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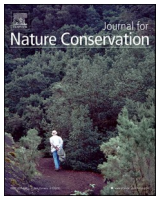

Local community attitudes towards mangrove forest conservation

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ABSTRACT

Local communities have preferences and expectations regarding mangrove ecosystems that are typically underrepresented in valuation studies. Therefore, this study identifies how the local community of Mahahual (Mexico) perceives the ecosystem services provided by the mangrove forest and how these preferences differ between households. A survey was designed by one of the authors and local stakeholders building on previous knowledge and experts (local environmental research centre and non-governmental organisation Takata and its experts in biology and coastal conservation, ecotourism businesses' owners, and the mayor of the village). The survey is used to cover a wide range of ecosystem services such as carbon sequestration, recreation and cultural activities as well as improved connectivity with local seagrass beds and coral reefs. Ecosystem services were specifically chosen by biologists and ecologists of the local NGO to perfectly reflect the local mangroves ecosystem. The small land area of the village, its low population and its rapid expansion offer a unique context, aiming at preserving the natural environment while keeping in mind that the main economy is based on tourism. While mangroves are greatly appreciated for the local protective services they provide such as coastal protection, local inhabitants also care about services that have a wider impact such as biodiversity and carbon sequestration. We find that the educational background of local inhabitants plays an important role in determining the importance of local ecosystem services and that information provision can help to counterbalance this effect. We also observe that preferences for specific ecosystem services differ based on how close residents live to the mangroves and to the coast, which accentuates the different needs and ideas of the households based on their local neighbourhood.

1. Introduction

Mangroves are tropical coastal ecosystems consisting of trees and shrubs that are uniquely adapted to marine and estuarine conditions. They are considered to be some of the most valuable and productive coastal ecosystems on the planet (Millennium Ecosystem Assessment, 2005; Barbier et al., 2011; Wylie et al., 2016). Mangrove ecosystems are found in 128 countries worldwide and are a relatively rare forest type, covering an estimated area of 136 714 km^2, less than one percent of all tropical forests (FAO, 2020). Still, the breadth and quantity of services that mangrove ecosystems provide (such as timber, carbon sequestration, biodiversity conservation, and coastal disaster mitigation) make these ecosystems a focal point for many international conservation programs, especially as mangroves continue to decrease at a disturbing rate. According to Giesen et al. (2007), 20 percent of mangrove area, or 3.6 million hectares, was lost between 1980 and 2005, while more recent data from the Global Mangrove Watch shows that approximately 6000 km^2 (600 000 ha) of mangroves have been lost between 1996 and 2016 (FAO, 2020). The ecosystems are vulnerable to extreme weather phenomena such as hurricanes and storms as well as to human activities such as urban development, pollution, agriculture and tourism (Hirales-Cota et al., 2010; Duke et al., 2014).

To help design and assess mangrove conservation programs, researchers increasingly focus on the identification, quantification and valuation of the ecosystem services (ESS) delivered by mangroves and other tropical coastal ecosystems. A recent picture of the state of the art by Himes-Cornell et al. (2018) highlights two main issues of the mangrove valuation literature: firstly, an overuse of benefit transfer ("… the use of existing data or information in settings other than for what it was originally collected" (Rosenberger and Loomis, 2003, p. 445)) in valuing mangrove ESS, and secondly, a lack of attention paid to the cultural ESS that mangroves provide. This literature overview also reveals that many ESS important to local communities are ignored (Himes-Cornell et al., 2018). To counter this gap, the current study sheds light

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on local preferences for mangrove ESS and mangrove conservation. Specifically, we focus on the mangrove ecosystem in Mahahual, a village in the state of Quintana Roo on the southeast coast of Mexico. Mexico is the country with the fourth-highest mangrove cover (5.4%) in the world (FAO, 2020), with nearly 17% of that coverage distributed in Quintana Roo, in the Yucatán Peninsula (Valderrama-Landeros et al., 2017). We believe that improving our understanding of the perceptions and needs of the local inhabitants when it comes to mangrove ecosystem services is key to the conservation of these coastal ecosystems as they interact with these ecosystems on an almost daily basis.

Even though mangroves are protected by law in Mexico, they have been steadily decreasing in area in the region of Mahahual. Based on satellite images, Hirales-Cota et al. (2010) have estimated a loss of 1070 ha of mangrove forest in the area of Mahahual-Xcalak (Quintana Roo, Mexico) between 1995 and 2007, with an annual deforestation rate of 0.85%. For the whole state Quintana Roo, Valderrama-Landeros et al. (2017) report a decrease of 9862 ha (approximately 7%) between 1981 and 2015. On the positive side, an increase of 1854 ha is reported between 2010 and 2015 (Valderrama-Landeros et al., 2017). The main threats to mangroves are the urban expansion of the village, causing mangroves destruction for road construction and settlements, and the arrival of mass tourism after the construction of a pier suitable for major cruise ships in 2001. To preserve the coastal ecosystem, supportive actions by the local and federal authorities are needed. However, local perceptions and preferences are insufficiently known at the moment. Therefore, a survey of the local community's preferences and expectations regarding the local mangrove ecosystem has been undertaken. This study examined a wide range of local perceptions regarding ESS such as carbon sequestration, recreation and cultural activities as well as improved connectivity with local seagrass beds and coral reefs. In summary, the aims and objectives of this research were to identify how the local community of Mahahual perceives the ESS provided by local mangrove forests and what drives their preferences. Moreover, we investigate the impact of information provision about the ESS on the perceived importance of these ESS for different types of households by providing each participant with information on the importance of mangroves. After educational provision, the importance of each system for the participants is measured again, which allows us to comment on the impact of information campaigns.

The small population size of the village, its small land area and its rapid expansion offer a unique context to contribute to the sustainable development of the village, aiming at preserving its environment while keeping in mind that the main economy is based on tourism.[1] Through the survey-based approach, microdata were collected that are representative of the village, as information on local perceptions is still lacking in the region. Our findings confirm the importance of the mangrove ecosystem for the local population. The majority of the community considers mangroves as an important place for them and the environment. While the cruise ship industry is important for the local economy, it does not seem to be the most favoured option for the development of the village, and other economic alternatives may be considered for future development. These alternatives could be more in line with the sustainable development goals (e.g. Valdés-Rodríguez and Pérez-Vázquez, 2011). Learning about local perceptions regarding mangrove forest management is not only relevant for these local communities but also for society as a whole since the value of protecting mangroves extends to the national and even international level.

In the next section, some background regarding Mahahual and ESS associated with mangroves in Mexico is provided. The section helps to understand the challenges of the local area. Next, the survey method and data collection approach are described in Section 3. Section 4 presents the results of the statistical analysis regarding local preferences for mangrove ESS. The findings are discussed in Section 5, followed by some conclusions in Section 6.

2. Background to Mahahual

Mahahual is a village with a population of close to 1700 inhabitants (according to our most recent census in 2020) on the Costa Maya in the municipality of Othón P. Blanco on the Caribbean Sea coast of the state of Quintana Roo, Mexico (see map in Appendix A). Previously a fishing village, it is now rapidly developing as a tourist centre since the construction of the cruise port in 2000–2001 (Malbos, 2019). This new development has transformed the physical and social landscape of the area: diversification of the labour market, tertiarization of the local economy, and a transition from a fishing to a mass tourism village. In addition to a transformation of activities, the construction of the Port cleared most of the mangroves on the construction site and its surroundings, altering the close bond between the coastal ecosystems encompassing the coral reef, seagrass, coastal dunes and mangroves (Bonnefoy, 2020). Furthermore, the construction of the concrete road in 2007 along the seaside locally known as 'El Malecón' sealed the soil. The road hindered the direct connection between the ocean and mangroves, two ecosystems that strongly depend on each other (de Pereyras, 2020). In the following sections, the main spatial characteristics of Mahahual are described in Section 2.1, followed by a brief literature overview of the main ESS provided by mangroves in Section 2.2.

2.1. Background to the urban development of Mahahual

Mahahual and its surrounding is an area where several ecosystems coexist with mangroves, including coral reefs, seagrass meadows, coastal lagoons, beaches, coastal dune vegetation, and rainforests. Hirales-Cota et al. (2010) have estimated a loss of mangrove forest in the area of Mahahual-Xcalak (part of the municipality Othon P. Blanco) from 7690 ha in 1995 to 6620 ha in 2007. More recently, the research centre Takata (2018) reported that Mahahual's ecosystems and biodiversity have been greatly affected in the past 20 years. The data collected in the area by CINVESTAV and HRI show a 90% decline in coral cover and 70% decline in fish biomass. In Mahahual, 57% of mangroves have been destroyed in 2001 due to the port construction and the remaining mangrove forests appear to be in very poor conditions, with a vegetation cover decline of about 40% since 2009 (Takata, 2018). Mahahual is not part of a natural protected area but is located inside a triangle made up of three major poles for the conservation of coastal ecosystems. It is encircled to the north by the large UNESCO-listed Sian K'aan Biosphere Reserve, to the south by the Xcalak protected reef area and to the east by the Banco Chinchorro atoll (see Appendix A). As Mahahual is surrounded by remarkably diverse natural protected areas, its mangrove ecosystem could play an important role in connecting these conservation poles and ensuring ecological continuity.

The village itself can be subdivided into four zones (Fig. 1): wilder areas located in El Sur and the city centre El Pueblo are located next to the coast, while the residential area Casitas and the popular district La 55 are located more inland. Casitas and La 55, therefore, do not have direct access to the coast. As this paper illustrates in the next section, geographical differences in neighbourhoods have an impact on the perception of different ESS associated with the mangrove ecosystem. The urban development of Mahahual has accelerated sharply in recent years to become a seaside town. Transforming its economic model formerly based on fishing and local crafts, Mahahual has since 1990 started to focus on mass tourism. As the result of a joint effort between the Mexican government and a local Mexican developer, a touristic port'Puerto Costa Maya' opened in 2001. The town quickly became a seaside resort and in 2019 Puerto Costa Maya represented Mexico's

[1] According to Google Maps, the overall land area is about 16 square kilometers, while the center of the village is about 3 square kilometers. In terms of population, the most recent census took place in 2016 (INEGI) and identified 1251 inhabitants. According to our survey in 2020, the population was about 1657 local inhabitants.

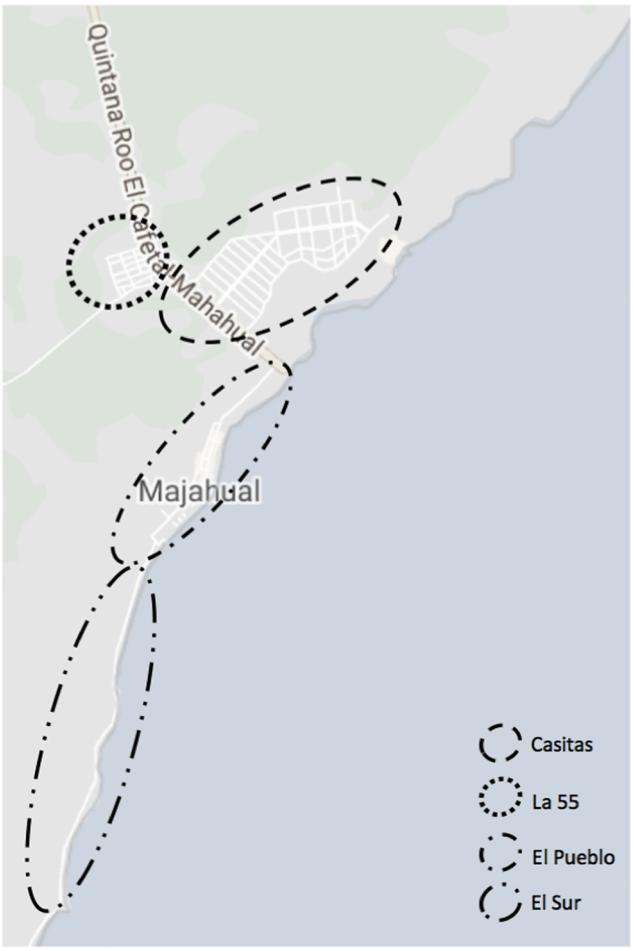

Fig. 1. Four study zones in Mahahual.

second cruise destination with 482 cruise ships and 1.6 million passengers arriving (General Coordination of Ports and Merchant Marine, s. d.). The boom in this economic activity has been accompanied by significant job creation locally, and an increase in the population of the village, as can be seen in Table 1. However, the current COVID-19 crisis has revealed the extreme fragility of the tourism sector, resulting in massive layoffs. During the global pandemic, no cruise ship docked in the port, leading to an economic crisis for the village.

Although Mahahual is a medium-sized locality with fewer than 2000 residents (Table 1), the urban and demographic projections prescribed by the Urban Development Plan appear to be ambitious in terms of the urban transformation of the village. In its current form, the plan would provide more than 3 300 ha for new development, which could welcome 70 000 new inhabitants by 2030, and 130 000 by 2050 (Takata, 2018). However, the local research centre Takata focusing on conservation of ecosystems, environmental management and environmental education has expressed concerns that the urban development plan provides insufficient integration of coastal ecosystems in general and mangroves in particular (Takata, 2018).

Table 1
Population of Mahahual.

	Total	Casitas	La 55	El Pueblo	El Sur
2015 (INEGI, 2016)					
Inhabited houses	445	238	154	53	
Residents	1 251	552	504	195	
Residents older than 15	880	424	320	136	
2020 census (own data)					
Households	542	217	189	98	38
Residents	1657	564	691	298	104

2.2. Literature overview of mangrove ecosystem services

Mangroves are a diverse group of halophytic plant species, which form highly productive forests in the area between mean sea level and the highest spring tide mark along tropical and sub-tropical coastlines and estuaries. Once perceived as mosquito-infested wastelands, these areas have now been recognized globally as highly productive and ecologically important ecosystems (Zaldivar-Jimenez et al., 2010; Duke et al., 2014). The mangroves are part of the coastal ecosystem, closely connected with barrier reefs and seagrass meadows, and these ecosystems provide many direct and indirect benefits and services to the local and global community (Camacho-Valdez et al., 2013; Perez-Verdin et al., 2016; Himes-Cornell et al., 2018; Lara-Pulido et al., 2018). Mangroves serve as pivotal support to commercial fisheries acting as nursery, breeding, spawning and hatching habitats for offshore fisheries. The mangroves ecosystem is necessary for local and migratory birds such as the white stork (Comisión Nacional para el conocimiento y Uso de la Biodiversidad, 2020). In addition, mangroves export organic matter to the marine environment, producing nutrients for fauna in both mangroves themselves and in adjacent marine ecosystems. Increasingly, their significant potential for carbon sequestration and storage is acknowledged and studied (Vázquez-González et al., 2017; Himes-Cornell et al., 2018; Sjogersten et al., 2021). Mangroves also play a crucial role in shoreline protection and climate adaptation as they serve as natural barriers, dissipating the destructive energy of waves and reducing the impact of hurricanes, cyclones, tsunamis and storm surges. Moreover, mangroves are needed to preserve the coral reef since it heavily depends on the water cycle, filtration and sediment removal, the reef being an important touristic attraction. Mangroves are thus one of the main natural assets of Mahahual.

Studies collecting primary data on the values associated with mangrove ESS in Mexico are relatively scarce. For instance, Cabrera et al. (1998) valued the mangrove ecosystem of the Terminos Lagoon, Campeche, Mexico for the residents of Ciudad del Carmen. They studied the mangroves to reflect their value as a timber resource, a nursery for fisheries, a water filtering system and a critical habitat for threatened species. As another example, Kaplowitz (2000) used focus groups and individual interviews to learn about the relative importance of ESS of the mangrove ecosystem in Chelém and Chuburna (Yucatán, Mexico). He noted the dominance of extractive uses such as lagoon fishing over non-extractive uses such as the beauty of the mangrove forests. Furthermore, some studies focus on fishing values only: Aburto-Oropeza et al. (2008) estimated the economic value of fisheries in the Mexican Gulf of California as 37 500 USD per hectare, while Vázquez-González et al. (2015) estimated the commercial fishing value of the mangroves in the Alvarado Lagoon System at 18 849 USD per hectare.

3. Method

3.1. Survey design and data collection

The survey included six main sections: local sensitivity to conservation problems, perceptions of local ESS of mangroves, willingness to contribute to the conservation of the coastal ecosystem, views on sustainable development of Mahahual township, fishing industry and socio-

demographics.[2] To facilitate communication with participants, the researchers classified mangrove ESS into six types: carbon sequestration; biodiversity (natural habitat for marine and terrestrial species); recreational and cultural activities; coastal protection (erosion prevention, natural disaster prevention, flooding and storm prevention); sediment retention, nutrient absorption and regulation of water quality; and connectivity to coral reefs and seagrass beds. These six categories were constructed from an initial literature review, followed by feedback and brainstorming sessions with local marine experts and coastal protection biologists from the Takata Research Centre[3], the mayor, local actors specializing in ecotourism such as Mahahual Ecotours[4] and other local stakeholders. By regrouping them into these categories, most ESS reviewed in the literature were encompassed and the survey questions remained feasible for the participants. The most similar classification to what we presented to local inhabitants is the classification from the Mesoamerican Reef foundation 'MAR Fund' (Rivas et al., 2020).[5]

As we were also interested in the impact of information campaigns, we first identified how the local community of Mahahual perceives the ESS provided by mangroves forest. Next, we provided each participant with information on the importance of mangroves and the different ESS connected to the mangroves via a presentation made by the interviewer based on the infographic included in appendix B. To investigate the impact of information provision, we again measured the perceived importance of different ESS. This allowed us to investigate the impact of information for different types such as participants with different educational backgrounds.

In total, the survey contained 61 questions, although participants did not necessarily have to answer all questions due to use of filter questions. Surveys were conducted and completed by trained interviewers. The majority of the questions used a variety of closed formats (e.g. list questions, rating questions using a Likert scale) with a limited number of open questions were included to allow the participants to provide more detailed information.

Primary data were collected on the field throughout July, August and September 2020. Five hundred and forty-two questionnaires were conducted by a team of six investigators, with an initial objective of interviewing 445 households based on previous numbers of households censored in 2015 (see Table 1). For the design of the survey and a comprehensive sampling of the village, the method employed was to walk along all the streets of Mahahual and interview one person from each household. Investigators all started with one zone, each assigned to a street. Once they had interviewed all households in their assigned street, they moved to another street. Once all inhabited households in the zone were covered, investigators moved to a new zone. If no one was at home, the interviewers would return until a household member could be contacted unless the household was vacant. The small size of the village made it possible to cover all the streets and implement a census at the household level. As such, there was no sample selection bias as one household member of each inhabited house was interviewed.[6] The 542 responses covered all the residences of the village identified in 2015 and several other new residences, according to demographics illustrated in Table 1.[7]

3.2. Statistical models

The Stata software package was used for all statistical analysis. As there were different types of dependent variables defined, several variations of the logistic model based on maximum likelihood estimation were used (Kleinbaum and Klein, 2010).

In the first approach we used an ordered logistic regression to evaluate the preferred ranking of participants for local ESS. We define two model specifications: first, only the ecosystem type (ESS_s) was used as control variable and second, interaction terms were added to study the impact of participants' characteristics:

(Model 1). $RankingESS_{si} = \beta_0 + \beta_1 ESS_s + \epsilon_{si}$

(Model 2). $RankingESS_{si} = \beta_0 + \beta_1 ESS_s + \gamma ESS_s * X_i^{'} + \epsilon_{si}$

with $RankingESS_{si}$ being the rank given by the participant i to each specific ESS s taking a value ranging from 1 to 6 to consider all ecosystem services relative to each other. β_0 is a constant, β_1 is the estimated coefficient associated with each ecosystem service type s, γ is a vector of estimated coefficients associated with the interactions between ESS type and participants' characteristics $X_i^{'}$ (gender, education, age, neighbourhood, homeowner or not, practicing fishing or not) and ϵ_{si} the error term. Results of this specification are available in table 4 (Model 1) and appendix C (Model 2).

In the second approach, we decided to run a multinomial logit (MNL) regression to assess the impact of the awareness campaign presenting information to the local community on the importance of each ESS (Kleinbaum and Klein, 2010). The dependent variable is an outcome variable consisting of the following discrete categories: the importance for an ESS increased, decreased or remained stable after a presentation of information concerning mangroves ESS. We used the type of ESS as well as participants' characteristics to explain the change in importance due to the information provision:

$$ChangeinrankingESS_{si} = \beta_0 + \beta_1 ESS_s + \gamma X_i^{'} + \epsilon_{si}$$

The results of the MNL are available in table 5.

Finally, we focused on whether or not the community would be ready to contribute to the conservation of mangroves and not on estimating the magnitude of this contribution. This choice was motivated by two contextual factors that were highly likely to bias the reported contribution. First, the majority of the community had a low income and second, the Covid-19 crisis led to higher than usual unemployment. Thus, we used a set of binary logistic regressions to estimate the personal factors influencing the willingness to contribute (WTC) to mangroves and coral reef conservation. Using a dichotomous choice question format on whether or not the participant was willing to contribute to different aspects of coastal ecosystem conservation, the binomial logit regression was an appropriate statistical analysis tool to measure char-

[2] Before the start of data collection and awareness campaign, meetings with the mayor of the village were organized to seek his approval of the project. Note that before the start of the field project, interviewers followed a one-week training to learn how to maintain openness and non-judgment throughout the interviews. They also became familiar with how to treat each interviewee with fairness and impartiality irrespective of socioeconomic status, associates, race, religion, or physical appearance. Note that when asking the participants to participate, investigators would always start by reminding that participation in the survey is not compulsory but that it is a personal choice, and that if at any time the participant does not feel like answering any question, they are allowed not to answer. Note that none of the participants asked not to respond to any of the survey questions.

[3] Takata's Research Centre webpage: https://takataexperience.com/research-conservation/.

[4] Mahahual Ecotours is owned by Victor Rosales, biodiversity expert in the area. More information can be found on the webpage: https://www.mahahual-ecotours.com/?fbclid=IwAR0yPVrrlsnRVMLRxPIDmJVAeHoFAD-iffTZvHcl94-S0oHC_Gk_d9mMYjYQ.

[5] Note that the only difference in terms of ecosystem services with respect to the MAR Fund classification is that we decided to put 'Bird habitat' and 'Fishery Production' into one single category 'biodiversity', encompassing all natural habitats for species.

[6] The potential threat would be that the time of the day would dictate who was at home. We discard it because of the months during which we interviewed households: as it was the COVID-19 pandemic, most workers were home due to the lack of tourism.

[7] We interviewed fewer households in the zone 'Casitas' compared to the censored houses of this zone in 2015. The reason was because these houses were no longer inhabited in 2020. Investigators passed by many times and asked neighbours, that confirmed the absence of any inhabitant in these houses.

acteristics of variables influencing the willingness to contribute to local coastal ecosystems conservation. The empirical model of willingness to contribute is based on a bid function, i.e. a function that relates WTC with variables that may influence the choice of contributing or not, as follows:

$$WTC_{investmenti} = f\left(X_i^{'}, \epsilon_i\right)$$

where $WTC_{investmenti}$ is a vector of binary variables illustrating whether the participant i is willing to contribute to the following investments: protection against natural disasters, protection against erosion, protection against flooding, and lastly, mangroves and coral reef conservation. Participants' willingness to contribute to each type of investment was analysed separately for each of the projects. $X_i^{'}$ is a vector of personal controls including the same personal characteristics as above and ϵ_i is the error term. Results of the binary logistic regressions are presented in table 7.

4. Results

4.1. Local population characteristics

The participants were 246 women and 296 men (Table 2). The highest share of participants was from the zone Casitas (40%), followed by La 55 (35%), El Pueblo (18%), and finally El Sur (7%) (Table 1). The participants were on average 38 years old, with the youngest being 12 years old and the oldest 85. Note that also the six participants younger than sixteen (one was 12, two were 14 and three were 15) were important caretakers in their households, which is why they were included. Note that before interviewing them, we asked for approval from the parent or guardian of the teenager. In all cases, the guardian of the teenager would agree that the teenager would do the interview in their place as they were unavailable. The average size of a residence was two. This small household size was linked to the fact that the majority of the inhabitants of Mahahual were seasonal workers in the hospitality sector, while their families remained in more distant native villages. Out of the 542 participants, 117 stated they were economically dependent, and 289 highlighted that they were the major economic provider. Also, approximately 28% of the participants have a Bachelor's or Master's degree (Table 2).

While most participants (497; 92%) considered the mangrove forest as an important place for them and the environment, a minority of the participants nonetheless perceived the mangroves as a location for waste disposal (14; 2.6%) or for additional construction (54; 10%). All questions related to the importance of mangroves and the ESS the participants were asked to scale their attributed importance on a Likert scale from one (not important) to five (very important). On this scale, 79% of the participants attributed the highest importance level to the mangroves. The highest percentage (89%) was found in the zone El Sur and the lowest in El Pueblo (75%) and La 55 (74%), and Casitas laying in between with 82% of its residents considering mangroves as very important for the future of the village and therefore also for themselves. The difference in responses between the four zones is statistically significant at the 10% level (Pearson's chi-squared test value = 20.31, p-value = 0.061).

The majority of participants (463; 85%) perceived the current state of mangroves as degraded, a minority perceived it as unchanged (23; 4%) or even improved (22; 4%), while the remainder did not know how to assess the current state. Most participants believed that the state of the mangrove forest would deteriorate even more in the future (446; 82%), while some believed it to remain stable (17; 3%) or expected an improvement (43; 8%). The majority (366; 68%) believed that the mangroves' degradation would have a direct impact on them, but there was still a sizable part of the households that did not expect a direct personal impact (176; 32%). Several threats to the mangroves' health were identified as (very) serious by the participants; Pollution (497; 92%) was the most important and was closely followed by coastal development (465; 86%) and climate change (447; 82%), and lastly overfishing (335; 62%). Moreover, we found that the majority of participants were in favour of designating mangroves as a protected area, with only three participants opposing such a suggestion and four being unsure.

Concerning the uses of the ecosystem, the local mangrove forest was used by the local community in a variety of ways. When asked about direct uses (Table 3), nature contemplation was clearly the dominant use category with 470 participants reporting this benefit from access to the mangroves. The other use categories were clearly less frequently selected with 11% reporting use of forest products, 8% harvest of medicinal plants, 3.7% disposal of household waste, 3.1% hunting and 2% construction activities. When asked about other uses in an open question

Table 2
Local inhabitants' characteristics.

Characteristic		Characteristic	
Gender	N	Education	N
Men	296	None	11
Women	246	Primary	78
Civil status	N	Lower secondary	112
Married	176	Higher secondary	149
Separated	29	Technical formation	35
Single	202	Bachelor	140
Civil union	120	Master	13
Widow(er)	12		
Professional status	N	Home	N
Homemaker	70	Renting	307
Unemployed	50	Owner	232
Employed	217	Access to water	N
Student	22	and sewage system	
Independent with business	103	No	72
Independent without business	62	Yes	466
Retired	15		
Income (before COVID 19 crisis)	N	Age	Years
No income	13	Mean	38.2
Less than 1000MXN	23	Median	36
Between 1000 y 2000MXN	34	Min	12
Between 2000 and 4000MXN	60	Max	85
Between 4000 and 6000MXN	60		
Between 6000 and 8000MXN	48		
Between 8000 and 10000MXN	36		
More than 10000MXN	119		
No response	146		

Table 3
Local use of mangrove forest.

	Casitas	La 55	El Pueblo	El Sur	Total
Nature contemplation	191	165	81	33	470
Use of forest products	21	18	13	8	60
Medicinal plants	22	9	7	5	43
Disposal of household waste	10	5	4	1	20
Hunting	6	7	2	2	17
Area for urban development (construction)	4	4	3	0	11
Other uses (incl. walking (10), fishing (7), ecotourism (4))	26	9	12	3	50

a wide variety of activities were mentioned, including walking, fishing and ecotourism. However, several participants also mentioned ESS such as reef protection, hurricane and erosion protection and turtle conservation.

Lastly, examining the local preferences for the future development of Mahahual, conservation programs and improving urban infrastructure received most of the support from the local community (98% and 96% respectively). Despite their economic importance, maintaining current tourism activities received the lowest level of support (71%). These preferences were reflected in the local debate regarding the possible future sustainable development for the village as a significant part of the local community was not in favour of mass tourism.

4.2. Preferences for local ESS

When asked to rank the six local ESS from most important to least important, biodiversity was most frequently ranked first (by 28% of participants), followed by coastal protection (22%), carbon sequestration (17%), connectivity to coral reefs and seagrass beds (15%), water management (13%) and recreational activities (5%). We then calculated a weighted sum of the rankings[8] to generate an overall ranking of the six local ESS according to the importance score presented in Fig. 2. This led to an identical relative ranking for five of the six ESS with the exception of carbon sequestration which dropped from the third to the fifth place.

To increase our understanding of the ranking of local ESS, we estimated two ordinal logistic regressions (see Section 3.2): in Model 1 (Table 4) we only included the ecosystem type, while in Model 2 (Appendix C) we interacted the ecosystem type with several socio-demographic characteristics to explore the existence of heterogeneous priorities within the households. To facilitate the interpretation of the estimated coefficients, we reversed the ranking implying that 1 is lowest ranked and 6 is highest ranked. Based on Model 1 (Table 4), we found that biodiversity is most likely to be ranked high, closely followed by coastal protection. Water management comes third, followed by carbon sequestration, ecosystem connectivity and lastly recreational and cultural activities (i.e. reference category). In the case of Mahahual, recreational activities related to mangroves refer to walks that can be organised to discover the fauna and flora, and kayaking activities through the mangroves. Cultural services refer to the effect mangroves have on the identity and image of the village. Without mangroves, Mahahual would not be as aesthetically pleasing and thus would not be perceived as an attractive place to live or spend holidays. The results of Model 2 (Appendix C) also reveal heterogeneity in the preferences of the local community as different groups of participants have significantly different rankings. Carbon sequestration was ranked lower by residents from La 55 and by participants with a degree in higher education, while biodiversity was ranked lower by residents from El Pueblo. Coastal protection was ranked lower by participants that liked to go fishing. Water management was ranked higher by participants with a higher education, but lower by women. Lastly, ecosystem connectivity, linking mangroves habitat with the coral reefs and seagrass beds, was valued higher by participants with a higher education. Based on a set of t-tests, we note that the estimated coefficients of the ESS are all statistically different from each other at the 1% statistical significance level in both models.

Besides providing a relative ranking of the local ESS associated with mangroves, participants could also indicate what their perceived importance of each of the ESS was on a scale from 1 (being not important) to 5 (being very important). After the initial measurement of perceived importance, investigators moved on to an educational section (see Appendix B), where they explain the importance of each ESS in more detail. This part was considered as an awareness campaign focusing on mangroves ecosystem and was also one of the main objectives of the study. Afterwards, participants were asked again to indicate the perceived importance of the local ESS.[9] It allowed to observe any change in perception after the awareness campaign. The detailed results are presented in the appendix D. All ESS were felt to be very important to the local community with biodiversity (452) and ecosystem connectivity (448) getting the most support initially. Next ranked are coastal protection (441), water management (441) and carbon sequestration (400), while recreational and cultural ESS (230) were the least important. After the educational part, many participants revised their score upwards and only a minor group reduced their scores. While the perception of the importance of recreational and cultural ESS remains the lowest (343), the perceived importance of the other local ESS equalized to a similar level, with water management receiving the highest number of 'very important' scores (513) and ecosystem connectivity the lowest (501).

Out of 3210 ($=535 \times 6$) decisions made by the participants, only 31 implied a downward adjustment while 585 involved an upward adjustment. The results of a multinomial logistic regression are presented in Table 5 and allow us to learn more about the participants that adjusted their scores. First, we find that older people were less likely to adjust their score downwards than younger people. Next, we see that scores for carbon sequestration and recreation were significantly more likely to be adjusted upwards than the scores for the other ESS. Moreover, participants with a Bachelor's or Master's degree, homeowners and participants who like to go fishing are significantly less likely to increase their scores. Thus, it seems that specific information provision can help to counterbalance the effect of being higher educated. The channel we find most plausible to explain the higher changes in perception for people with a lower educational degree is the assumption that residents with a higher education were already aware of the importance of the ESS, while less educated people needed to be nudged in order to realise it. It strengthens the role of education for raising support for better conservation.

4.3. Willingness to contribute to mangrove conservation efforts

In order to gain insight into the local households' willingness to contribute to the protection and management of the local ecosystems, we used two approaches. First, we asked them if they would be willing to pay for protecting their home from natural disasters, erosion or flooding. From Table 6, we learn that the willingness to contribute (WTC) is the highest for protection from natural disasters, then flooding and last erosion. Second, we asked if they would be willing to pay or to contribute time to help with the conservation of the mangroves and the coral reef. Participants were less willing to contribute financially to the conservation of mangroves, but they seemed very willing to contribute part of their time (Table 6). A high proportion of participants (62%) were willing to spent time on conservation actions and another 17% were willing to contribute both time and money. This high percentage of the inhabitants indicate the broad level of local support towards protecting the mangrove ecosystem, although the economic slowdown due to the global pandemic may have also influenced this willingness to

[8] Rank 1 received weight 1, rank 2 received weight 1/2, rank 3 wt 1/3, rank 4 wt 1/4, rank 5 wt 1/5 and rank 6 wt 1/6. Then, we calculate the importance score as the sum of the number of participants that selected each of these ranks weighted by these weights.

[9] Before asking participants to rank again the importance of ecosystem services and directly after the awareness campaign that took place for each inhabitant during his interaction with the investigator, the investigators asked the participants to confirm if they understood what each ecosystem service presented was. If anything was unclear, investigators were trained to be able to make sure the inhabitants would understand the concepts, rephrasing the information given and/or using illustrative examples. It ensured the fact that inhabitants were in the end familiar with mangroves ecosystem services presented.

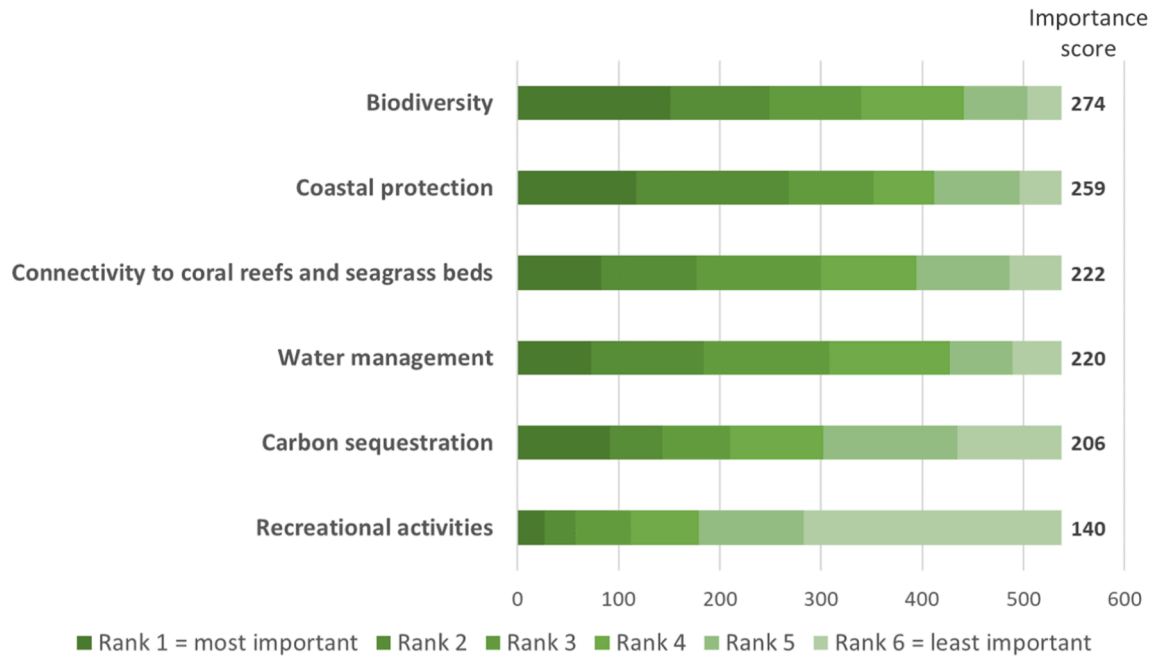

Fig. 2. Ranking of six local ecosystem services according to an importance score reflecting a weighted sum of individual rankings.

Table 4
Ordinal logistic regression of ranking local ESS (1 = least important; 6 = most important).

	Model 1	
	coeff	St.error
cut1	−0.239***	−2.974
cut2	0.820***	−8.382
cut3	1.596***	−15.092
cut4	2.366***	−21.495
cut5	3.329***	−29.452
Biodiversity	2.271***	−15.991
Coastal protection	2.193***	−15.956
Water management	1.840***	−13.256
Ecosystem connectivity	1.765***	−12.908
Carbon sequestration	1.219***	−8.935
Obs. (cluster)	3228 (538)	
Prob > chi2	0.0000	
Pseudo R^2	0.0459	
Log pseudolikelihood	−5518	

***: statistically significant at 1 % level.

contribute through labour. When asked why they were not willing to contribute to mangrove and reef conservation, several participants (23 participants) stated that it was not their role but that of the government. Other reasons that were mentioned included that they lacked resources (6 participants), time (16 participants) or both (10 participants).

Based on the information collected on the WTC, we investigate the characteristics of participants who were willing to contribute by using a set of logistic regressions (one per project type). We focus on the willingness to contribute financially as these results are less susceptible to a social desirability bias. Also, we assume that participants who did not answer this question are not willing to contribute. The results are summarized in Table 7.

First, we find that women and older participants were less willing to contribute to projects improving protection from natural disasters, while participants with a higher educational degree and homeowners were more willing to contribute financially. Secondly, residents from El Sur and La 55 were markedly more willing to pay for protection from flooding, while women were less willing to do so. Thirdly, residents from El Pueblo and El Sur and participants with a higher degree were more willing to contribute for protection from erosion, while women and older participants were less willing to so. Finally, participants with a higher or technical degree were more willing to contribute to the conservation of mangroves and coral reefs in general, while residents from La 55 were less willing to do so. These differences in willingness to contribute may be justified by the difference in income between men and women, lower or higher educational levels driving income, and homeowners also being more at ease financially than non-owners. The next section discusses differences across groups in further details.

5. Discussion

The findings confirm the importance of the mangrove ecosystem for the local population when looking at high level of importance assigned to most of the ecosystem services and to the mangrove forest ecosystem as a whole. Most of the local community perceives mangroves as important and as providing several relevant services with nature contemplation being reported as the dominant use (Table 3). Moreover, as 85% of the community assess the current state of mangroves as degraded, they are willing to contribute to the conservation and restoration of the local mangrove ecosystem. The main threats to mangroves' health reported by the residents are pollution, coastal development and climate change. While the local economy is highly dependent on tourism, 30% of the local residents did not consider maintaining current tourism activities as important for local development. Conservation programs and improved urban infrastructure received almost unanimous support.

Focusing on six local ESS and controlling for households' characteristics such as the zone in which they live and demographics (Appendix C), biodiversity is most likely to be ranked high, closely followed by coastal protection. Water management comes third, followed by carbon sequestration, ecosystem connectivity and lastly recreational and cultural activities. Appendix C reveals that even within a small local community, preferences can be heterogeneous. Education mattered in all specifications, as participants with a Bachelor's or Master's degree had significantly different preferences. They appreciated carbon sequestration, water management and ecosystem connectivity significantly more than the other participants. Assuming that these concepts are more complex to understand, it underlines the importance of

Table 5
Multinomial logistic regression of change in score after information provision.

	downward change		**upward change**		**no change**
	coeff	st.error	coeff	st.error	
Carbon sequestration	−0.2309	0.5986	0.6369***	0.1338	base outcome
Recreation	0.4951	0.5155	1.1133***	0.1313	
Coastal protection	−0.8588	0.6984	0.0074	0.1437	
Water management	−0.5546	0.6345	0.1021	0.1352	
Connectivity	−0.8864	0.6993	−0.2162	0.1405	
Woman	0.2234	0.3716	−0.3073*	0.1642	
El Pueblo	−1.2632	0.8848	−0.4178*	0.2361	
El Sur	0.5361	0.7075	0.1757	0.3452	
La 55	−0.5130	0.6778	0.1037	0.2084	
Fishing	−0.0222	0.4012	−0.3390**	0.1612	
Lower secondary	−0.1267	0.7211	−0.4754*	0.2613	
Higher secondary	−0.9179	0.7034	−0.2703	0.2613	
Technical degree	−0.7308	1.0626	0.0238	0.4109	
Higher education	−0.4340	0.7150	−0.6596**	0.2773	
Home owner	0.8633*	0.5045	−0.5812***	0.1631	
Age	−0.0395***	0.0168	−0.0126*	0.0066	
_cons	−2.5908	1.1181	−0.4999	0.4442	
Obs (cluster)	3198 (533)				
Prob > chi^2	0.0000				
Pseudo R^2	0.0644				
Log pseudolikelihood	−1581				

* / ** / ***: statistically significant at 10 / 5 / 1 % level.

Table 6
Willingness to contribute to the management of local ecosystem (N = 542).

	Number of participants that are…				
	not willing to contribute	willing to contribute only money	willing to contribute only time	willing to contribute money and time	no answer
Protection from natural disasters	168	355			19
Protection from erosion	346	170			26
Protection from flooding	257	262			23
Mangrove and reef conservation	72	37	338	91	4

Table 7
Logistic regressions exploring participants' willingness to contribute.

		Natural disaster protection	**Erosion protection**	**Flood protection**	**Mangrove conservation**
Woman	Coeff	−0.401**	−0.428**	−0.377**	−0.058
	s.e.	−2.012	−2.078	−2.002	−0.267
El Pueblo	Coeff	−0.272	1.088***	0.202	−0.071
	s.e.	−0.993	−3.978	−0.771	−0.257
El Sur	Coeff	−0.125	1.206***	0.763**	−0.401
	s.e.	−0.316	−3.13	−1.99	−0.949
La 55	Coeff	−0.121	0.021	0.492**	−1.300***
	s.e.	−0.469	−0.077	−1.986	−4.123
Fishing	Coeff	−0.119	−0.111	0.008	−0.197
	s.e.	−0.587	−0.523	−0.044	−0.855
Lower secondary	Coeff	−0.184	−0.642*	−0.263	0.323
	s.e.	−0.6	−1.764	−0.85	−0.766
Higher secondary	Coeff	0.222	−0.068	0.058	0.439
	s.e.	−0.688	−0.196	−0.184	−1.048
Technical degree	Coeff	0.088	0.636	0.651	0.978**
	s.e.	−0.206	−1.412	−1.516	−1.97
Higher education	Coeff	0.899***	0.357	0.753**	0.787**
	s.e.	−2.706	−1.046	−2.386	−1.974
Homeowner	Coeff	0.475**	−0.233	0.246	0.325
	s.e.	−2.252	−1.086	−1.249	−1.403
Age	Coeff	−0.017**	−0.016*	−0.022***	0.001
	s.e.	−2.238	−1.904	−2.884	−0.158
_cons	Coeff	1.210**	−0.182	0.357	−1.304**
	s.e.	−2.314	−0.332	−0.716	−2.127
N		539	539	539	539
prob > chi2		0.0005	0.0000	0.0007	0.0000
pseudo R^2		0.0481	0.0725	0.0431	0.0731
log likelihood		−329	−312	−357	−281

* / ** / ***: statistically significant at 10 / 5 / 1 % level.

education in emerging economies to achieve better conservation objectives. We also found preference differences between the different zones in Mahahual. The geographical closeness to the ocean and the reef in El Sur and El Pueblo may explain the relatively lower importance of indirect, global ESS such as carbon sequestration and biodiversity. As a matter of fact, residents from El Sur and El Pueblo were directly affected by the closeness to the ecosystems and perceived observable ESS such as coastal protection as most important.

Providing information about the different ESS of mangroves has an impact on the relative importance of these ESS for local residents, as the awareness campaign modified the importance of ESS predominantly upward. The scores for carbon sequestration and recreation were most likely to be adjusted upwards after the information provision. Moreover, while biodiversity initially was the service with the highest importance, it was joined by water management and coastal protection after the awareness campaign was presented by the interviewers. Recreational services remained the ESS with the lowest importance. Raising awareness of the community regarding the benefits from mangroves can thus increase local knowledge concerning the coastal ecosystem and most likely increase public support for mangroves' protection. Additionally, as residents with a higher education already attached significantly more importance to the local ecosystems, their insensitivity to the information is hardly surprising. Emphasizing the importance of further education to local communities is a key policy recommendation of our research.

Local residents are also willing to pay for protecting their homes from natural disasters, flooding or erosion. Again, we find that residents' educational background matters as residents with a higher degree are more willing to contribute. This result may be explained by the higher income levels obtained by individuals with a higher education. Geographical location and exposure to natural disasters also impact the willingness to contribute to mangrove conservation. Residents from El Sur and La 55 are markedly more willing to contribute for protection from flooding. It may be explained by the closeness to the ocean for people from El Sur and by the bad water management due to the lack of any sewage system for people from La 55.[10] The neighbourhood does not benefit from any connection to the sewage system since it is the most recent neighborhood of the village that was constructed very quickly to host workers who migrated to Mahahual when the Costa Maya port opened in 2001. Once inhabitants started to live in La 55, the neighborhood became a real part of the village.[11] In addition, residents from El Pueblo and El Sur are more willing to pay for protection from erosion, as they live close to the shore.

From a policy-based approach, the paper shows that since the help of the local community is required to protect the mangroves ecosystem, local support can be achieved more efficiently knowing the needs of the local population. For example, in order to motivate residents from the zone El Sur to contribute to mangroves conservation, an emphasis on the role of mangroves in coastal protection could be used, as they are more affected by any extreme weather event. To motivate residents from La 55, an emphasis on the importance of mangroves conservation for a better water management could be put forward, as residents from the zone La 55 do not all benefit from a clean watering system. To motivate people from Casitas, an emphasis on carbon sequestration and biodiversity could be put forward, as residents from this zone are very aware of indirect and more complex ESS. To incentivize households from El Pueblo to contribute, additional emphasis could be put on the importance of the mangroves to fight against erosion. The majority of residents from 'El Pueblo' work in resorts directly on the coastline and therefore would be directly impacted by erosion. In the end, the main challenge is to present the importance of mangroves conservation from different angles, based on the heterogeneity of the local community perception.

Finally, we would like to point to the important role that can be played by civil society organisations, which can be defined as organisational structures whose members serve the general interest through a democratic process, and perform the role of mediator between public authorities and citizens (Eur-Lex, 2022). Examples include social partners, NGO's and grassroot movements. As shown by Del Valle-Cárdenas et al. (2020), these organisations have been key for implementing local actions in projects of climate change adaptation in local communities in Mexico. In line with our findings regarding local mangrove conservation, Del Valle-Cárdenas et al. (2020) also emphasize the importance of community interaction and educational processes to develop skills in climate change adaptation.

6. Conclusion

The results of this case study in Mahahual show that mangroves are a valuable ecosystem to the local community despite the low standard-of-living characterising the village. The survey reveals that biodiversity is the most preferred ecosystem service relative to the other services, but that we can still find significant heterogeneity in preferences among the small community, especially depending on educational levels and geographical zones in the village.

Moreover, when estimating the impact of the awareness campaign led in the summer of 2020, we find that most upward adjustments of the importance of ESS made by participants after investigators shared informational material on the importance of the mangrove forest ecosystem related to carbon sequestration and recreational activities. It shows the effectiveness of awareness campaigns and provides incentives to consider access to environmental education for the local community as a tool to enhance the sustainable development of the village. Moving on to the economic valuation of ESS, we find significant heterogeneity of responses. Again, residents' educational background matters as residents with higher levels of education are more willing to contribute for extreme events protection and coastal ecosystem conservation.

Our research illustrates that raising awareness of the community regarding the benefits provided by mangroves most likely increases local and public support for their environmental protection. The question on how to convince additional donors and funding for coastal ecosystem protection remains and could be subject to further research. As a matter of fact, tourists are also heavy users of the coastal ecosystem and may therefore be key actors in its conservation. They also are considered as donors with more financing capacity, thanks to their higher standard-of-living. While it is out of the scope of this paper which focused on heterogeneity of preferences of the local community, including all relevant actors will be an important element in future research. Lastly, the research project and its policy recommendations for better management of mangrove forests in Mahahual based on understanding the needs and perceptions of the local community could be extended to the Costa Maya and other coastal regions benefitting from similar ecosystems and victim of similar environmental challenges.

To conclude, we would like to point out that learning about local perceptions regarding mangrove forest management and the relevance of local ecosystem services is not only relevant for local communities. Improving and protecting the health of coastal ecosystems plays a crucial role in climate and biodiversity policies around the globe and generates local, national as well as international benefits.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

[10] Without any sewage system, the water from floods may destroy houses more than if manholes would be part of the infrastructure.

[11] This information comes from meetings with the mayor of the village, Takata Research Centre, and testimonies from participants living in La 55. Note that it can also be observed when walking in the streets of La 55 that there are no manholes. Manholes are present in the streets of the rest of the village.

Data availability

Data will be made available on request.

Acknowledgements

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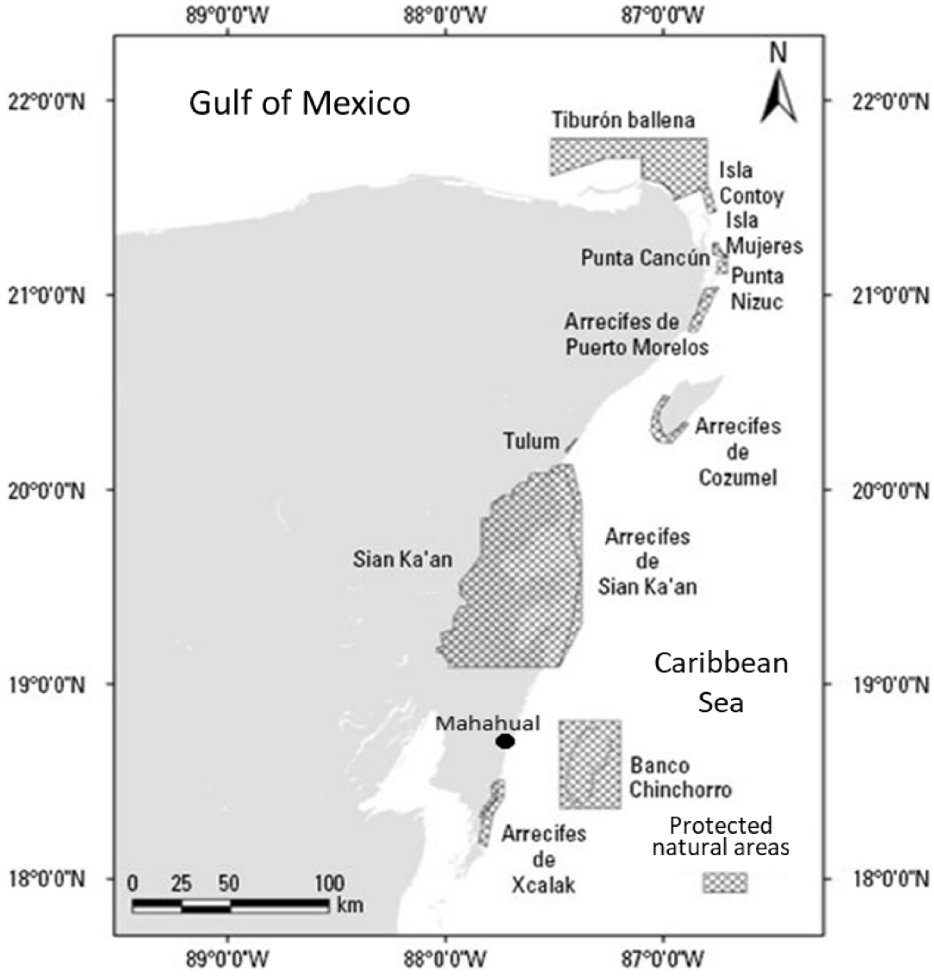
Appendix A

Map with marine and coastal protected natural areas in Quintana Roo, Mexico



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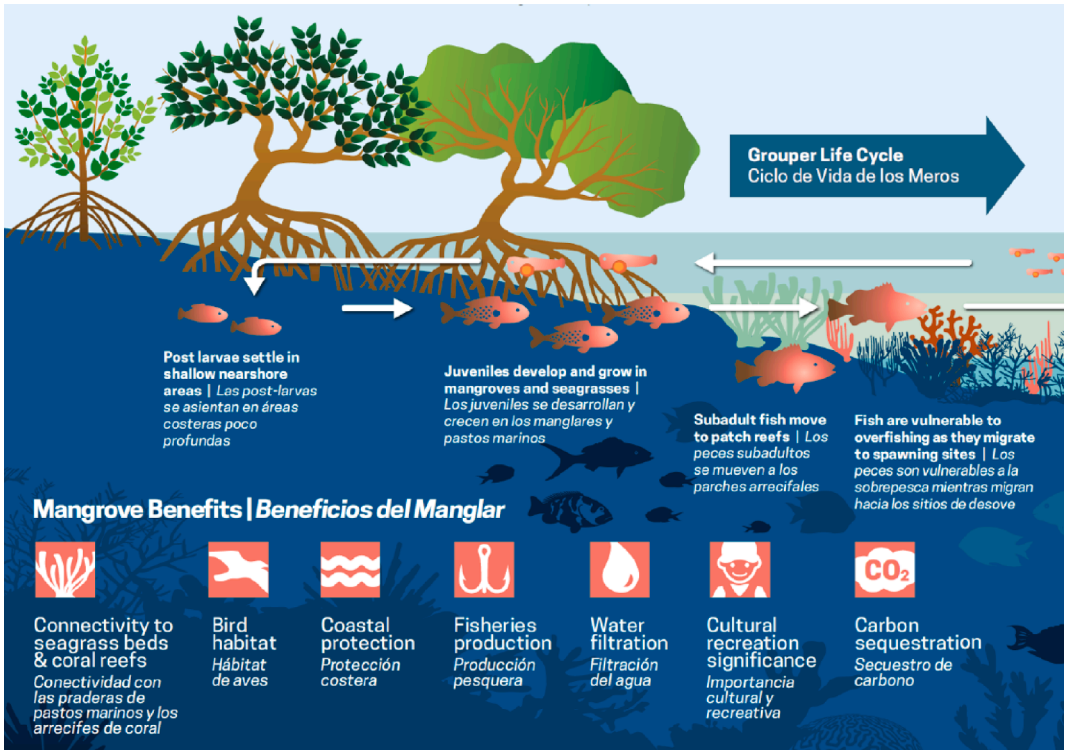
(adapted from https://everythingcozumel.com/maps/map-quintana-roo-protected-areas/).

Appendix B

The following figure was used to educate residents about the different ecosystem services provided by the local mangrove forests.



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Appendix C

Ordinal logistic regression of ranking local ESS including interactions terms with socio-demographic variables (1 = least important; 6 = most important).

	Model 2				
Variable	coeff	St.error	Variable	coeff	St.error
cut1	−0.246***	0.081			
cut2	0.827***	0.098			
cut3	1.616***	0.107			
cut4	2.399***	0.111			
cut5	3.374***	0.114			
Carbon sequestration	1.295***	0.363	Water management	1.872***	0.289
x woman	0.009	0.186	x woman	−0.316**	0.143
x El Pueblo	−0.279	0.252	x El Pueblo	0.182	0.170
x El Sur	−0.562**	0.281	x El Sur	−0.340	0.337
x La 55	−0.678***	0.236	x La 55	0.117	0.178
x higher education	−0.516***	0.188	x higher education	0.332**	0.154
x age	0.006	0.007	x age	−0.003	0.004
x home owner	0.070	0.193	x homeowner	0.226*	0.136
x fishing	0.334*	0.189	x fishing	−0.009	0.152
Biodiversity	2.761***	0.329	Ecosystem connectivity	1.413***	0.299
x woman	−0.011	0.164	x woman	0.078	0.143
x El Pueblo	−0.475**	0.228	x El Pueblo	0.133	0.192
x El Sur	0.384	0.302	x El Sur	0.048	0.267
x La 55	−0.198	0.203	x La 55	−0.106	0.202
x higher education	−0.022	0.177	x higher education	0.493***	0.162
x age	−0.005	0.006	x age	0.005	0.006
x home owner	−0.069	0.166	x homeowner	−0.003	0.157
x fishing	−0.300*	0.168	x fishing	0.065	0.153
Coastal protection	2.142***	0.296			
x woman	0.190	0.157			
x El Pueblo	0.108	0.225			
x El Sur	0.106	0.445			
x La 55	0.275	0.202			

(continued on next page)

(*continued*)

Variable	Model 2 coeff	St.error	Variable	coeff	St.error
x higher education	0.083	0.195			
x age	0.000	0.006			
x home owner	−0.105	0.173			
x fishing	−0.300*	0.163			
Obs. (cluster)	3216 (536)				
prob > chi2	0.0000				
pseudo R^2	0.0520				
log pseudolikelihood	−5467				

* / ** / ***: statistically significant at 10 / 5 / 1 % level.

Appendix D

Comparison of perceived importance of local ESS before and after information provision

	after 1	after 2	after 3	after 4	after 5	Total
Carbon sequestration						
initial 1 – not important	2	0	0	2	28	32
initial 2	0	0	1	3	7	11
initial 3	0	0	2	6	33	41
initial 4	0	0	2	6	43	51
initial 5 – very important	0	0	0	3	397	400
Total	2	0	5	20	508	535
Biodiversity						
initial 1 – not important	0	0	0	0	0	0
initial 2	0	0	1	1	5	7
initial 3	0	0	4	5	23	32
initial 4	0	0	0	5	39	44
initial 5 – very important	0	2	3	2	445	452
Total	0	2	8	13	512	535
Recreation						
initial 1 – not important	18	3	3	4	8	36
initial 2	1	24	11	11	13	60
initial 3	1	1	60	21	59	142
initial 4	0	1	1	28	37	67
initial 5 – very important	0	1	1	2	226	230
Total	20	30	76	66	343	535
Coastal protection						
initial 1 – not important	0	0	0	0	2	2
initial 2	0	1	0	0	8	9
initial 3	0	0	1	4	27	32
initial 4	0	0	2	15	34	51
initial 5 – very important	0	0	0	1	440	441
Total	0	1	3	20	511	535
Water management						
initial 1 – not important	1	0	0	1	2	4
initial 2	0	0	0	0	7	7
initial 3	0	0	3	4	26	33
initial 4	0	0	0	9	41	50
initial 5 – very important	0	1	0	3	437	441
Total	1	1	3	17	513	535
Ecosystem connectivity						
initial 1 – not important	7	1	0	1	1	10
initial 2	2	1	1	2	5	11
initial 3	0	0	7	3	17	27
initial 4	0	0	0	8	31	39
initial 5 – very important	0	0	0	1	447	448
Total	9	2	8	15	501	535

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