Colegio de Postgraduados

Environmental services of the mangrove ecosystem in the Mecoacán lagoon in Paraíso, Tabasco, México

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ABSTRACT

Objective: To identify the environmental services provided by the mangrove ecosystem in the Mecoacán Lagoon, located in the municipality of Paraíso, Tabasco, Mexico.

Design/methodology/approach: The study was carried out in the Mecoacán Lagoon, Tabasco, where four strategically selected sites were established for data collection. Random surveys of local residents, along with field observations, were conducted to evaluate the structure, composition, and species diversity of the mangroves, as well as community perceptions of this ecosystem.

Results: Survey findings revealed that 98% of the local population utilizes mangrove resources for personal benefit, primarily for firewood and timber. Furthermore, the absence of effective government protection measures for these wetlands was noted.

Limitations/implications: Although field observations were performed, the lack of detailed methodologies for assessing species density, diversity, and richness may limit the precision of the ecological findings.

Findings/conclusions: The restoration of mangroves, particularly in areas degraded by oil industry activities, should be prioritized. Efforts must focus on mitigating negative environmental impacts and encouraging land-use practices that align with conservation goals. Mangrove preservation is vital not only for its ecological significance but also for the numerous benefits it offers to human communities.

Keywords: mangrove conservation, coastal protection, biodiversity, biodiversity, mangrove conservation

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INTRODUCTION

The identification of environmental services is a key aspect of ecological research, particularly in the conservation of mangrove ecosystems, which are typically found along the coastal margins of tropical and subtropical regions (Connelly, 2001). In Tabasco, mangroves are distributed along the rear of the littoral barrier, bordering lagoons that run parallel to the coast and connect to the sea. Their presence is determined by flooding conditions and the concentration of dissolved salts in the water (Moreno *et al.*, 2002). Mangrove ecosystems possess exceptional ecological value as irreplaceable and unique habitats that support remarkable biodiversity and rank among the most productive

ecosystems globally. They play a critical role in coastal protection by preventing erosion, regulating floods, retaining sediments and toxic substances, purifying water that flows into the sea, and serving as a source of organic matter. Mangroves also provide essential support to numerous vulnerable and endangered species, acting as a vital habitat for marine and estuarine fauna (International Mangrove Network, 2009). Their trees, branches, and foliage are home to a vast array of birds, reptiles, mammals, insects, lichens, and fungi (Tomaló and Aracely, 2014). In Mexico, mangroves are primarily composed of three species: red mangrove (*Rhizophora mangle*), white mangrove (*Laguncularia racemosa*), and black mangrove (*Avicennia germinans*) (Hernández and Junca-Gómez, 2020). In the state of Tabasco, the municipalities with the most extensive mangrove areas are Paraíso, Cárdenas, and Jalpa de Méndez. Several local communities in these regions maintain a close relationship with the mangrove ecosystem, engaging in sustainable management and resource use. Notable examples include the ejidos La Solución Somos Todos and Gurría Ordóñez in Paraíso, and El Golpe in Cárdenas. Other communities that utilize mangrove resources include Ejido La Victoria and Cuauhtémoc in Centla; Las Flores, Chiltepec, and Jalapita in Paraíso; Úrsulo Galván in Jalpa de Méndez; and Sánchez Magallanes in Cárdenas (Domínguez *et al.*, 2011).

Given this context, the aim of the present study is to identify the environmental services provided by the mangrove ecosystem in the Mecoacán Lagoon, located in the municipality of Paraíso, Tabasco.

MATERIALS AND METHODS

The present study was conducted in the Mecoacán Lagoon, located in the state of Tabasco, Mexico (Figure 1).

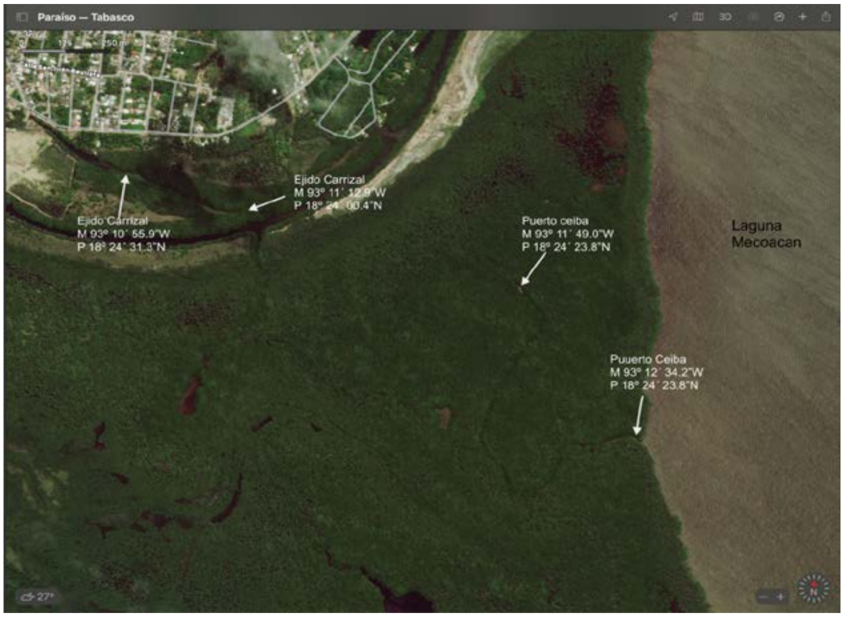

Figure 1. Location of the Mecoacán Lagoon.

Four strategic points were determined during the field trip. Using a GIS (geographic information system) LG PRO-LITE, the geographic coordinates of the site to be visited were obtained (Table 1; Figure 2).

Surveys were randomly conducted among the residents of the study area, which has a population of approximately 1,500 people and 386 households. A total of 10% of the dwellings were surveyed, corresponding to 38 households. The sample size was determined using simple random sampling methodology (Figure 2).

Another method involved field observations conducted through boat trips, allowing access to the mangrove areas. Researchers disembarked at various points and proceeded on foot, using appropriate equipment to assess the structural characteristics, species composition, and diversity of the mangrove ecosystem. These observations aimed to evaluate plant composition, species dominance, density, diversity, species richness, and the overall dynamics of the mangrove communities.

RESULTS AND DISCUSSION

Based on the data collected during the research activities, Table 2 presents the main mangrove species identified in the study area.

The black mangrove is characterized by the prominent development of its aerial roots, known as pneumatophores, which protrude from the ground and can reach heights of 20 cm or more. These trees can grow up to 20 meters tall and are distinguished by their dark

Table 1. Location of the 4 points where the research was carried out and their coordinates.

Location	Meridians	Parallel
Ejido carrizal	93° 11' 12.9" W	18° 24' 00.4" N
Ejido carrizal	93° 10' 55.9" W	18° 24' 31.3" N
Puerto ceiba	93° 12' 34. 2" W	18° 24' 23.0" N
Puerto ceiba	93° 11' 49. 0" W	18° 24' 23.8" N

Figure 2. Location of the ejido carrizal where the surveys were conducted, acquired by google maps.

Table 2. Mangrove species identified in the Mecoacán Lagoon.

Common Name	Scientific Name	Status
Red Mangrove	*Rhizophora mangle*	Protected
White Mangrove	*Laguncularia racemosa*	Protected
Black Mangrove	*Avicennia germinans*	Protected

gray to black outer bark. The leaves are yellowish-green, often bearing fine hairs and salt crystals on the underside. The flowers are small and white, while the fruit is oval, flattened, and covered with fine hairs, as illustrated in Figure 3 (Baranda, n.d.).

The white mangrove is a tree that can reach up to 20 meters in height and is characterized by its fissured bark. Its leaves measure between 4 and 10 cm in length and have reddish petioles with two distinctive glands located on either side of the stem (Figure 4). The flowers are small, numerous, and whitish-gray in color. The fruit is small and slightly flattened. The root system is shallow and may occasionally emerge above the ground near the base of the trunk (Orozco, 2019).

Figure 3. Black mangrove.

Figure 4. White mangrove.

The red mangrove (*Rhizophora mangle*) is one of the most ecologically significant mangrove species due to its growth characteristics, which contribute substantially to coastline stabilization and play a vital role in the life cycles of numerous commercially important marine species. It belongs to the Rhizophoraceae family, which comprises approximately 120 species across 16 genera. The *Rhizophora* genus is the most well-known and predominates in the most frequently flooded zones of mangrove ecosystems. Species in this family are notable for their stilt-like roots that extend laterally from the trunk. Additionally, some members possess pendulous roots that descend from the branches and anchor into the soil (Figure 5) (Yáñez *et al.*, n.d.).

- Benefits: According to survey responses, 98% of the population reported utilizing mangrove resources for personal benefit, primarily for firewood, timber, fencing, and housing construction. In contrast, the remaining 2% indicated that they either saw no benefit or were unaware of any.
- Protection: A total of 98% of respondents indicated that mangroves are not protected or monitored by any governmental agency responsible for ensuring the proper use and conservation of these wetlands.
- Opinions on Care: Sixty percent of respondents stated that mangrove conservation could be supported by avoiding deforestation, preventing pollution, and actively protecting the ecosystem. The remaining 40% emphasized the importance of reforestation efforts.
- Pollution: Fifty-five percent of respondents reported that mangroves are primarily affected by crude oil contamination and other pollutants. The remaining 45% were uncertain or unaware of any pollution affecting the mangroves.
- Projects: All respondents (100%) reported that no projects related to mangrove conservation or management have been implemented in the area.
- Conservation Awareness: Ninety-eight percent of those surveyed indicated that they had not received any information on mangrove conservation. Only 2% recalled attending a talk or receiving information more than a decade ago.

Figure 5. Red mangrove.

- Knowledge of Mangrove Types: Ninety percent of the population reported not knowing the different types of mangroves.
- Knowledge of Ecological Factors: Similarly, 90% of respondents lacked information regarding the ecological factors necessary for the proper development of fauna within the mangrove ecosystem, while only 10% reported having some knowledge of these requirements.

Mangroves are exceptional coastal ecosystems with a remarkable capacity to adapt to varying salinity levels influenced by tidal fluctuations. During high tides, their aerial roots, known as pneumatophores, play a critical role by absorbing oxygen from the air and transporting it to the submerged roots anchored in the waterlogged substrate. These submerged roots absorb nutrients from the saline water and, with the help of oxygen, convert them into energy for the plant, while excess salt is expelled through the leaves (PNUMA, 2012). This unique physiological mechanism enables mangroves to survive and thrive under extreme and fluctuating environmental conditions.

Mangroves also display notable structural variability, resulting in diverse physiognomic forest types defined by differences in density, basal area, and tree height. Common classifications include riparian, basin, overwash, fringe, and scrub mangroves (Lugo and Snedaker, 1974; Flores-Verdugo, 1992). Recent studies have identified riparian and basin-type mangrove forests, primarily composed of *Rhizophora mangle*, *Avicennia germinans*, and *Laguncularia racemosa* (Santiago, 2018). This structural diversity reflects the ecological resilience of mangroves and emphasizes the importance of conserving a range of habitat types within these ecosystems.

Beyond their ecological importance, mangroves provide vital resources to the human populations living nearby. Regardless of educational background, local communities rely on mangroves for materials such as timber used in housing construction and fishing activities. However, this frequent and often unsustainable exploitation is contributing to mangrove loss at an alarming annual rate of 1% to 2% (Duke *et al.*, 2007). This decline is particularly concerning given mangroves' essential roles in coastal defense, biodiversity conservation, and climate change mitigation.

Mangrove restoration faces considerable challenges, especially in regions impacted by oil industry activities. Infrastructure development for accessing oil wells such as roads has led to deforestation, fires, the spread of grasslands, and logging. Additionally, these areas are frequently exposed to oil spills, which further intensify environmental degradation (García *et al.*, 2006). These issues highlight the urgent need for integrated and sustainable management strategies that prioritize ecological restoration while mitigating the impacts of industrial activity.

CONCLUSIONS

In Tabasco, many coastal communities often living under conditions of significant marginalization overexploit mangrove resources for timber, firewood, and charcoal. Economic pressures drive these communities to convert mangrove areas into coconut plantations, pasturelands, or agricultural fields for short-term economic gain. Such land-use changes have become a major contributor to the loss of mangrove cover and the degradation of these ecosystems.

Mangroves are highly productive ecosystems that generate substantial quantities of nutrients. These nutrients are carried by tidal flows into adjacent marine environments, supporting seagrass beds, coral reefs, and various commercially important fish species. Additionally, mangroves provide critical habitat, protection, and nursery grounds for economically valuable marine species such as fish, shrimp, crabs, and mollusks, thereby delivering both direct and indirect benefits to local economies and marine biodiversity.

The conservation of mangroves is essential not only due to their adaptive capacity and ecological functions but also because of the diverse benefits they provide to human communities. The alarming rate of mangrove loss estimated at 1% to 2% annually highlights the urgent need for effective and sustainable conservation strategies. Restoration efforts should be prioritized in areas affected by industrial activities, particularly those linked to the oil industry. These efforts must address environmental degradation and promote land-use practices that are compatible with mangrove conservation.

To curb mangrove degradation, it is critical to implement policies that integrate ecological conservation with the sustainable economic development of local communities. Key strategies include the development of environmental education programs, promotion of sustainable agricultural practices, and strengthening of environmental legislation. Equally important is the active involvement of local communities in conservation and restoration initiatives, ensuring they recognize the long-term benefits of sustainable natural resource management.

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