

Environmental Impact on the Mangroves of the Municipality of Tecpan De Galeana, Guerrero, Mexico

García Domínguez Yarely Berenice¹, Castillo-Elías Benjamín^{2*}, Sonder Kai³, Sampedro-Rosas María Laura⁴, Gervacio-Jiménez Herlinda⁵, Bedolla-Solano Ramón⁶

¹*Estudent of the Center for Regional Development Sciences of the Autonomous University of Guerrero, Mexico. E-mail: gadyb87@gmail.com*

²*Research and Postgraduate Center in Socioterritorial Studies of the Autonomous University of Guerrero, Mexico. E-mail: bcastilloe@hotmail.com*

³*International Center for Maize and Wheat Improvement, Mexico. E-mail: k.sonder@cgiar.org*

⁴*Center for Regional Development Sciences of the Autonomous University of Guerrero, Mexico. E-mail: laura_1953@live.com.mx*

⁵*Research and Postgraduate Center in Socioterritorial Studies of the Autonomous University of Guerrero, Mexico. E-mail: lindagj09@gmail.com*

⁶*School of Sociology of the Autonomous University of Guerrero, Mexico. E-mail: rabedsol@hotmail.com*

Abstract

Mangroves have a broad connection with riparian communities, where environmental, social and economic benefits arise. These ecosystems influence directly and indirectly the economic situation of the inhabitants. The objective of this study was to identify the anthropogenic activities that affect the mangrove ecosystem in a rural town called El Veinte in the South Pacific of Mexico next to the coastal Lagoon of Nuxco in Tecpac de Galeana, Guerrero. A survey was elaborated and applied to a random sample of 158 people out of a total of 705 inhabitants, key informants were semi-structured interviewed and tours were made in the mangrove area. Information about the impact caused by anthropogenic activities was obtained, defining four central topics: Social characteristics of the population, mangrove uses, management of solid waste and situation and perspective of the mangroves; with the results obtained, it was possible to document the effects on the mangrove ecosystem; and the socio-environmental problem in the rural community El Veinte was identified.

Keywords: coastal lagoon, anthropogenic activities, urban solid waste.

* Corresponding Author:
E-mail: bcastilloe@hotmail.com

INTRODUCTION

Mangroves have been recognized as highly productive and ecologically important ecosystems. These provide ecosystem services to marine and terrestrial environments, as well as to humans [14, 17]. Some of the ecosystem services of importance to society include: coastal protection (against storms, hurricanes and tsunamis); sewage treatment; production of removable materials; and provision of cultural sites [34, 48].

In Mexico, mangrove ecosystems are distributed along the lagoons, estuaries and coastal deltaic systems, generally in areas with a predominantly tropical climate, both in the Caribbean Sea, Gulf of Mexico and the Pacific Ocean, reaching in the latter the northern limit of its geographical distribution towards the northern part of Baja California [20].

Mexico has 7 645 km² of mangrove coverage, representing 5% of the world's mangroves [42], and there are six mangrove species, four of which are common: red mangrove (*Rhizophora mangle*), white mangrove (*Laguncularia racemosa*), black mangrove (*Avicennia germinans*) and button mangrove (*Conocarpus erectus*). *Avicennia bicolor* and *Rhizophora harrisonii*, have a very restricted distribution, with the presence of some isolated populations in Chiapas and Oaxaca [3, 20, 30].

The Guerrero littoral, located in the southeast of Mexico, has an area of 484.9 km, and only presents one type of coastal dune, the frontal dunes, which can form frontal dune plains, covering 20,470 ha [38]. Guerrero has nine coastal lagoons, which are: Laguna Potosí, Laguna de Mitla, Laguna de Nuxco, Laguna de Coyuca, El Plan and Laguna Valentín (Costa Chica Region); Tres Palos Lagoon, Chautengo Lagoon and Tecomate Lagoon (Costa Grande Region) [27]. In accordance with the Regionalization of Mangroves of CONABIO in Mexico, the Nuxco Lagoon is immersed in the area called the South Pacific, which includes the state of Guerrero, Oaxaca and Chiapas [7].

In accordance with current environmental legislation in Mexico, mangrove species found in the state of Guerrero are subject to protection through NOM-022-SEMARNAT-2003 [21], NOM-059-SEMARNAT-2010 [22] and ART. 60 TER of the General Law of Wildlife [24]. However, during the period from 2010 to 2015, the state of Guerrero had a 17.8% loss of mangrove areas, equivalent to 1,448 ha [42]. Likewise, Mexico is part of an international treaty related to the conservation of wetlands, "Ramsar Convention"; It currently has 142 sites designated as Wetlands of International Importance (Ramsar sites), ranking second worldwide, with an area of 8,657,057 hectares. The State of Guerrero has a Ramsar site called "Tortuguera-Tierra Colorada Beach" is reported, with an area of 54 hectares [33].

Mangroves have a broad relationship with the riparian communities, where other important roles in terms of social and economic benefits arise and play [41]. Coastal localities exert strong pressure on mangrove ecosystems with the demand for wood that is used to build rooms, falsework, fences, fishing gear, docks, firewood, fodder and other non-wood forest products [12].

The present work was carried out in a rural town (El Veinte) next to the Nuxco lagoon, in the Tecpan de Galeana municipality, in the state of Guerrero in Mexico. The

objective of the present study was to identify the anthropogenic activities of the inhabitants of the El Veinte locality, with the purpose of knowing the link between the environmental components of the mangrove resource and the inhabitants of the rural locality, to propose alternatives for sustainable use and conservation of that forest resource.

MATERIALS AND METHODS

Description of the area of Study

The study area will be located 20 km southwest of the Municipal capital of Tecpan de Galeana, in the state of Guerrero, at the geographic coordinates of 17° 12'56.96" N and 100° 47'25.61" W (Figure 1), The Nuxco lagoon has an area of approximately 6,300 ha [8]; it presents a sub-humid tropical climate, of the type Aw''(w)i with rains in summer, droughts in winter and temperatures above 20 °C [35]; it is located in the hydrological region No. 19: Costa Grande formed by the Atoyac river basin; the Sabana river basin and the Papagayo river basin; with Chernozem-type soils [18]. The locality El Veinte presents a degree of marginalization "High", and has a total population of 705 inhabitants, of which 365 are men and 340 women [37].

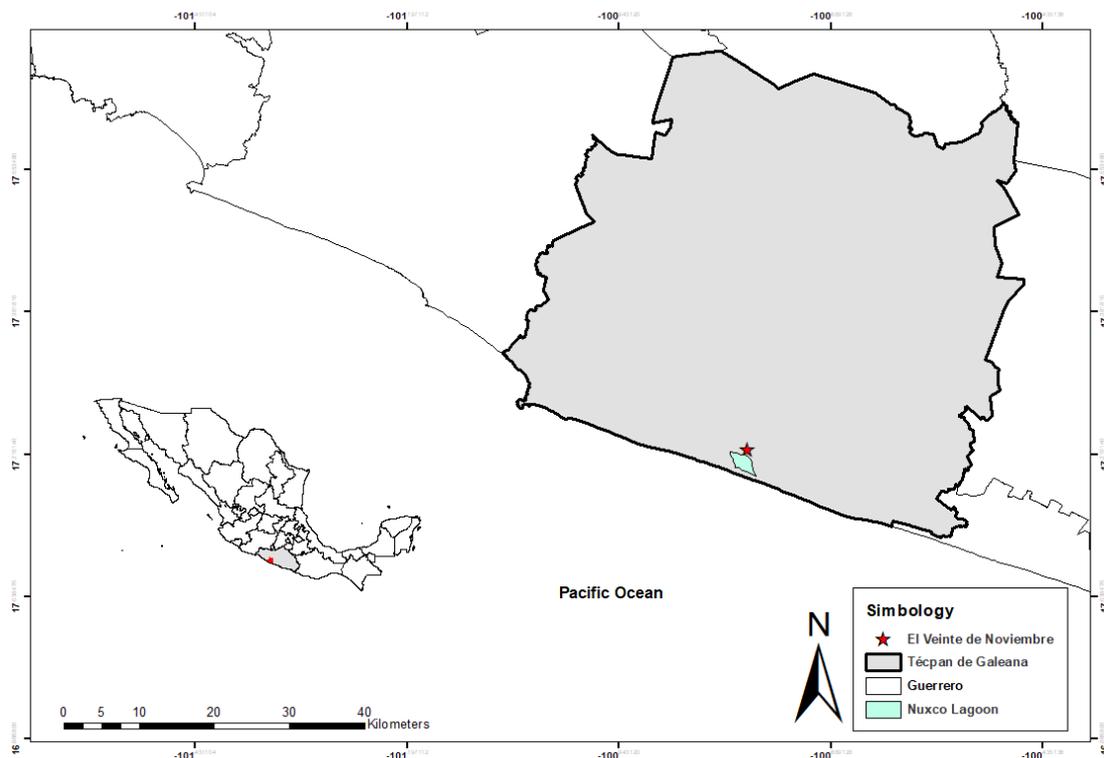


Figure 1. Location of the study area.

Source: Prepared by the author based on the INEGI Geographical Information Geoportal, 2010. Coordinate Systems WGS 1984.

A pilot survey was designed and applied to tenants of El Veinte, which consisted of 30 items; With the results obtained in the pilot survey, the final survey was designed with which the present study was carried out, consisting of 18 items. In the final survey, four central issues were addressed:

1. Social characteristics of the population.
2. Uses of mangrove.
3. Urban solid waste management (USW).
4. Situation and perspective of mangroves.

During the period from November 2015 to March 2016, surveys were applied to the inhabitants of the El Veinte locality; a simple random sample of 158 people was chosen from a total of 705 inhabitants, [37]; according to Pértigas and Pita [31] cited by Castillo [6], the sample size was determined considering that it is a finite population using the following formula:

$$n = \frac{N * Za^2p + q}{d^2 * (N - 1) + Za^2 * p * q}$$

Where:

n = Sample size to choose

N = Total population

Za² = 1.96² (95% security)

p = Expected proportion (in this case 5% = 0.05)

q = 1-p (in this case 1-0.05 = 0.95)

d = Precision (in this case we want 3%)

The surveys were applied in docks next to the Nuxco Lagoon where fishing is carried out, meeting places for the residents of the El Veinte locality, schools in the El Veinte locality and/or in the private homes of tenants of El Veinte.

Interviews were conducted, semi-structured, with two key informants from the rural town of El Veinte, to learn about the conditions of the mangrove, municipal public services and main economic activities.

With the help of key informants, 4 representative sites of the Nuxco Lagoon were chosen to carry out tours and corroborate the information provided by the population. The location data was recorded through a field GPS and processed with the help of ArcGis 10.4 Software.

RESULTS

According to the applied surveys, the current perception and expectations of the respondents regarding the natural resources found in their locality, such as mangroves, were obtained, obtaining the following indicators:

1. Social characteristics of populations

In relation to the work activity carried out by the respondents in the rural town of El Veinte in the state of Guerrero in southern Mexico, 2.5% is dedicated to livestock, 5% to agricultural activities, 22.5% is dedicated to commerce, 32 % is classified in “Others * (* electricians, bricklayers, students, housewives, and street vendors) and 38% are engaged in fishing (Figure 2).

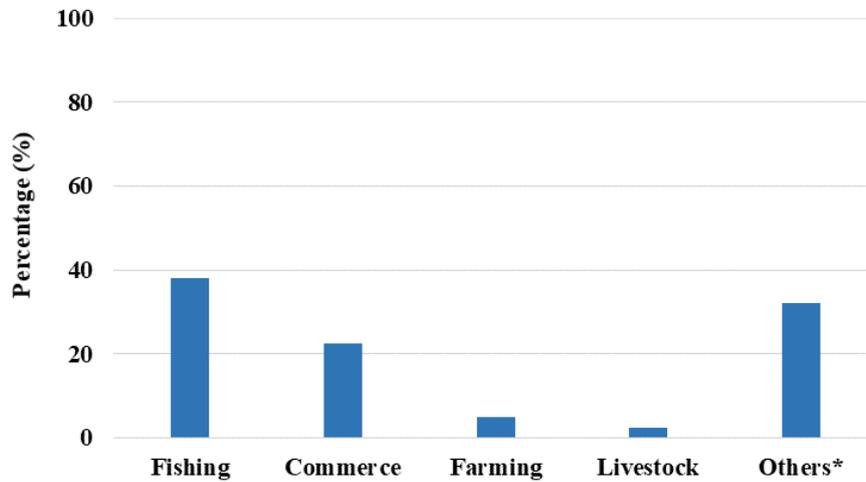


Figure 2. Work activity of inhabitants of El Veinte, Gro., Mexico.

Source: Prepared by the author based on information collected in the field research.

With reference to the educational level of the inhabitants of the El Veinte locality in the Southeast of Mexico (Guerrero), 3% have a completed degree; 14% do not have studies; 15% with high school; 21% primary; and 47% secondary (Figure 3).

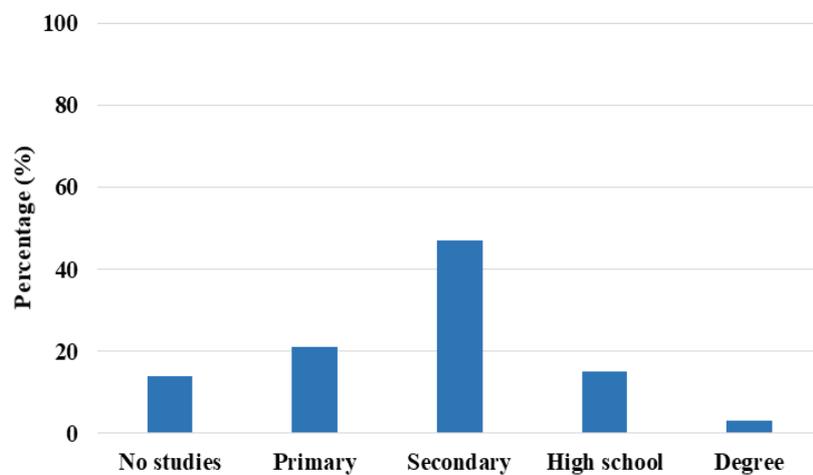


Figure 3. Schooling of inhabitants of El Veinte, Gro., Mexico.

Source: Prepared by the author based on information collected in the field research.

2. Uses of mangrove

In Figure 4, we can see the uses that are given to mangroves in the El Veinte locality. In 34%, the inhabitants of the town of El Veinte, use the mangrove wood to obtain "firewood", which they use to prepare their food through a stove; 26% of El Veinte inhabitants use mangrove for construction; 12% of the inhabitants affirmed that they use mangrove for commercial purposes; 13% of the inhabitants use mangrove to obtain coal; and 15% of the inhabitants surveyed affirmed that they did not use mangrove.

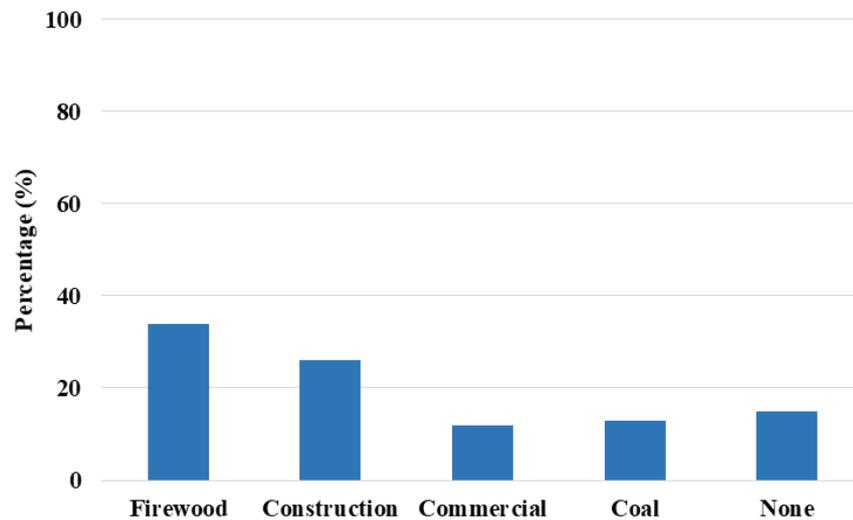


Figure 4. Mangrove uses in El Veinte, Gro.

Source: Prepared by the author based on information collected in the field research.

According to the results of the surveys, the species that is mostly used for forestry purposes in the El Veinte locality is the button mangrove (*Conocarpus erectus*) with 34%, due to the fact that this specimen provides greater resistance to pests and rot; In second place with a 19% use is dark or salty mangrove (*Avicennia germinans*); with 16% the mandel candelilla or red (*Rhizophora mangle*), which the population uses as medicinal using the shell or bark of the tree; 4% the white or silly mangrove (*Laguncularia racemosa*), this has less use because it is a very easy wood to be attacked by pests, and 27% of the surveyed inhabitants do not use mangrove as a forest resource.

3. Deforestation of mangrove

According to the participation of the inhabitants of El Veinte in relation to deforested mangrove areas in the Nuxco Lagoon, 32% totally agree that there are deforested areas; 23% agree that there are deforested areas; 17% disagree that deforested areas exist and 28% totally disagree that deforested areas exist.

Referring to the current state of the mangrove compared to 15 years ago, 41% of the respondents mentioned that the mangrove was "deteriorated"; 24% who were "deforested"; 22% mentioned that it is "the same", that is to say that there is no change in the mangrove swamp; and 13% mentioned that the mangrove area "increased".

Regarding participation in reforestation activities, 43% said they fully agree; 38% agree; 12% disagree; and 7% totally disagree.

4. Situation and perspective of mangroves

According to the affinity for the development of a mangrove protection and conservation program in the El Veinte locality in the state of Guerrero, in southern Mexico, 52% of the respondents totally agree; 45% agree; 2% disagree; and 1% totally disagree.

Regarding the interest in installing a mangrove nursery in the El Veinte locality, 46% totally agree; 43% agree; 7% disagree; and 4% totally disagree.

With reference to the destination of solid waste due to the lack of the Municipal collection service, 67% carry out the burning of garbage in the patios of their homes; 11% stores it at home; 9% clandestine garbage dumps; 8% deposit it in containers; and 5% throws it on the banks of the Nuxco Lagoon or among the mangrove.

Key informants interview

According to key informants in the town, the conditions of the mangrove are bad compared to 20 years ago; coverage has decreased with the opening of roads and gaps, followed by the Acapulco-Zihuatanejo federal highway. Another factor that affected mangrove coverage was the increase in the inhabitants of the region who had gradually settled in this locality, encompassing own zones of the wetland.

In relation to the current conditions of the mangrove, key informants commented:

"The mangrove was deteriorated due the people who cut down and sold wood without permission, We organized ourselves with some neighbours to look after at least one part of the mangrove and prevent illegal logging, but we could not look after all the mangrove because of its expansion on a large area" (Municipal Commissioner, 65 years old).

"People use mangrove wood as firewood and to build huts, but there are people who are not from here but come to cut down and carry away the wood to sell while the government could not do anything. We temporarily organize ourselves to look after the mangrove but sometimes we have not enough time to do it" (partner of the fishing cooperative, 73 years old).

In relation to the public services the key informants commented:

"Most people who live in El Veinte, do not have drainage system, they throw on the street the water they use to wash dishes and clothes; while they use a fossa for

bathroom waste water” (Municipal Commissioner, 65 years old).

“There is a need for a support from the government to pick up our rubbish on regular basis so that we don’t have to burn it. Some people suffer because they do not have water supplies, and the ones who have, take a long time to pour” (partner of the fishing cooperative, 73 years old).

In relation to the main economic activities that are developed in the locality, they commented:

“Most of the people have fishing or agriculture as their main livelihood; others to a lesser extent, do the masonry work” (Municipal Commissioner, 65 years old).

“Women are engaged in housework, there are three or four that help their husbands in fishing. Fishing is the main livelihood here.” (Partner of the Fishing Cooperative, 73 years old).

Tours in the mangrove area

With the help of key informants, 4 representative sites were established in the mangrove area to carry out tours: Varadero El 20, La Barra, La Piedra and El Seseque (Figure 5). The anthropogenic impacts observed by site, during the tours in the mangrove area, are listed below:

Name of the site	Anthropogenic impacts
Varadero El 20	<ul style="list-style-type: none"> • Road opening or gap. • Presence of garbage. • Logging of mangrove specimens. • Traces of grazing. • Burning that affects mangrove. • Change in land use derived from agriculture and livestock.
La Barra	<ul style="list-style-type: none"> • Presence of garbage. • Illegal logging of mangrove specimens. • Use of mangrove in construction (horcones) of cottage (restaurants). • Open defecation.

La Piedra

- Presence of garbage.
- Traces of grazing.
- Change in land use derived from agriculture and livestock.

El Seseque

- Opening of roads and gaps.
- Presence of garbage.
- Traces of grazing.
- Land use change derived from agriculture and livestock.

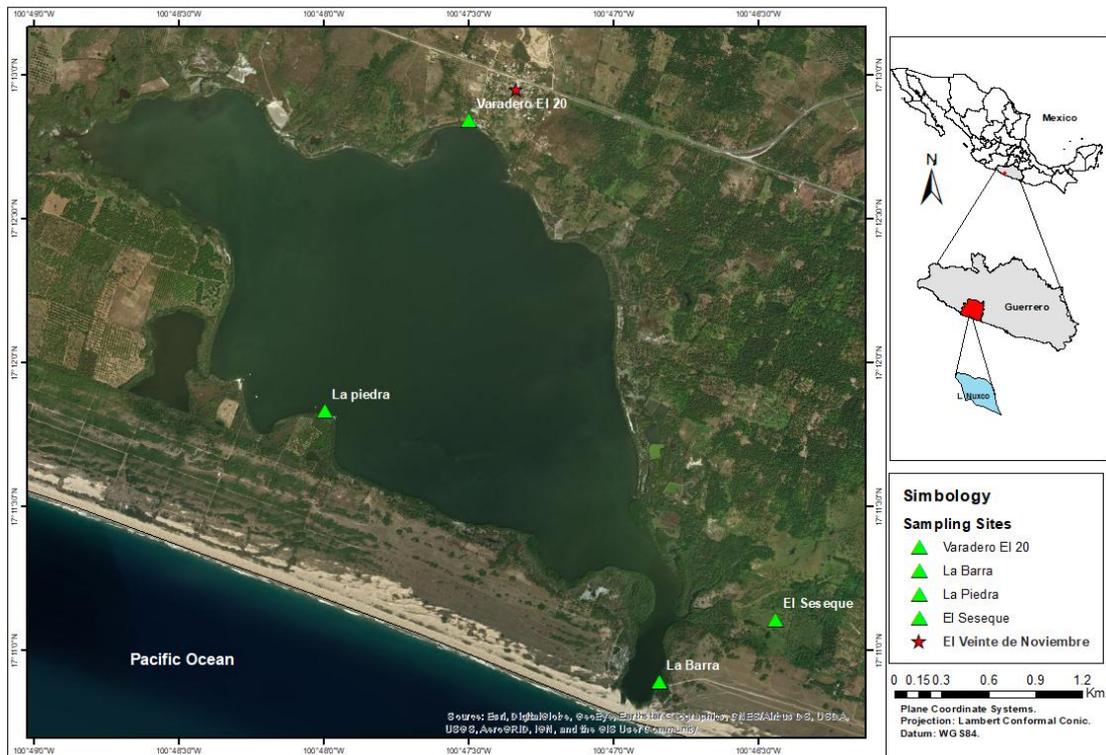


Figure 5. Location of representative sites in the mangrove zone in Nuxco.

Source: Prepared by the author based on information collected in the field research. ArcGis 10.4: WGS 1984 Coordinate System.

DISCUSSION

Globally, the main threats to mangroves include: coastal development; felling of wood and fuel; aquaculture; salt extraction; and agriculture [1, 34, 44]; the above coincides with the results of the surveys to the tenants of the Locality El Veinte in relation to the

use they make of the mangrove in Laguna de Nuxco, 34% stated that they use mangrove wood to obtain “firewood” to prepare their foods; 26% use mangrove wood for construction, 12% for commercial purposes; 13% to obtain coal; and 15% stated not to use mangrove. Also, the testimonies of the key informants affirm that the tenants of El Veinte use mangrove wood as firewood and to build their houses. With the field trips, at the point called "La Barra" (Nuxco Beach-Nuxco Lagoon), it was found that in the restaurant strip they use mangrove wood as pitchforks, regularly to build the branches. The activities and uses described above, as a whole, represent a risk for mangrove species since they are carried out without sustainable use. The historical drivers of mangrove loss in South America due to human impacts are: sanitary landfill, eutrophication (sewage and agriculture), pollution (chemical, organic and oil spills), inadequate planning policies, ignorance of the value of the ecosystem, invasion illegal land, failure of community participation, use of wood for construction, obtaining charcoal and animal fodder [16], which coincides with the results of this work.

The 97% of the surveyed population in the El Veinte locality agrees to carry out a protection and conservation program for the mangrove surrounding the Nuxco Lagoon, in order to promote environmental education among the inhabitants of the locality; the above coincides with Linares et al. [19], who affirm that environmental education is necessary to help raise awareness of the problems facing mangrove forests today; This also coincides with the work of Vences et al. [47], who mentions that 61% of the inhabitants surrounding the Nuxco Lagoon, consider the need to promote environmental education in the area important. The government representatives should be involved before conducting the research to foster a dialogue that can promote mangrove management and conservation. Promoting public awareness to obtain political will is also important; a greater understanding of the ecosystem services provided by mangroves to local communities and their inclusion in management has the potential to increase protection and conservation of mangroves [9, 36, 39]

Vences, et al. [47] during his investigation to find out the environmental perception of three towns near the Nuxco Lagoon, he found that there is a lack of waste collection, wastewater discharge and mangrove deforestation, which coincides with the current scenario set by the inhabitants of the locality El Veinte and what was observed in the tours in the sites Varadero El 20, La Barra, La Piedra and El Seseque, in which within the mangrove area there is the opening of roads or gaps, there is presence of garbage, there is Logging of mangrove specimens, traces of cattle grazing, burning of garbage that affects mangroves, use of mangrove for construction in the beach area, change of land use derived from agriculture and livestock, and air defecation were observed free in the area for tourism at the site "La Barra"; In addition to the above, the inhabitants of El Veinte consider that clandestine garbage dumps and the discharge of residual water in the lagoon are environmental problems that have not been resolved due to the lack of public policies by the government, the lack of strategies with low environmental impact and the lack of management plans [4].

Castillo [6] carried out an environmental diagnosis of the mangrove in the Coyuca de Benítez lagoon, in the state of Guerrero, and showed that due to the inadequate management of natural resources, in the representative mangrove areas there are

deteriorations of the environmental environment due to the use and irrational use of mangroves; land use change due to different anthropogenic activities; Lack of ecological culture regarding the importance of mangrove protection; soil erosion; decrease in water currents; the disappearance of both wild flora and fauna associated with mangrove ecosystems and which are considered endangered; generation of forest fires due to the burning of garbage and an overexploitation of the fishing resource; This is similar to the results obtained in the mangrove ecosystem of the Laguna de Nuxco in the state of Guerrero.

Despite the known “environmental” value of these forests, mangroves are highly threatened. Deforestation estimates suggest that mangrove cover has decreased by 30–86% since the mid-1990s [10] and that mangroves will continue to decline globally at unprecedented rates [11]. When referring to the residents of El Veinte, about the current state of the mangrove in Laguna de Nuxco compared to 15 years ago, 63% of those surveyed mentioned that they were deteriorated and deforested; also in relation to the deforested mangrove areas in the Nuxco Lagoon, 55% affirmed that there are deforested areas; while 45% stated that they disagree that there are deforested areas; which agrees with Vences et al. [46], where he mentions that at the subaccount level, in which the mangrove ecosystem of the Laguna de Nuxco, adjacent to the rural town of El Veinte, is immersed, had a loss of coverage of 296.49 ha during the period from 1981 to 2015.

The 96% of the surveyed inhabitants of the El Veinte locality are interested in installing a mangrove nursery in the locality, in order to promote the environmental culture of conservation and use of the mangrove species found in the coastal ecosystem of Nuxco; Castillo and Gervacio [13] mention that the establishment of a mangrove nursery is a sustainable alternative to carry out reforestation actions and thus achieve the conservation of these ecosystems.

Different studies have shown the close socioeconomic relationship of the riparian communities and their direct influence with mangroves, making possible the sustainable use of this forest resource through the establishment of productive projects promoting viable alternatives to improve the regional socioeconomic situation with the use mangrove products (firewood, charcoal and wood) for the market and generating technical capacity and employment opportunities, in turn projecting restoration and reforestation activities [2, 5; 43, 45].

Evidence-based decision making has been well documented as an important component of resource management [32]. Finally, only through the full awareness of the residents about their responsibility in the management and protection of resources, ecosystems and the strengthening of their capacity for action and organization, can the social base for sustainable development be achieved. [27].

CONCLUSIONS

Despite strict national legislation and international agreements that provide protection for mangroves, mangrove coverage continues to decline, as is the case of the Laguna de Nuxco Mangrove Ecosystem. The inhabitants of the rural town of El Veinte, which

is immersed in the South Coast of Mexico, in the state of Guerrero, agree that there is an environmental problem associated with the mangrove ecosystem of the Laguna de Nuxco and the need to establish actions aimed at the conservation and use of the coastal ecosystem.

In accordance with the points of the analysis, it is concluded that the realization of this diagnosis allowed to visualize the current panorama in which a part of the coastal zone is immersed in the Costa Grande of the State of Guerrero in the South of Mexico.

It is recommended to generate a sustainability strategy for the town of Colonia Veinte de Noviembre next to the Nuxco lagoon, considering the environmental characteristics of the environment where different anthropic activities take place that have caused ecological deterioration on natural factors such as mangroves, seeking improve the ecological conditions of the area, based on the interest and willingness of the inhabitants to participate in projects of protection, conservation and sustainable use in favor of solving this problem. There should also be a responsibility for researchers to increase the availability of their research to administrative authorities, through the creation of a repository of regional scientific literature, leading to greater dialogue between government authorities and the scientific community.

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