Field horsetail	*Equisetum arvense*	Yellow trumpetbush	*Tecoma Stans*
Guava	*Psidium guajava*	Mexican pepperleaf	*Piper auritum*
Kapok	*Ceiba pentandra*	Mountain arnica	*Arnica montana*
Leather fern	*Rumohra adiantiformis*	Pennyroyal	*Mentha pulegium*
Mexican honeysuckle	*Justicia spicigera*	Pink trumpet	*Tabebuia rosea*
Data Deficient (DD)			
Green tea	*Camellia sinensis*	Nopale	*Opuntia ficus-indica*
Papaya	*Carica papaya*		
Not Evaluated (NE)			
Aloe	*Aloe vera*	Lemon	*Citrus limon rutaceas*
Anise	*Pimpinella anisum*	Lemon grass	*Cymbopogon citratus*
Balm mint	*Melissa officinalis*	Life plant	*Kalanchoe Pinnata*

Basil	*Ocimum basilicum*	Madagascar coleus	*Plectranthus madagascariensis*
Bat flower	*Tacca chantrieri*	Mayan spinach tree	*Cnidoscolus chayamansa*
Beach apple	*Crataeva tapia*	Mexican coriander	*Eryngium foetidum*
Bitter orange	*Citrus aurantium*	Mexican tea	*Chenopodium ambrosioides*
Bitter-melon	*Momordica charantia*	Mexican thistle	*Eryngium heterophyllum*
Bittervine	*Mikania micrantha*	Moses in the cradle	*Rhoeo discolor*
Castor bean	*Ricinus communis*	Mother-in-law's tongue	Dracaena Sansevieria
Chamomile	*Matricaria chamomilla*	Oregano	*Origanum vulgare*
Chenille plant	*Acalypha hispida*	Passion fruit	*Passiflora edulis*
Chinese hibiscus	*Hibiscus rosa-sinensis*	Patchouli	*Pogostemon cablin*
Cinnamom	*Cinnamomum zeylanicum*	Peppermint	*Mentha piperita*
Clove	*Syzygium aromaticum*	Piper mistletoe	*Phoradendron piperoides*
Cocoa	*Theobroma cacao*	Poreleaf	*Porophyllum ruderale*
Coconut	*Cocos nucifera*	Princess vine	*Cissus sicyoides*
Cosmic lobster	*Coleus comosus*	Purple shamrock	*Oxalis triangularis*
Dandelion	*Taraxacum officinale*	Rose periwinkle	*Catharanthus roseus*
Dill	*Anethum graveolens*	Roselle	*Hibiscus sabdariffa*
French rose	*Rosa gallica*	Rue	*Ruta graveolens*
Freshcut	*Justicia pectoralis*	Saffron crocus	*Crocus sativus*
Garlic	*Allium sativum*	Snake plant	*Sansevieria trifasciata*
Ginger	*Zingiber Officinale Roscoe*	Spiral ginger	*Costus pictus*
Guinea henweed	*Petiveria alliacea*	Sunset flower	*Asclepia curassavica*
Inch plant	*Tradescantia zebrina*	Sweetleaf	*Stevia rebaudiana*
Jericho rose	*Anastatica hierochuntica*	Tobacco	*Nicotiana tabacum*
John charles	*Hyptis verticillata*	Variegated mintleaf	*Plectranthus coleoides*

2.6 Donation of plants

The plant propagation activities and workshops were an ideal space for the donation to the participants of these activities, in addition to taking advantage of other community outreach activities, such as GayoTec, municipal events on environmental issues, and visits received at the Institution.

3. Results and Discussion

3.1 Participation of the student and academic community in the creation of the botanical garden

Through the awareness of students, teachers, administrators, and the community in general, the creation of the botanical garden was achieved, since the entire community of the Institute was involved in the creation of the botanical garden (Figure 2).

Figure 2. Creation of the botanical garden. Source: Authors, 2024.

In the Environmental Engineering career, the contributions were the following: Leadership in native species conservation and propagation activities, Use of tools and methods to evaluate soil quality, climate, and biodiversity, and Participation in the design of sustainable irrigation systems and composting methods.

In the Food Industry Engineering career, the contributions were as follows: Identification and management of plants with food and medicinal uses, Contribution to the development of compost from local organic waste, and Design of training workshops on the food use of cultivated species.

3.2 Analysis of the trees of ecological importance in the green areas of the institute

With the support of the students, the diameters and heights of the trees located in the green areas of the "Instituto Tecnológico Superior de Comalcalco" were measured (Figure 3).

Figure 3. Students take diameter and height data. Source: Authors, 2024.

The tree species with the highest structural values within the Institute were: Tabebuia rosea, Samanea samán, Ceiba pentandra, Persea americana, and Cedrela odorata (Table 3). These ecologically important tree species agree with other studies conducted in the region (Sánchez-Gutiérrez et al., 2016; Salvador-Morales et al., 2019; Sanchez-Diaz et al., 2023).

Table 3. Tree species with the highest value of ecological importance

Specie	**DBH (cm)**	**H (m)**	**biomass (Mg·ha^{-1})**	**stored carbon (MgC·ha^{-1})**
Tabebuia rosea	32.36	17.39	404.2269	202.113
Samanea samán	117.9	23.28	12565.23	6282.61
Ceiba pentandra	117.73	24.38	8234.438	4117.21
Persea americana	20.63	10.8	186.8072	93.4036
Cedrela odorata	37.8	13.35	803.4705	401.735

Studies in the Brazilian Amazon, for example, have documented average values of aboveground biomass between 150 and 400 Mg ha-¹, depending on tree density and edaphic conditions (Nogueira et al., 2008). Similarly, research in the tropical dry forest of Costa Rica reports significantly lower values, with an average of 50 to 150 Mg ha-¹ due to differences in annual precipitation (Brown and Lugo, 1992).

In contrast, the results obtained at the TecNM Campus Comalcalco for species such as Tabebuia rosea and Cedrela odorata indicate intermediate values of aerial biomass, with an average of 120 to 200 Mg ha-¹, corroborating that the humid tropical ecosystems in Tabasco have a high carbon storage potential, similar to that of other humid tropical regions.

3.3 Propagation, reforestation, and donation of plants produced in the botanical garden

We were able to adapt a space that would allow the reproduction and propagation of the different plants, reusing materials to give them a second use (Figure 4).

Figure 4. Plants propagated in the Institute's botanical garden. Source: https://www.facebook.com/watch/live/?ref=watch_permalink&v=444328847438811

Gallegos (2017) in Babahoyo, Ecuador, also implemented a botanical garden where he identified several medicinal species, similar, to the species reproduced in the ITSC botanical garden, which underlines their importance in traditional medicine in both Ecuador and Mexico. He also highlighted the use of plants to treat digestive ailments, infections, and respiratory diseases, coinciding with data from ITSC where plants such as mint and oregano, known for their digestive and antimicrobial properties, are grown. Workshops were given to high school students on good practices for the creation of pollinator gardens so that they could implement a botanical garden in their educational centers (Figura 5).

Figure 5. Workshops are given to high school students. Source: https://www.facebook.com/100064708444945/posts/pfbid0r5e9sD6JtTXiKKSfxmoU2bUaGXGcWcBb4dDgSp89ShuVAiJFixqzPafM9r3YqFnel/?app=fbl

The ReforestaTEC campaign was carried out, through the reforestation of trees, the technological community contributes to the mitigation of the effects of climate change by capturing carbon dioxide. It also favors the increase of natural areas, a source of food and refuge for wildlife (Figura 6).

Figure 6. Reforestation of trees generated in the botanical garden. Source: https://www.facebook.com/share/p/1aYXdPFzK6HaMTFR/

Plants reproduced in the botanical garden were donated to people who came to visit the Institute and to people in the community, since at fairs or academic events, the plants were given to people in their homes or businesses (Figura 7), thus promoting sustainable development and environmental awareness, not only to the Institute's community but also to the community of the entire municipality of Comalcalco, Tabasco, Mexico.

Figure 7. Donation of propagated plants from the botanical garden. Source: Authors, 2024.

The donation of plants as part of the botanical garden and medicinal plant nursery project at the Instituto Tecnológico Superior de Comalcalco (ITSC) has generated multiple positive impacts on the local community, encompassing environmental, educational, and social dimensions.

Environmental Impact

Increased Green Coverage: Donated plants have been incorporated into public spaces, contributing to biodiversity conservation and improving air quality by absorbing carbon dioxide and releasing oxygen.

Rescue of Native Species: The collection, propagation, and donation of native and endangered species such as Tabebuia rosea, Ceiba pentandra, and Coffea arabica have aided in the conservation of these ecologically and culturally significant plants.

Biodiversity Promotion: The variety of plants propagated (89 species) has strengthened ecosystems in the region, supporting local fauna like pollinators.

Educational Impact

Hands-on Learning: Workshops and activities involving propagation techniques, such as cuttings and seed sowing, have provided practical learning experiences for students and educators from high schools and the ITSC.

Awareness and Knowledge: Participants have gained knowledge about the importance of medicinal plants, sustainable practices, and biodiversity conservation.

Integration into Curriculum: The project has reinforced subject learning across various disciplines, including Biology, Environmental Economics, and Sustainable Development.

Social Impact

Community Engagement: Collaboration between educational institutions and the local community has fostered a sense of ownership and responsibility toward green spaces.

Cultural Preservation: Donated plants with medicinal properties have revived traditional knowledge and practices, connecting generations.

Improved Well-being: Recipients of donated plants have reported a greater sense of environmental connection and satisfaction, along with reduced stress attributed to the presence of vegetation in their surroundings.

Participant Feedback

Comments from Educational Institutions

"The propagation workshops have been incredibly enlightening. It's rewarding to see students take pride in planting and nurturing life." — High School Teacher from CECyTE #9.

"*Our students are now eager to create similar green spaces within our campus. The training was practical and*

engaging." — Administrator from CONALEP #291.

Comments from the Local Community

"*We've planted medicinal plants at home thanks to the donations. It's been a bonding activity for our family while helping us rediscover our heritage*." — Local Resident.

"*The plants donated have brightened our surroundings and served as a natural remedy source. Thank you for this initiative!"* — Community Leader.

Comments from ITSC Participants

"*This project has given us the tools and knowledge to not only contribute to the environment but also to take action in our homes and communities*." — Environmental Engineering Student.

"*It's inspiring to see how a shared effort can create something as meaningful as this nursery. We hope it becomes a model for other institutions*." — ITSC Faculty Member.

4. Conclusions

Promote environmental care within higher education institutions, aligning these actions with national policies such as SDG 15. In Mexico, both the Constitución Política de los Estados Unidos Mexicanos, la Ley General de Educación Superior, and the Ley de Educación del Estado de Tabasco emphasize the importance of sustainability and environmental education in the integral development of students. This project, developed at the TecNM Campus Comalcalco, is a clear example of how these guidelines can be put into practice.

The implementation of a plant nursery has not only strengthened environmental awareness among students, teachers, and the community but has also had an impact beyond the institution, with workshops and plant donations that have involved the community of Comalcalco, Tabasco, in general. In addition, the conservation of species such as Cedrela odorata which is considered a vulnerable species by the International Union for Conservation of Nature (IUCN; 2017), and Ceiba pentandra which is a protected species because it is considered cultural heritage of the State of Tabasco, Mexico (Rovirosa, 1982). These activities foster a culture of sustainability, promoting practices that contribute to the restoration and conservation of ecosystems, and support the sustainable management of natural resources.

The collection of dasometric data and the identification of tree species within the Institute have not only allowed a better understanding of local biodiversity but have also provided crucial information to estimate the biomass and carbon stored in trees, contributing to global efforts to mitigate climate change, promote sustainable management to avoid deforestation, promote the conservation of the world's natural heritage and promote a culture of sustainable development.

The nursery became an integral project since in the future it is intended that all students can replicate the nurseries in their homes with the knowledge gained at the Institute, to increase the spaces available for food supply and in turn promote the reduction of food insecurity faced by the world (UN, 2018). We will also seek to establish links and agreements with high school institutions to instill in them responsibility and environmental awareness of the importance of nurseries and green areas in their homes and educational centers from before their professional training.

Future Improvements:

Expansion of Nursery Capacity: Increase the physical space dedicated to growing and conserving additional plant species. This could involve adding more plant beds and expanding propagation techniques to include new methods such as tissue culture or hydroponics for certain species.

Incorporation of Technology: Implement modern technology such as digital monitoring systems for plant growth, weather sensors, and environmental conditions (e.g., soil moisture and temperature) to ensure better care and data-driven decisions.

Strategic Alliances:

Collaboration with Research Institutions: Forge partnerships with universities, botanical gardens, and environmental research centers to share knowledge and resources, and collaborate on research related to the conservation and medicinal properties of the plants.

Local Government Partnerships: Establish alliances with local governments to ensure financial and logistical support for the project. This could involve aligning with municipal or state sustainability programs to secure long-term funding and recognition.

Community Engagement Initiatives: Strengthen relationships with local communities and small-scale farmers, possibly through training programs on sustainable plant propagation, conservation, and the uses of medicinal plants.

5. Acknowledgments

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6. Authors' Contributions

Catalina del Socorro Vidal-Cornelio: original project idea and project leader. *Baltazar Sanchez-Diaz*: drafting, writing, and structure of the document. *Yareli Naythel Bolaina-Lorenzo*: development of the methodology and identification of medicinal plant species. *Fernando Perez-Marquez*: development of the introduction and summary of the document. *Raul Enrique Islas-Jesus*: data collection and data collection. *Fidel Olive-Hernandez*: models for biomass estimation.

7. Conflicts of Interest

No conflicts of interest.

8. Ethics Approval

Not applicable.

9. References

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