Local community attitudes towards mangrove forest conservation issues: the case of Mahahual

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This research project sought to understand the challenges and perceptions of the community towards mangroves ecosystem in a village of Mexico. Surveys were applied to the local population to know the social perspective of the residents to mangroves ecosystem. It establishes existing socio-economic and geographic characteristics potentially influencing a positive and receptive attitude towards future projects optimizing conservation and community benefits. Similarly, the paper identifies and highlights key opportunities that could be incorporated for the development of Mahahual. 72% of people surveyed who own a land at the seaside want to participate in mangroves replanting in front of their establishments, and more sustainable development including conservation of the coastal ecosystem is desired by the majority of residents.

Keywords Mangroves Management, Conservation, Ecosystem Services, Willingness to Pay

Contents

1. Introduction

Mahahual is a village on the Costa Maya in the municipality of Othon P. Blanco on the Caribbean Sea coast of the state of Quintana Roo, Mexico. Previously a fishing village, it is now rapidly developing as a tourist center since the construction of the cruise port in 2000-2001. The new development opportunity that appeared in this former fishing village has transformed the physical and social landscape of the area: diversification of the labor market, tertiarisation 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 required to cut mangroves and to alter the close bond between the coastal ecosystems encompassing the coral reef, seagrass, coastal dunes and mangroves. Furthermore, the construction of the concrete road along the seaside locally known as 'El Malecón' which started in 2007 hindered the direct connection between the ocean and mangroves, ecosystems strongly depending on each other[1].

Mangroves ecosystems[2] are among the most productive and biologically complex ecosystems on the planet and provide essential ecosystem services ([Smithsonian Ocean 2020](#)). They cover between roughly 138,000 and 200,000 square km globally, acting as a bridge connecting the land and sea. Each ecosystem and its components (water, living organisms, soil) play a key role in maintaining wellbeing and health. Ecosystem services are all the processes and outputs that nature provides humans with ([Science ABC 2020](#)). These include provisioning services (food, plants), regulating services (waste water treatment, pollution control), supporting services (support for coastal ecosystems), and cultural services (recreation and tourism).

Besides the start of mangroves damage which occurred two decades ago, there is an ongoing threat on mangroves forest: the urban expansion of the village causing mangroves destruction for road and dwelling purposes. Coastal ecosystems and their ecosystem services are necessary for the development of Mahahual to help the village not only with its increasingly exposure to climatic phenomena, but also to maintain tourism through its nature and biodiversity, generating the main source of income for the local population. In order to preserve the coastal ecosystem which is necessary for the sustainable preser-

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[1] As an illustrative figure, the rapid urbanization of Mahahual and the changes in land use that have already taken place destroyed 57 ha of mangroves in 1 year to build 25 hotels between 2000 and 2001.

[2] An ecosystem is a dynamic community that comprises living organisms, such as microorganisms, plants and animals, as well as non-living environments, each interacting with one another.

vation and development of Mahahual, raising awareness of the local population as well as of the local and federal authorities is needed. However, local perception and knowledge the local inhabitants have for ecosystem services is not precisely known at the moment. Therefore understanding perception, needs and expectations regarding mangroves and the the community's potential desire to preserve it is a major step before undertaking any conservation and restauration program. This research aims at filling this gap and opening future opportunities for conservation research on coastal ecosystems.

The research project aims at responding the following question: how does the local community of Mahahual perceive the ecosystem services provided by mangroves forest, and how do their personal characteristic influence their perception? Throughout the fieldwork, economic values were also collected. These values will aim at estimating the economic value the local community put on mangroves ecosystem, defined as their willingness to contribute to mangroves conservation. There are also resulting research questions ensuing: is the population aware of the benefits provided by the ecosystem services ensuing from mangroves? Is there any difference in terms of mangroves perception which is influenced by the geographical location of the inhabitants? Last, the research also offers accurate demographics for the village, which seem valuable looking at the scarcity of most recent data. It also opens doors for future research aiming to understand the impact of the COVID-19 crisis on local employment and income.

The small size of Mahahual and its rapid expansion offers a unique context in order to intent to contribute to a sustainable development of the village, aiming at preserving its environment while keeping in mind that the main economy is based on tourism. The survey based approach allows to collect micro data representative of the village, data which are still lacking in the region.

Results confirm the will of the local population to benefit from a protected ecosystem. It also concludes that while the majority of the community considers mangroves as an important place for them and the environment, residents from 'El Sur' are not only more sensitive to conservation issues, but are also the most enclined to contribute and help in the conservation and restauration of the mangroves ecosystem. Residents from 'La 55' are also the ones who believe the least that mangroves degradation can have a direct impact on them, relatively to the other three zones. Results also show that the cruiseship industry does not seem to be the most favoured option for the development of the village. Knowing that the local community would be ready to see the village develop in another way opens up opportunities for more sustainable development.

The research project provides policy recommendations for better management of mangrove forests in Mahahual, and could be extended to the Costa Maya with similar ecosystems. It also serves as an informative tool in order to know how the awareness of the inhabitants in Mahahual should be raised in order to better protect mangroves ecosystem. During the survey, an educational section was given to each respondent concerning the importance of ecosystem services, in order to raise their knowledge and awareness concerning mangroves.

Last, the research also allows to understand the need of the local population concerning the development of the village, and also their desire to preserve the environment in the near future. As such, a future conservation project will be easier to implement, knowing what, with, whom, and to what extent it should be put in place.

It also is a first step to be able in the futures to put an economic value on the mangroves ecosystem using a contingent valuation method, after reviewing meta analysis of methods such as Pandeya et al. (2016), Salem & Mercer (2012). It would also support the paper written by Misha Yoselin Rodriguez Abrego (2019) who put an economic value on the local coral reef. While Ciro Calderón (2009) put a value on the mangroves without differentiating ecosystem services, the potential of the database collected will allow in the future to put an economic value on each service, following methodologies of CONANP-GIZ (2017), de la Rosa (2017), Hamid (2018) who differentiated each service. It will help to implement a future cost-benefit-analysis of a mangroves conservation project, such as Tuan & Tin (2013).

2. Local Context

2.1. Mahahual context and its urban development

Located inside a triangle made up of three major poles for conservation of coastal ecosystems, Mahahual appears to be a geographical point where development logics are held. 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, Mahahual is surrounded by remarkably diverse natural protected areas, as observed in figure 1. However, mangroves of Mahahual constitute in an overall ecosystem logic an area of ecological continuity for the three conservation poles mentioned (Pereyras 2020).

Initially a fishing community, the urban development of Mahahual has accelerated sharply in recent years to become a seaside town. Although Mahahual remains a medium-sized locality today (1642 inhabitants according to the data collection of this research paper), the urban and demographic projections prescribed by the PDU (Plan de Desarollo Urbano) appear to be ambitious in terms of urban exodus to the village. Indeed, transforming its economic model formerly based on fishing and local crafts, Mahahual has since the 1990 started to focus on mass tourism.

In 2001, as the result of a joint effort between Mexico's government and a local Mexican developer, a touristic port 'Puerto Costa Maya' opened. The port was built and the government was paid back in taxes the port produced in the years following (Mahahual 2014). Cruise ships began to contract with the privately owned port and the town quickly became a seaside resort.
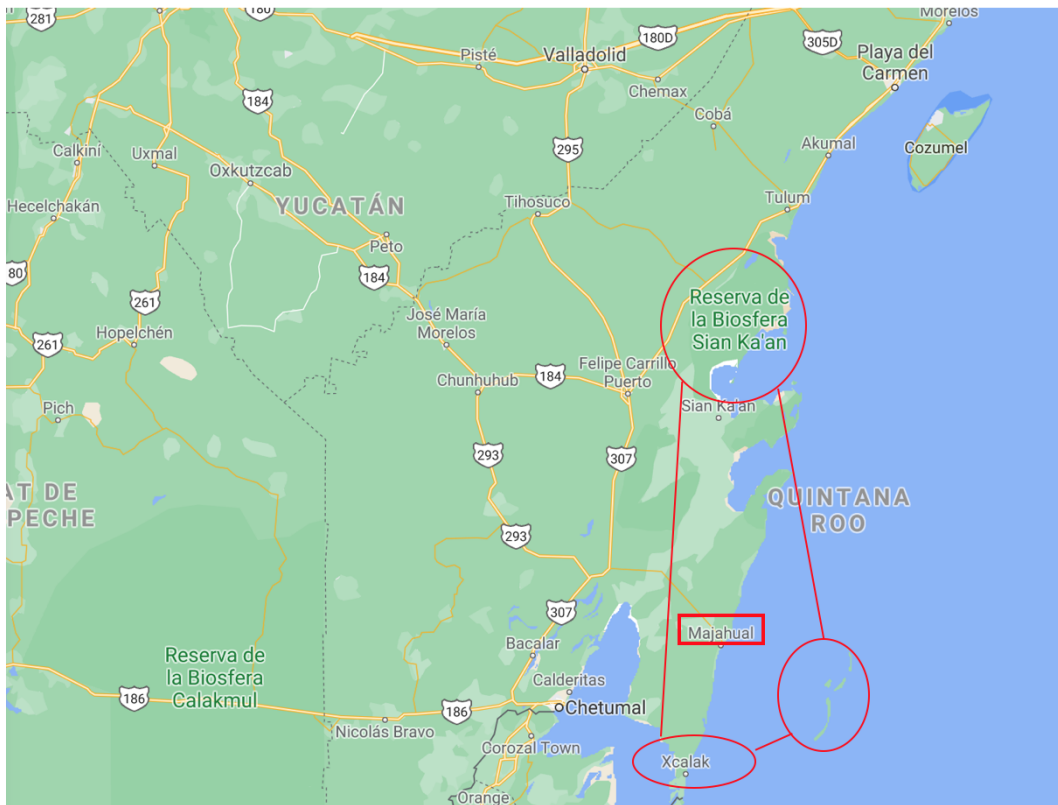

Figure 1: Spatial Location of Mahahual, surrounded by protected areas

Quickly, Puerto Costa Maya represented Mexico's second cruise destination with 10 to 12 cruise ships per week in 2007 (Meyer-Arendt 2009). The boom in this economic activity has been accompanied locally by significant job creation depending on the cruiseship

industry. However, the current situation of Covid-19 revealed the extreme fragility of the tourism sector, where massive layoffs have been following one another[3]

Following a collective examination conducted by Takata Research Centre on a local land use planning document (PDU "Nuevo Mahahual"), it appears that the currently followed plan provides insufficient integration of coastal ecosystems in general and mangroves in particular for the urban development of Mahahual(Pereyras 2020). They are however a needed ecosystem for any sustainable development, as explicated in the next subsection.

2.2. Mangroves local benefits

Mangroves are a diverse group of halophytic plant species[4], which form highly productive forests providing various benefits to the biosphere[5]. They are located 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, mangroves have now been recognized globally as a highly productive and ecologically important ecosystem (Canty et al. 2018).

Mangroves are part of the coastal ecosystem, in parallel with the coral reef and seagrass meadows. They provide many and varied benefits to humans as healthy ecosystems, known as ecosystem services.

Mangroves serve as pivotal support to commercial fisheries acting as nursery, breeding, spawning and hatching habitats for offshore fisheries. They are also a needed ecosystem for local and migratory birds[6]. They also export organic matter to the marine environment, producing nutrients for fauna in both mangroves themselves and in adjacent marine ecosystems, and also sequester a large amount of carbon. While they make up less than 2 percent of marine environments, they account for 10 to 15 percent of carbon burial (Smithsonian Ocean 2020). Studies indicate that, pound for pound, mangroves can sequester four times more carbon than rainforests can (Alongi 2012). Mangroves also play a crucial role in shoreline protection, where they serve as natural barriers, dissipating the destructive energy of waves and reducing the impact of hurricanes, cyclones,

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[3]The social approach of the project was also to help the local economy by hiring people from the community, and also buying field material directly to local businesses.

[4]A halophyte is a salt-tolerant plant that grows in soil or waters of high salinity, coming into contact with saline water through its roots or by salt spray.

[5]The biosphere corresponds to all living organisms on the whole planet, including all its strata and layers.

[6]Examples of migratory birds are pink spatula, white stork, and ring-necked duck.

tsunamis and storm surges. Furthermore, they also are needed to preserve the coral reef since it heavily depends on the watercycle and filtration, the reef being the main local touristic attraction. Last, mangroves also are one of the main asset of Mahahual, village still benefitting from an important nature. Figure 2 illustrates the ecosystem services provided by mangroves. The figure was used in the survey to educate and raise awareness of the local community, in addition to images of biodiversity found in mangroves.
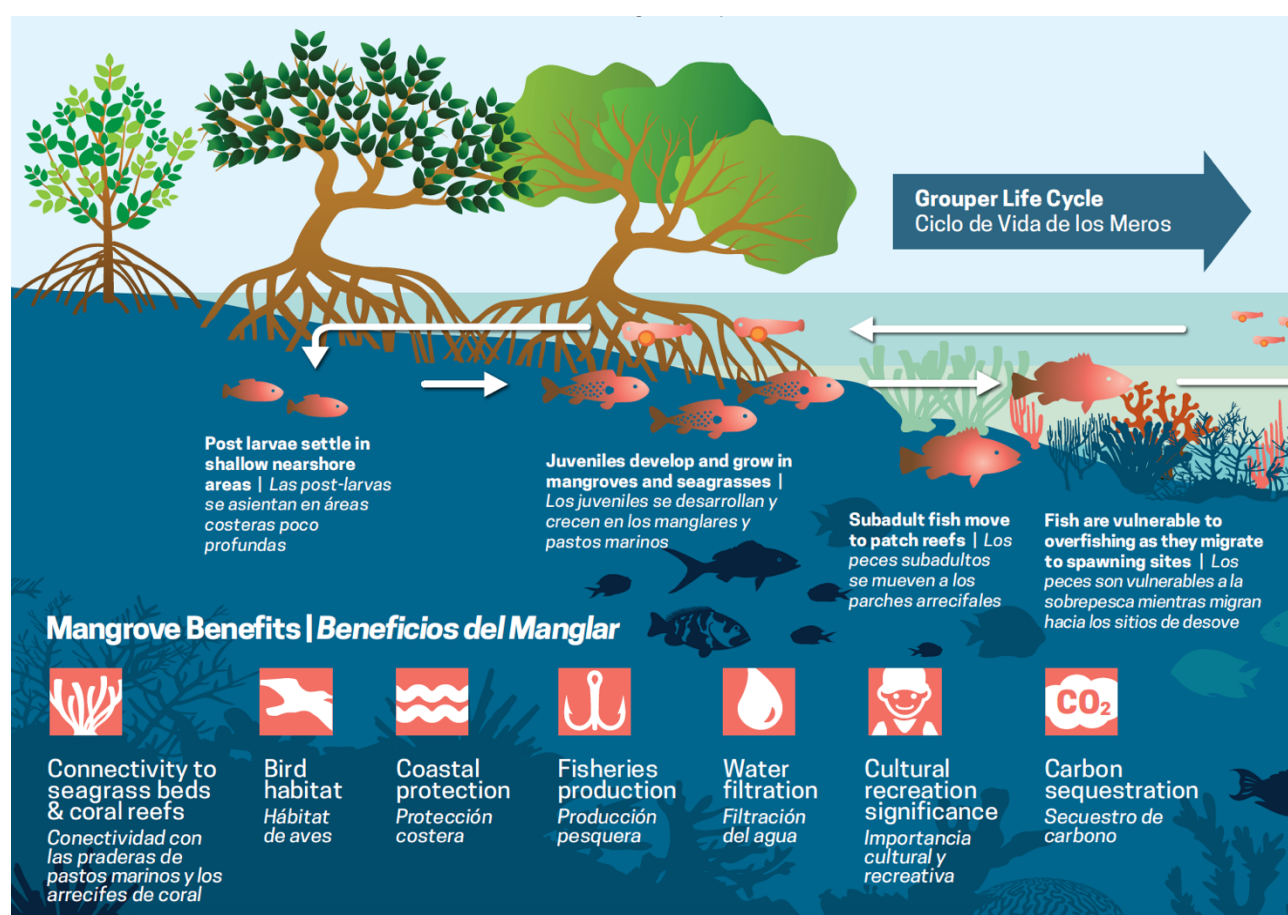

Figure 2: Ecosystem services of mangroves forest

The research led classified these ecosystem services in six groups, in order to be as clear as possible with respondents:

- Carbon sequestration

- Biodiversity: natural habitat for marine and terrestrial species

- Recreative and cultural activities

- Coastal protection (erosion prevention, natural disasters prevention, floodings and storms prevention)

- Sediments retention, nutrients absorption and regulation of water quality

- Support for the coral reef and the seagrass meadows

These six regroupements were used during fieldwork to measure the importance of the ecosystem services for each respondent. Next section presents previous demographic findings from other research led in order to introduce the community in the local context and justify the number of questionnaires planned in order to respect a statistical significance level allowing to make conclusions.

2.3. Previous demographics

Figure 3 illustrates demographics from 2015 during the last census of INEGI (Instituto nacional de estadística y geografía). It can be observed in column 3 that in 2015, 448 houses were censored as inhabited houses. As such, the initial objective was to interview 1 person from each household in order to have a general overwiew, depending on the expansion of the village between 2015 and the year of the research. Out of all the houses in Mahahual, 50% are located in Casitas, 34% in 'la 55' and 16% in 'El Pueblo'. Same proportions apply to inhabited houses. Among the 1251 residents, 44% live in Casitas, 40% in 'la 55' and 16% in 'el Pueblo'. Among these 1251 persons, 880 are older than 15 years old. 48% of them live in Casitas, 36% in 'la 55' and 16% in 'el Pueblo'.

Location	Houses in 2015	Inhabited houses in 2015	Inhabitant residents in 2015	Inhabitant older than 15 in 2015
Casitas	246	238	552	424
La 55	170	154	504	320
El Pueblo	77	53	195	136
Total	*493*	*445*	*1251*	*880*

Figure 3: Demographics for Mahahual in 2015
Source: Instituto nacional de estadística y geografía (INEGI) 2016

While the last census from INEGI goes back to 2015, el centro de Salud de Mahahual also did a survey in January 2020 and identified 1359 inhabitant residents, with 963 older than 15 years old. Comparing this census to the one of INEGI from 2015, it can be seen that there has been an increase of 8% of the population from 2015 to 2020. Findings from the present allow described in the next section will allow to precise local demographics.

Inhabitants residents in January 2020 (all ages)	Inhabitants residents older than 15 in January 2020
1359	963

Figure 4: Demographics for Mahahual in 2020
Source: Centro de Salud del Pueblo, Mahahual

Next section describes main trends of data collected during the two months fieldwork.

3. Trends of data collected

In order to determine perceptions of Mahahual population, a questionnaire design approach was launched so as to understand the awareness of the inhabitants concerning ecosystem services, as well as to collect demographic/social/economic information. The questionnaire is available in section 5, the appendix of the paper.

3.1. Data source

The research project is based on data collected on the field throughout the Months of July, August and September 2020. With an initial goal of 448 respondents, 542 questionnaires were conducted by the team of 6 investigators. In order for the design of the survey and the sample choice to be random, the method employed was to walk across all the streets of Mahahual and interview one person from each household. The small size of the village allowed to cover all the streets. As such, there is no bias of respondent choice, since it is considered as random due to the fact that each inhabited house was interviewed[7]. Considering the word-of-mouth saying there were more or less 2000 residents in the village before the COVID-19 crisis, a statistically viable sample

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[7]There were a minority of houses where no one answered the door, or an even smaller minority when the person did not want to take time to talk with the investigator.

size led to a minimum number of 333. In order to be cautious and knowing that the sample size needs to take into account the potentially high non-response rate so that the number of final useable questionnaires is sufficient for statistical purpose, a minimal sample size of 400 was chosen[8]. In the end, the 540 responses covered all of the houses of the village of 2015 and new others, according to demographics illustrated in figure 3. The initial objective of 400 residents interviewed was considered to be appropriate from a statistical point of view but also based on previous demographics by INEGI and 'El Centro de Salud'. The higher amount of responses strengthens the validity of findings.

3.2. Descriptive statistics of data collected

The subsection is divided into six subsections representing the six main sections of the questionnaire. It thus helps to find directly any relevant information[9]. For most of the questions, descriptives are undertaken at the zone level ('Casitas', 'El Pueblo', 'el Sur' and 'La 55'), representing the four main zones of Mahahual. During the whole study, a scale from 'one' to 'five 'was suggested to the respondents in order to measure the magnitude of their responses. 'One' is considered as 'not important' or 'not much', while 'five' is considered as 'very important' or 'a lot'.

3.2.1. Sensitivity to conservation problems

Figure 5 illustrates the magnitude of the personal belief that the respondent contributes to environmental conservation. Very few consider themselves as not really conservatives (when choosing the magnitude 1 or 2), while the majority in all zones consider themselves on a level 4 or 5. The main difference between zones is that respondents from 'El Sur' proportionally chose the highest level (5) more. However, differences between zones are not striking.

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[8]To also determine a statistically viable sample size (n) for the study, the following rule could be used: $n = \frac{2000}{(1+Ne^2)} = \frac{2000}{(1+2000.05^2)} = \frac{2000}{6} = 333.333$ (with a margin of error of 5%).

[9]Only relevant information is mentioned in the report. For any additional information not present but available in the questionnaire, please refer to the raw database.
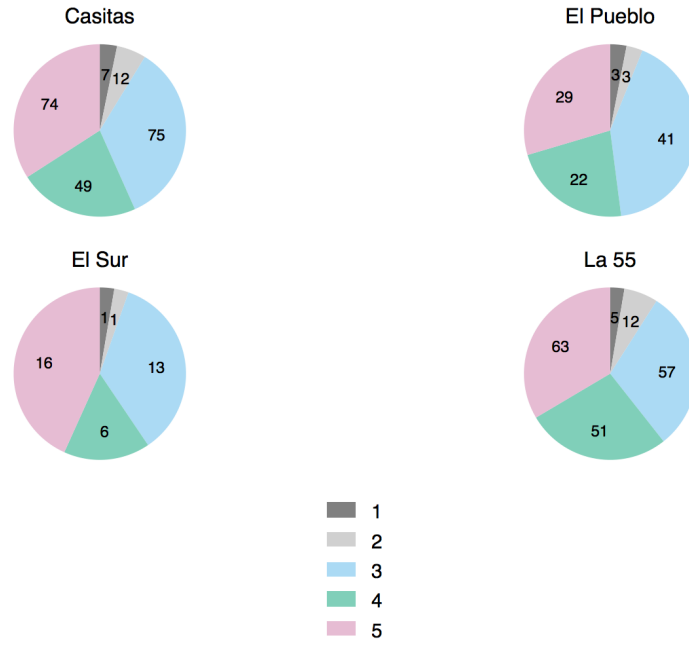
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Figure 5: Personal Beliefs of the respondents about conservation of the environment Figure 6, 7 and 8 illustrate the proportions of respondents who would define mangroves as a 'place important for the local community and the environment', as 'a place important for waste', or as 'a place where it is difficult to construct'. While the majority of the community considers mangrove as an important place for them and the environment, it can nonetheless be observed in figures 7 and 8 that there is a minority of respondents believing that mangroves could be used as a discharge or considered as a place to construct. Concerning differences of answers between zones, the main one can be observed in figure 7 where 'El Sur' also has a very small proportion of its respondents believing that mangroves are a place difficult to construct.
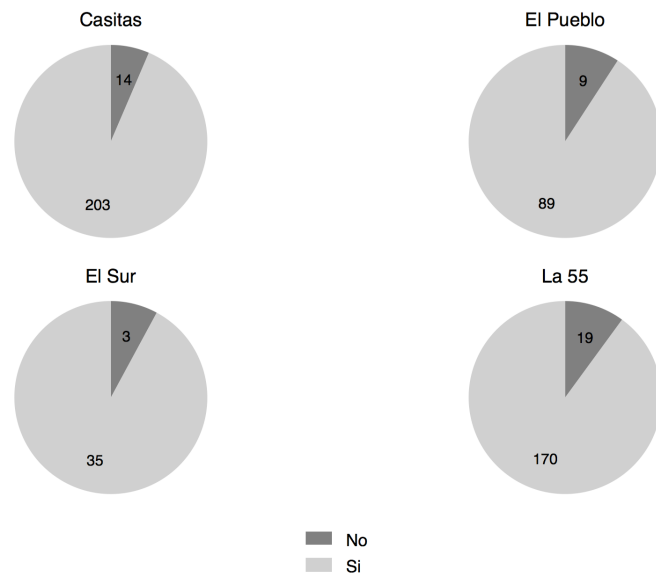
Figure 6: Perception of whether mangroves are an important place for the local community and the environment
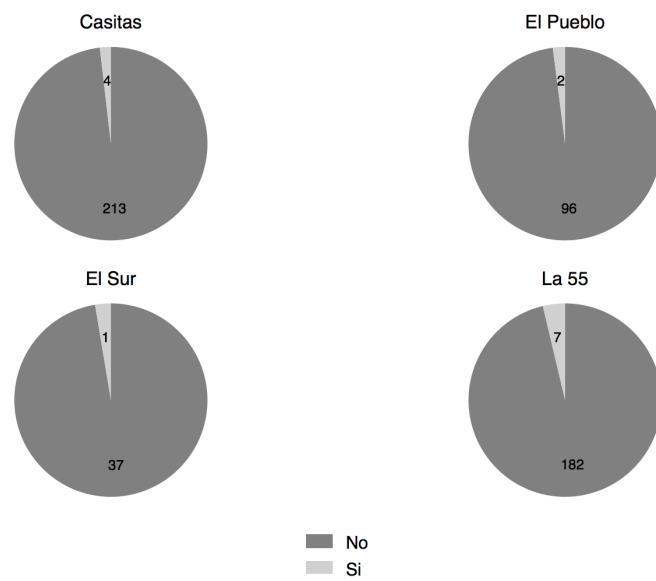

Figure 7: Perception of whether mangroves are an important place for waste
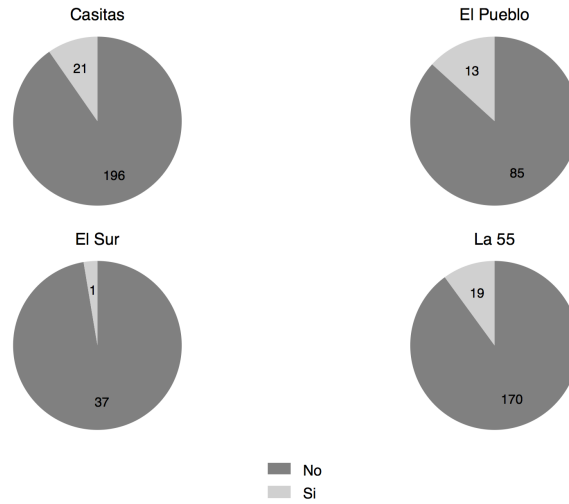
Figure 8: Perception of whether mangroves is a place difficult to construct

Figure 9 is a contingency table[10]. It shows in the first column perceptions of the current state of mangrove, while in the first row the perceptions of the state in the future, and as a whole the dependence between the two variables[11]. The majority of respondents (415) perceive the current state of mangroves as degraded, and also believe that in the future the state will deteriorate even more. There is also very few people believing that the state of mangroves has been currently improved (22), and it increases a bit more for the perception in the future (43).The majority of respondents chose a degraded state currently and also in the future.

Perception of the mangroves at the moment	Perception of the mangroves in the future				Total
	Not know	Degraded	Improved	Unchanged	
Not know	13	14	5	2	34
Degraded	20	415	18	10	463
Improved	3	4	13	2	22
Unchanged	0	13	7	3	23
Total	36	446	43	17	542

Figure 9: Perception of the evolution of the state of mangrove

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[10]A contingency table is a method of representing data resulting from a count that makes it possible to estimate the dependence between two characters. It consists in crossing two characters of a population (for example an age group and a score) by counting the number corresponding to the conjunction "character 1" and "character 2".

[11]Future was defined as in 5 years.
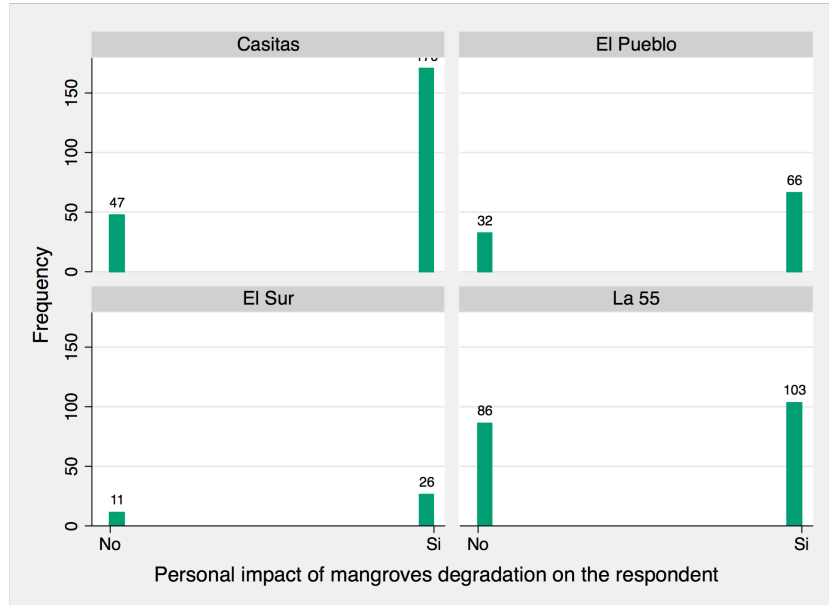
Figure 10: Perception of the effect of mangroves degradation on respondents

The impact of the degradation of mangroves seems to have a different effect on the community of Mahahual: as it can be observed in figure 10, inhabitants of 'la 55' are divided between whether the degradation of mangroves has an impact on them or not. For the three other zones, the majority of the respondents believe the degradation of mangroves affects them directly.
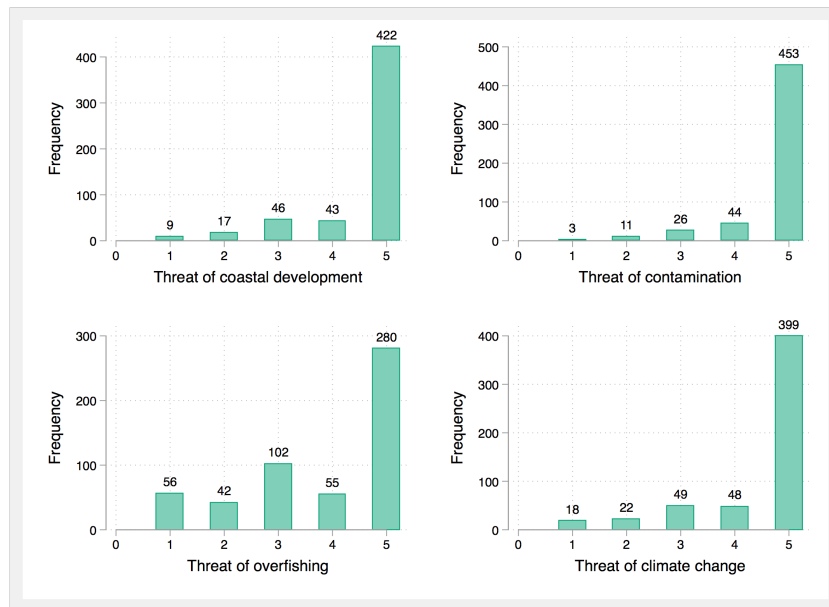
Figure 11: Importance of threats for mangroves

In figure 11, the importance of four suggested threats put by the community is illustrated, on a scale from 1 to 5. The threat with the most important magnitude for the local

community appears to be contamination of mangroves, with 453 respondents who valued its negative importance at the highest level. The second most important threat for mangroves valued by the local community is the coastal development of the village, for which 422 respondents evaluated this threat at the highest level. It is then followed by climate change and overfishing at a lower level.

Out of the 542 persons interviewed, only 3 responded mangroves should not be considered as a protected area. Respondents were located in the 55. Respondents from 'Casitas','El Sur y 'El Pueblo' all consider they should be protected, to the exception of Casitas with 4 unsure respondents. The will of the populations to benefit from a protected ecosystem is thus confirmed in the research.
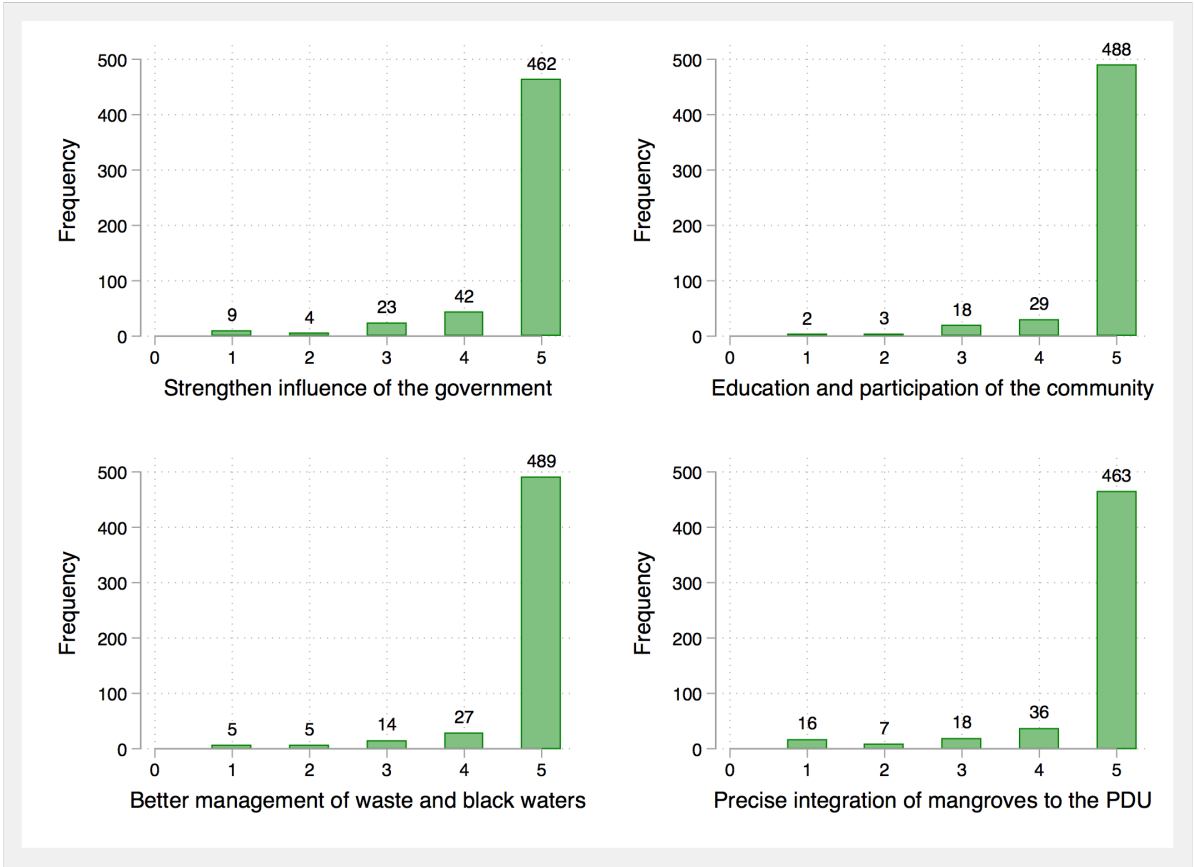
Figure 12: Importance of solutions suggested

Figure 12 highlights the community opinion concerning suggested solutions to better protect mangroves. While all of them were mostly approved, a better management of waste and sewage system water as well as the education and participation of the community concerning mangroves has more number of highest magnitudes. Strengthening the influence of the government and a precise integration of mangroves to the PDU ('plan

de desarollo urbano') are also considered to be important by the community, but to a lower extent than the two others. It is thus observed that local and direct solutions seem to be preferred at first glance.

3.2.2. Ecosystem services

One of the main objectives of the paper is to understand the relation between the community and mangroves ecosystem. Figure 13 is a contingent table illustrating the valuation respondent gave to the ecosystem on a scale from 1 to 5, depending on the zone in which they live [12]. While 78.8% of the respondents attributed the highest importance to mangroves, 89.19% of respondents living in 'El Sur' chose a 5, while only 75.26% and 74.07% from 'El Pueblo' y 'La 55' respectively. Casitas is between the two extremities, with 82.49% of its resident who chose a 5. None of the respondents from 'El Pueblo' and 'El Sur' considered mangroves as 'unimportant'(magnitude 1). The difference of responses between the four zones is statistically different, observing at the Pearson's chi-squared test[13].

Before introducing ecosystem services to the community, the survey has reported direct uses the respondents would benefit from mangroves. Direct uses suggested were the following: forestal products, nature contemplation, hunting, medicinal plants, disposal of household waste, and area of urban development. Geographical differences do not seem to be observable from a descriptive approach in figure 14, and with the exception of nature contemplation where the majority of respondents from all zones said they use mangroves for this purpose, the other uses were not considered by the majority of the community. Considering hunting, 17 respondents confirmed they were hunting in mangroves, with 7 from 'La 55' and 6 in 'Casitas'. Animals hunted and declared by the respondents are the following: crabs (3), crocodiles (2), fish (7), raccoons and armadillos (1), pigeons (1), pacas (1), deer (1), and ortalis (1). Other usages not initially in the questionnaire but presented by respondents are the following: grapes for consumption (2), paddle boards and kayaks (4), Search for orchids (1), growing some fruits and vegetables at the foot of mangroves (1).

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[12]The first numbers of each row are the frequency of respondents, and the second line represents the proportions.

[13]The the Pearson's chi-squared test is used to determine whether there is a statistically significant difference between the expected frequencies and the observed frequencies in one or more categories of a contingency table. The null hypothesis that there are no differences between the answers of the different zones is rejected, with a p-value of 0.061.

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Importance
    of the
 mangroves
   for the                           Zone
 respondent   Casitas  El Pueblo   El Sur    La 55       Total
──────────────────────────────────────────────────────────────
          1         2         0         0        3           5
               0.92      0.00      0.00     1.59        0.93

          2         0         0         1        2           3
               0.00      0.00      2.70     1.06        0.56

          3        12         3         1       15          31
               5.53      3.09      2.70     7.94        5.74

          4        24        21         2       29          76
              11.06     21.65      5.41    15.34       14.07

          5       179        73        33      140         425
              82.49     75.26     89.19    74.07       78.70
──────────────────────────────────────────────────────────────
      Total       217        97        37      189         540
             100.00    100.00    100.00   100.00      100.00

    Pearson chi2(12) =   20.3127    Pr = 0.061
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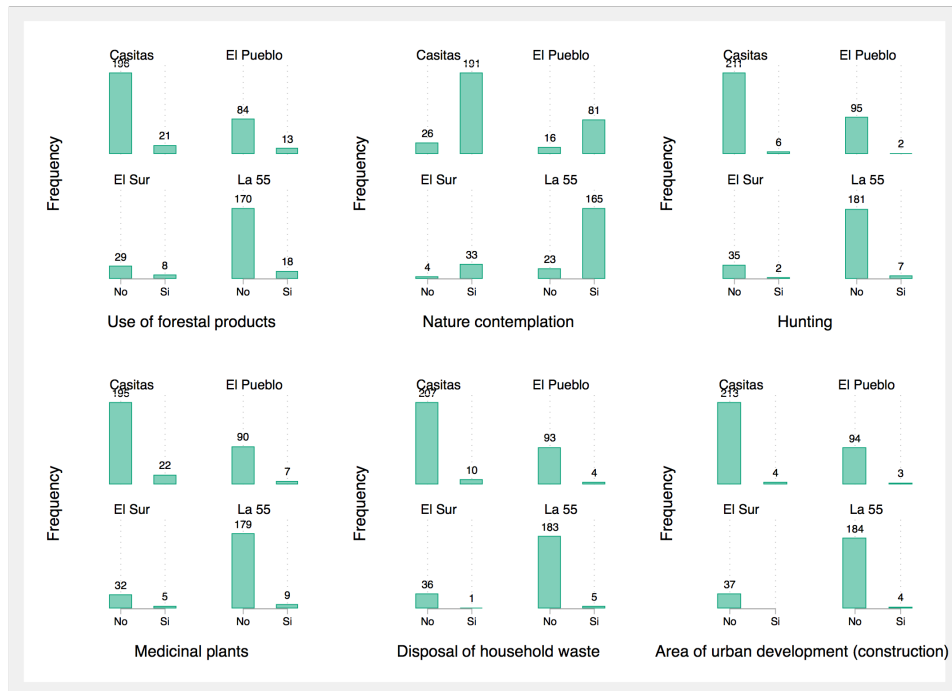**Figure 13:** Perception of the importance of mangroves

Figure 14: Direct uses of mangroves by the community

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Ecosystem services were then introduced to respondents. The way the questionnaire was designed aimed not to influence their answers by not giving too much explanation in the principle. Once first answers were stated, an educational part was presented by the investigators. The six ecosystem services described above were explained in details to the community, with the help of the diagram presented in figure 2.

First, it was asked to classify from 1 to 6 the ecosystem services (1 being the one considered as most major, 6 being the last) to benefit from relative preferences. Considering all respondents in figure 15, it is pictured that the ecosystem service counting the most responses by putting it in the first place of the order is biodiversity: 151 respondents considered it as the first one on the list of the services. It is followed by coastal prevention, carbon sequestration, support for coastal ecosystem, water quality, and last recreative opportunities.
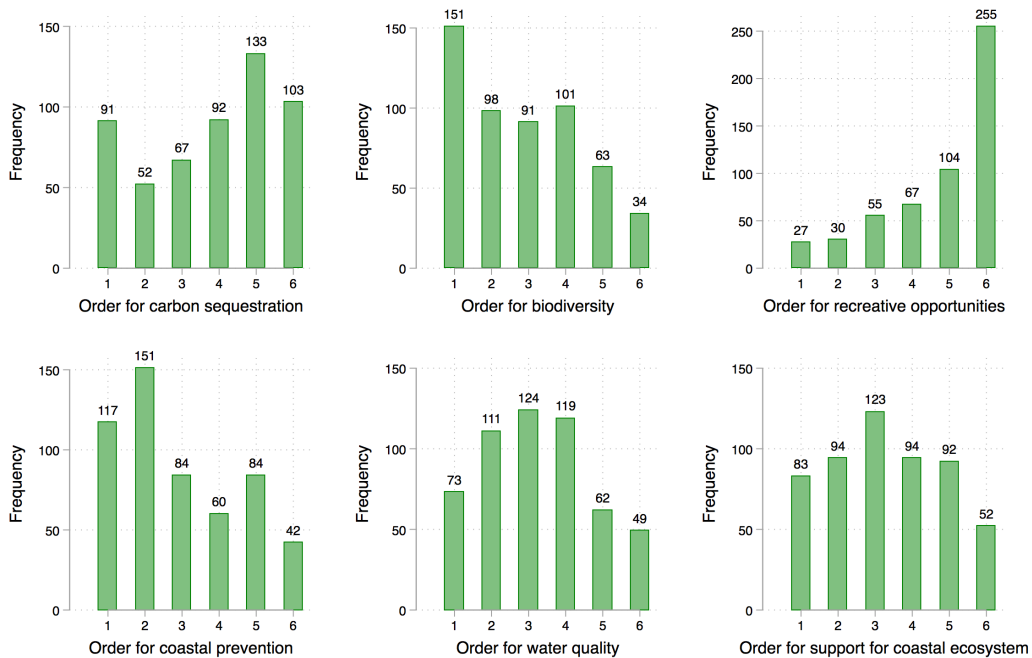
Figure 15: Order of ecosystem services for the whole community

The four figures below illustrate the same as figure 15, nonetheless differentiating the four zones. 'Casitas' in figure 16, 'El Pueblo' in figure 17 and 19 drive results from the whole community, since they follow the same order as when taking into account the village as a whole. Results are not the same when the South is considered.

Figure 16: Order of ecosystem services by 'Casitas'

Figure 17: Order of ecosystem services for 'El Pueblo'

The order for 'El Sur' is the following: the ecosystem service at rank number 1 is biodiversity, followed by coastal prevention, support for coastal ecosystem, water quality,
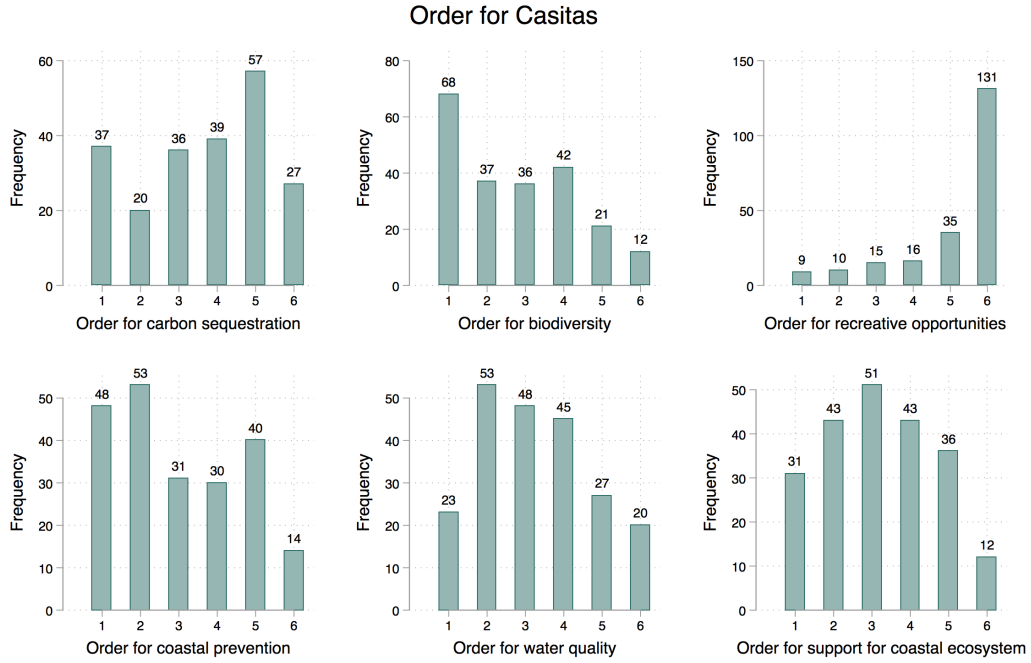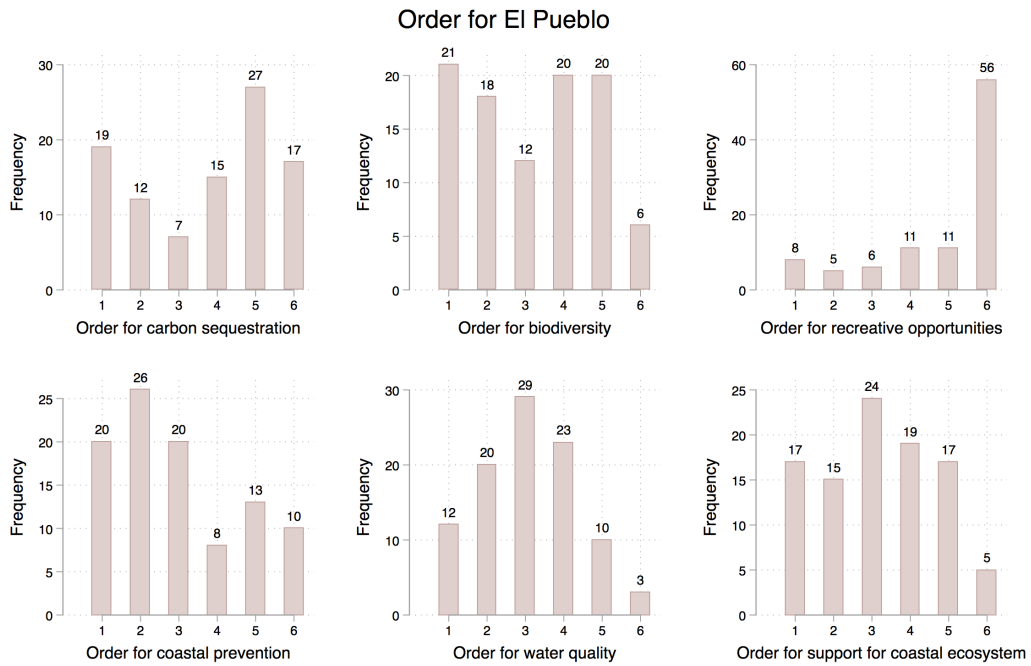
carbon sequestration and lastly recreative opportunities. The assumption for the difference of rankings compared to other zones may be due to the fact that inhabitants may be more affected by natural disasters than others because of their geographical location, therefore putting it at a higher rank. The geographical closeness to nature and to the reef may also drive the high ranking of support for coastal ecosystems[14].
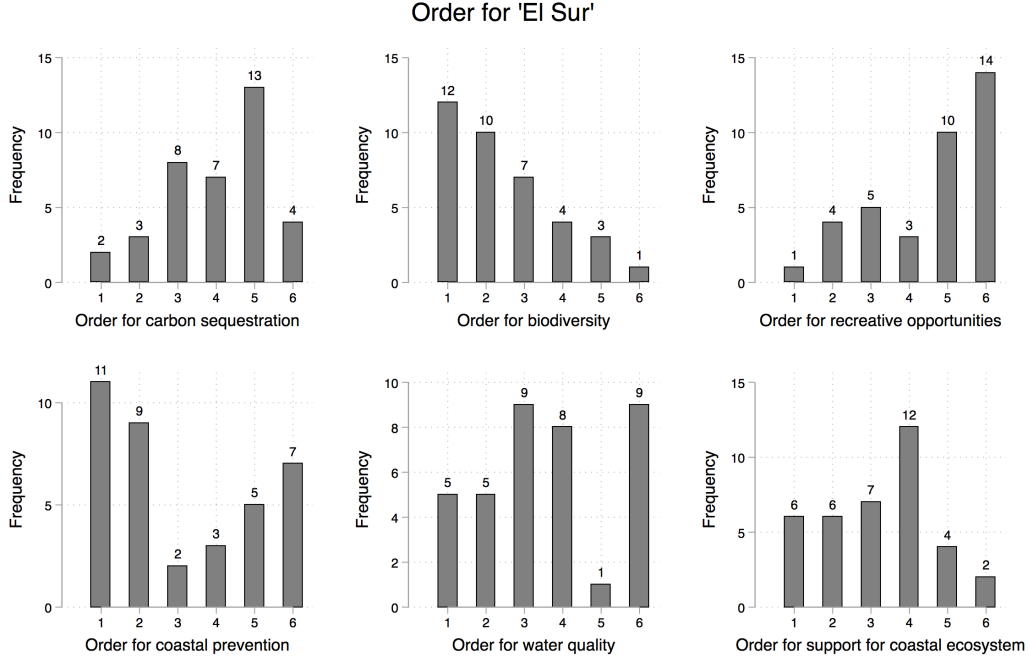
Figure 18: Order of ecosystem services for 'El Sur'

'La 55' also presents something different than the whole majority. Looking at figure 19, it is observed that the ecosystem service regrouping 'water quality' has the same number of respondents who consider it as the most important ecosystem service as carbon sequestration. This preference for water quality compared to other zones may be due to the lower amounts of houses and families with a connection to CAPA, as explained in subsection 3.2.6.

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[14]Channels and assumptions explaining the difference in results are hypothetical and based on the author's knowledge and understanding of Mahahual and its community.
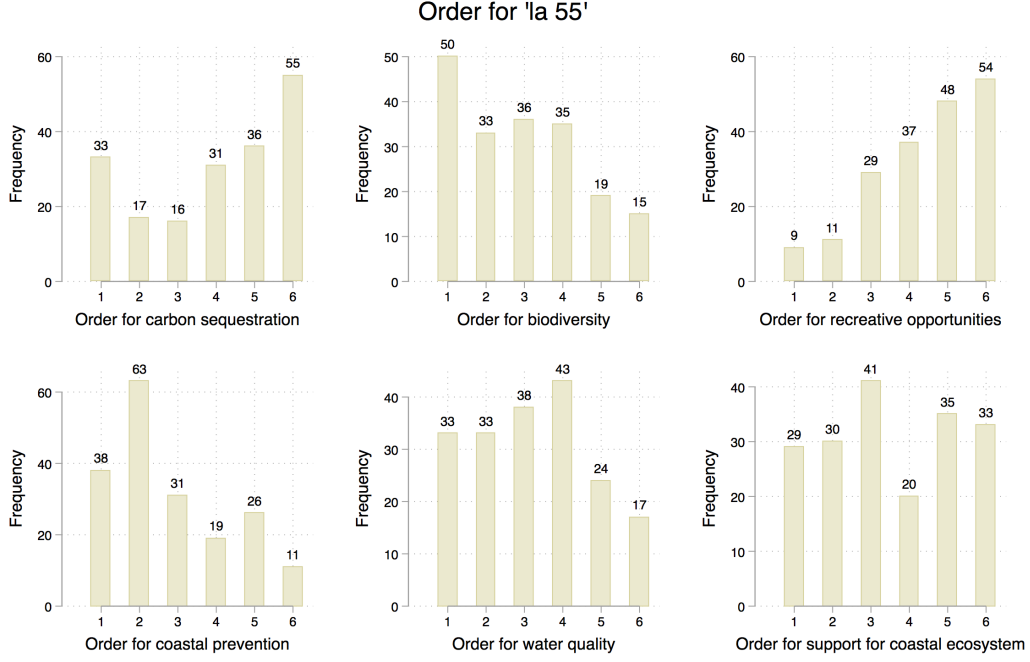
Figure 19: Order of ecosystem services for 'La 55'

After presenting results for preferences of ecosystem services relative one to the other, the magnitude of their importance is also summarised[15], before and after the educational part presented during every questionnaire. Next figures in purple illustrate answers before the educational part while figures in brown represent the ones after it.

For the whole community in figure 20 and 21, while biodiversity initially was the service with the utmost importance, it is replaced by water quality after the educational part given by investigators. It is also observed that the importance of all ecosystem services increases after the educational part, which illustrates the impact of the awareness campaign. While the ecosystem service with the lowest importance remains recreative opportunities, it nonetheless is the one with the biggest change of importance before and after the information given. It is followed by carbon sequestration and water quality. This change of opinion of respondents concerning the importance of ecosystem services may illustrate the importance of previous lack of information of the community. It also is supported by the fact that highest changes of magnitude of the importance of services are the ones of the most complex services, most likely unknown before.

Raising awareness of the community regarding benefits from mangroves thus increases local knowledge concerning the coastal ecosystem and most likely its protection.

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[15]For the importance, the same scale from 1 to 5 is used (1 being not important, 5 being very important).

Figure 20: Importance of ecosystem services for the whole community before educational part
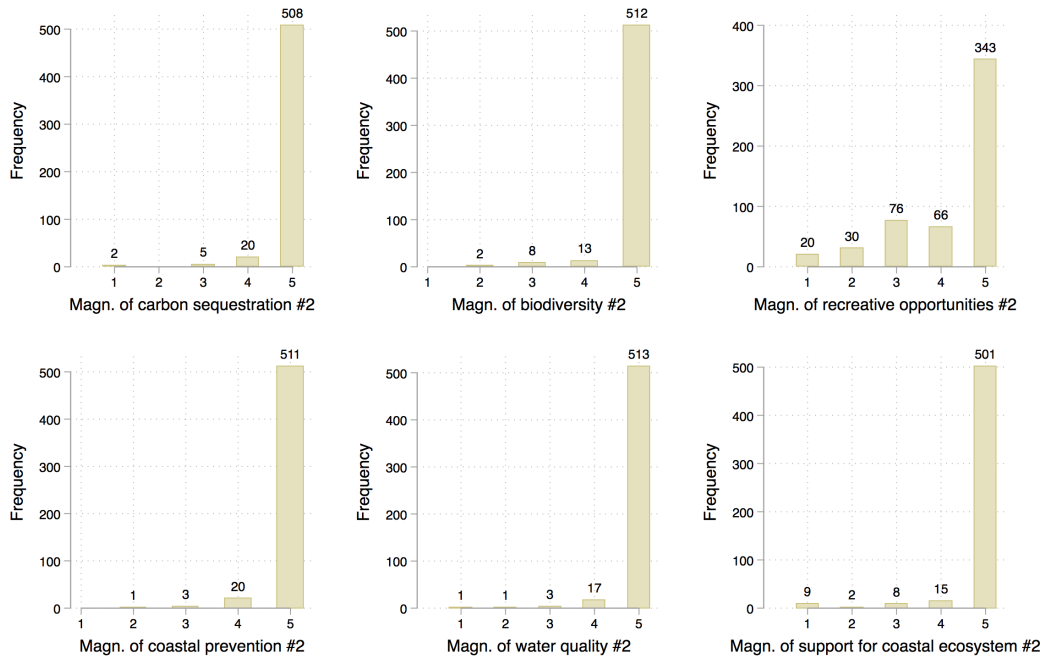
Figure 21: Importance of ecosystem services for the whole community after educational part

The following figures differentiate the analysis by zones. For Casitas in figures 22 and 23, the service considered as the most important post-education is quality of the water, while it was biodiversity before the educational part. The highest change remains for recreative opportunities.

Focusing on 'El Pueblo' in figures 24 and 25, the striking difference with Casitas is that most of the respondents post-educational part changed their valuation of services since almost all importances below level 3 switched to a higher level, with the exception of recreative opportunities.

Moving on to 'El Sur' in figures 26 and 27, the change of valuation of services is also more notable than for Casitas, with the totality of respondents evaluating support for coastal ecosystem as very important.

Concerning 'La 55' in figures 28 and 29, the most important change of valuation is attributed to carbon sequestration, where the majority of respondents switched to a higher level of importance after education.

All the figures above demonstrated that the educational part presented during fieldwork at the individual level has had a detectable effect on the responses and thus knowledge of the community[16].

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[16]While the order of ecosystem services as well as the magnitude of the importance were asked to respondents, it can allow to construct a variable encompassing the two, by multitplying them. As such, it would take into account the relative as well as the absolute importance.
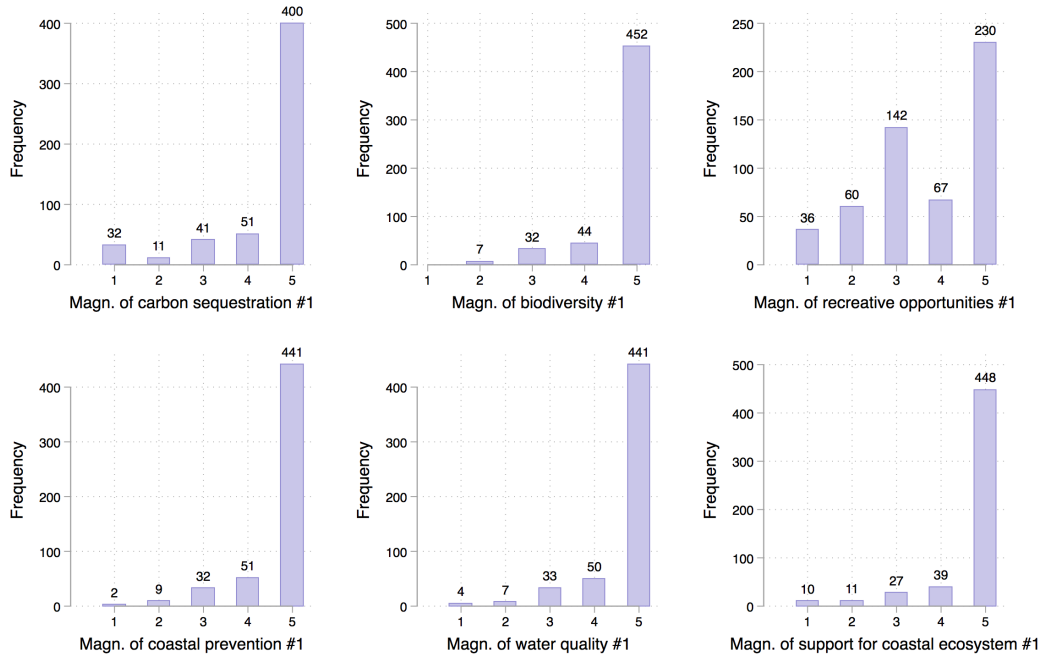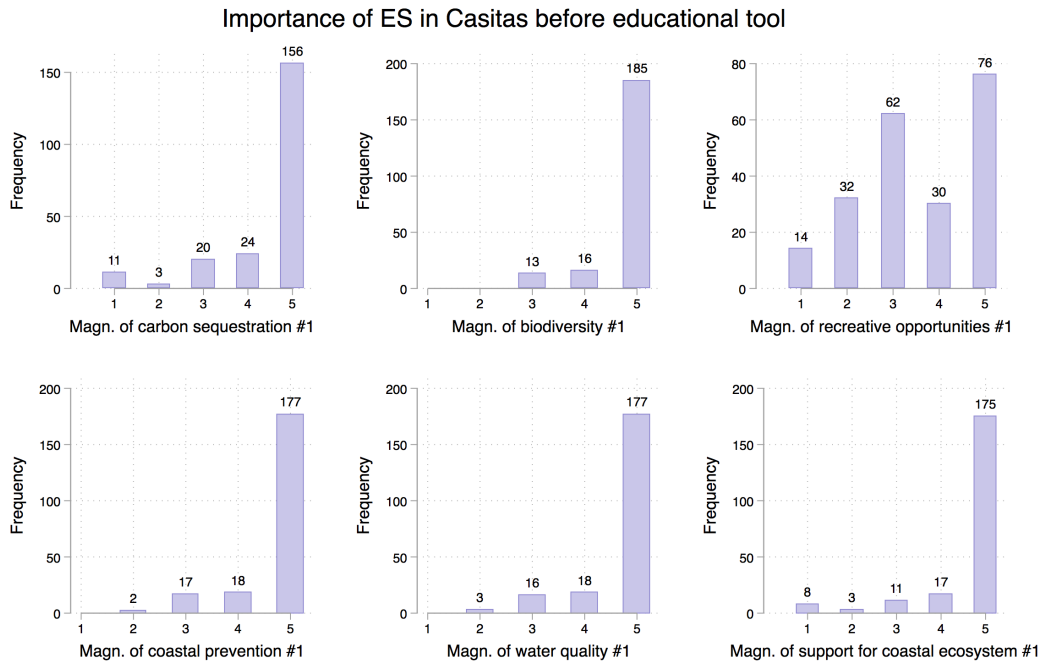
Figure 22: Importance of ecosystem services for 'Casitas' before educational part
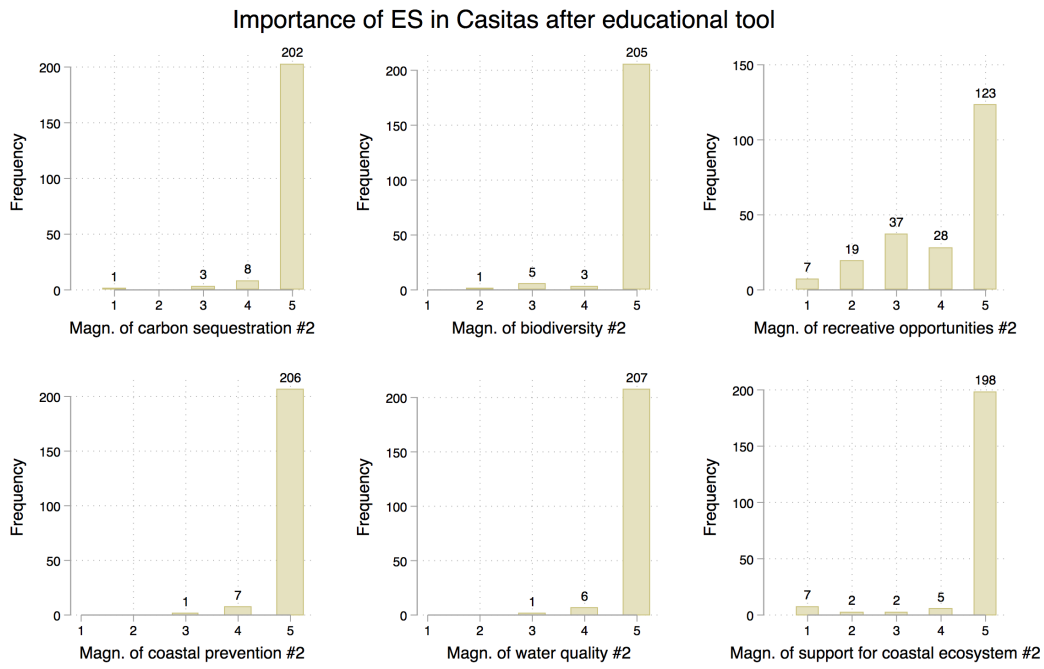
Figure 23: Importance of ecosystem services for 'Casitas' after educational part

Importance of ES in ' El Pueblo ' before educational tool
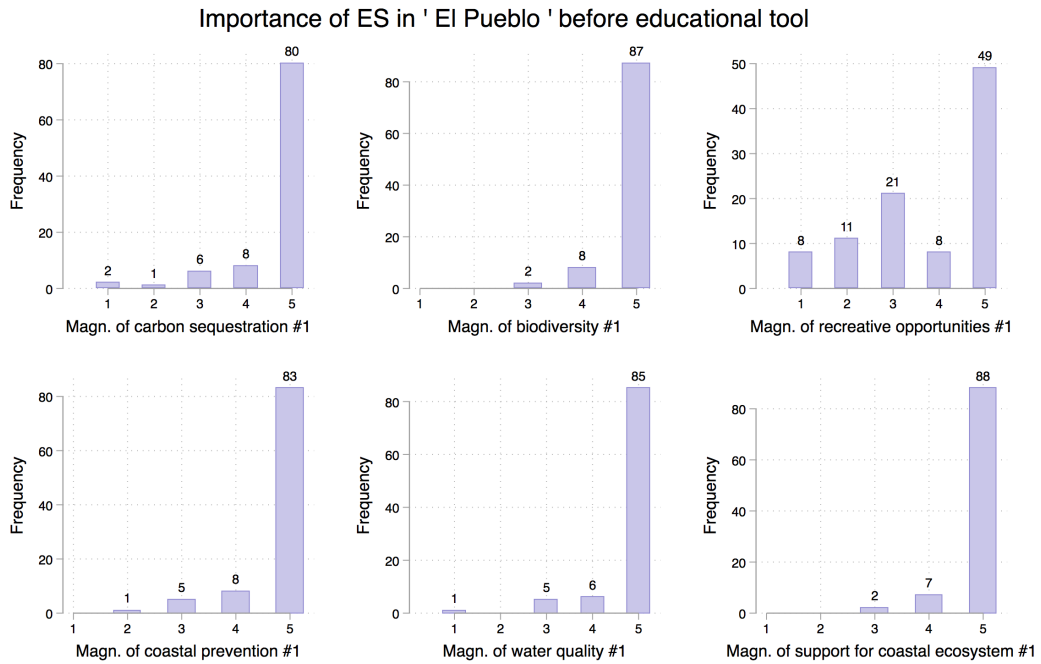
Figure 24: Importance of ecosystem services for 'El Pueblo'

Importance of ES in 'El Pueblo' after educational tool
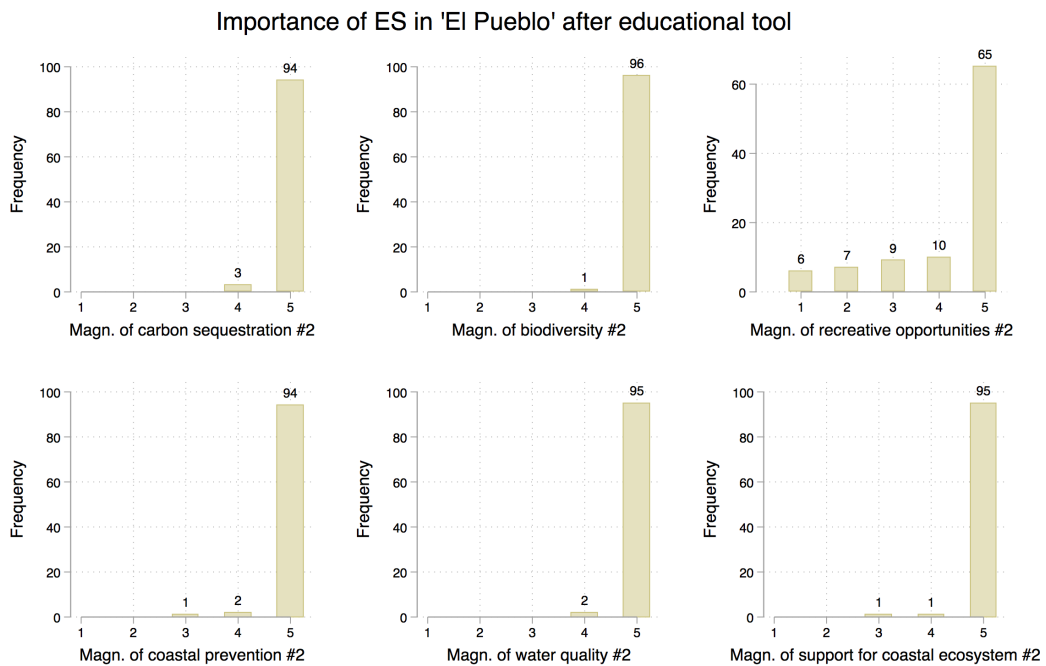
Figure 25: Importance of ecosystem services for 'El Pueblo'

Importance of ES in ' El Sur ' before educational tool
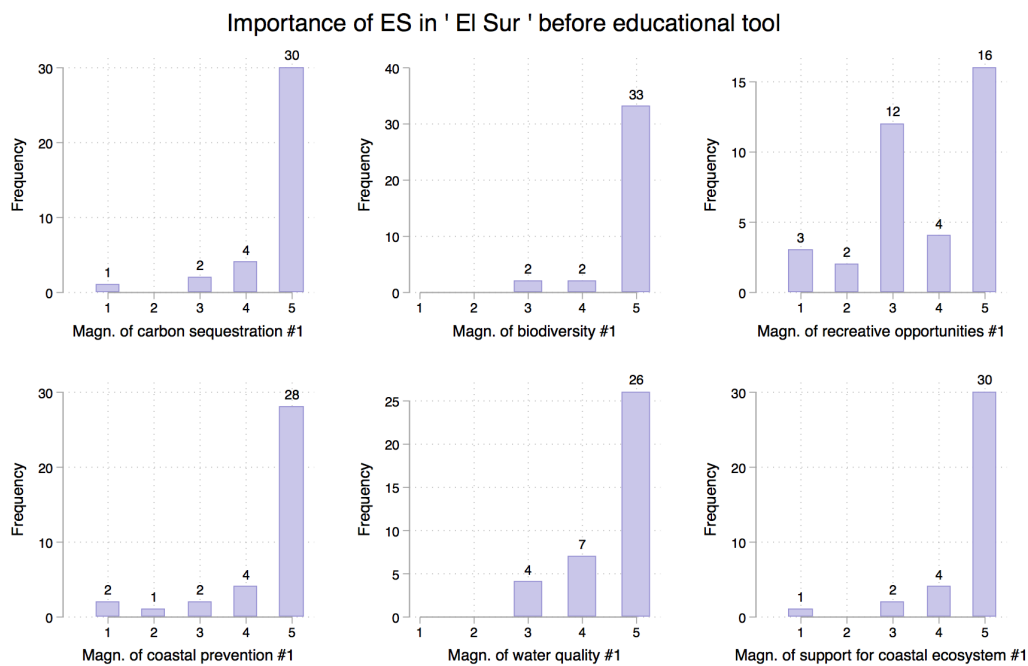
Figure 26: Importance of ecosystem services for 'El Sur'

Importance of ES in 'El Sur' after educational tool
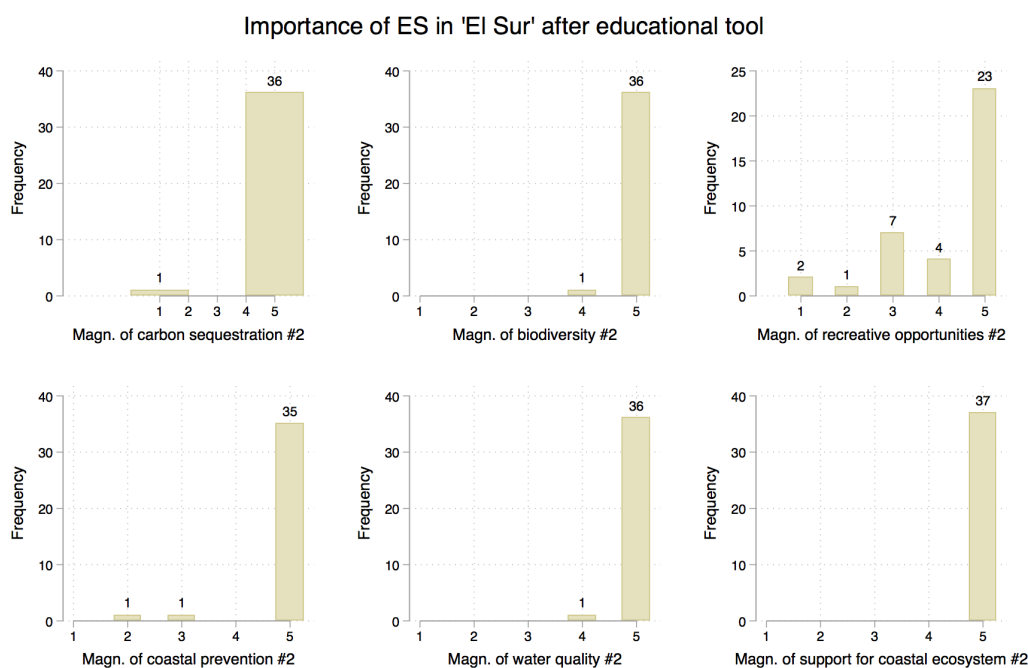
Figure 27: Importance of ecosystem services for 'El Sur'
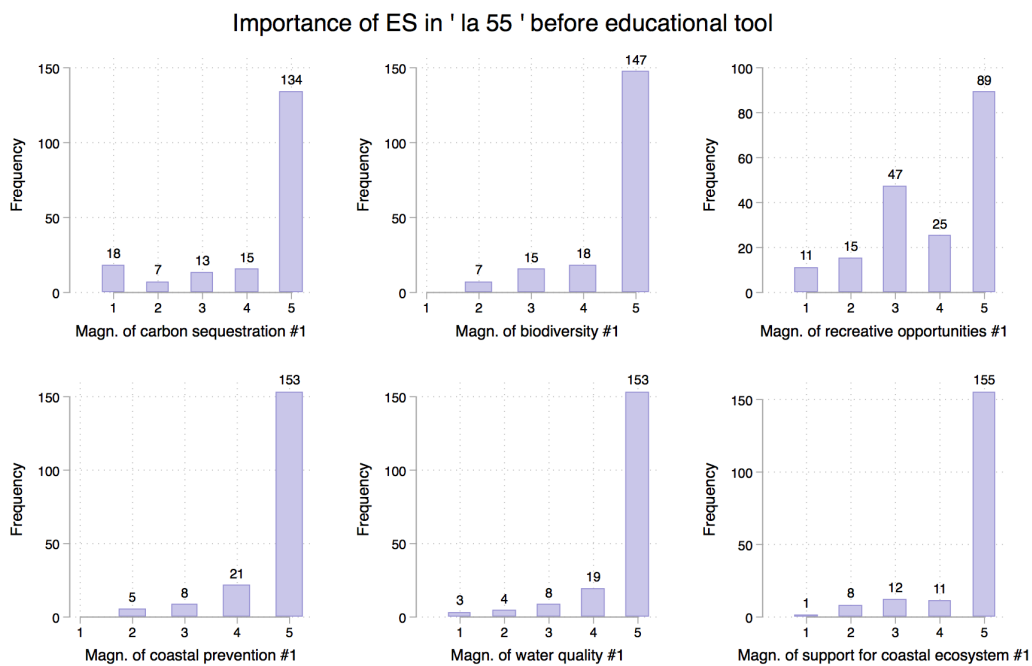
Figure 28: Importance of ecosystem services for 'La 55'
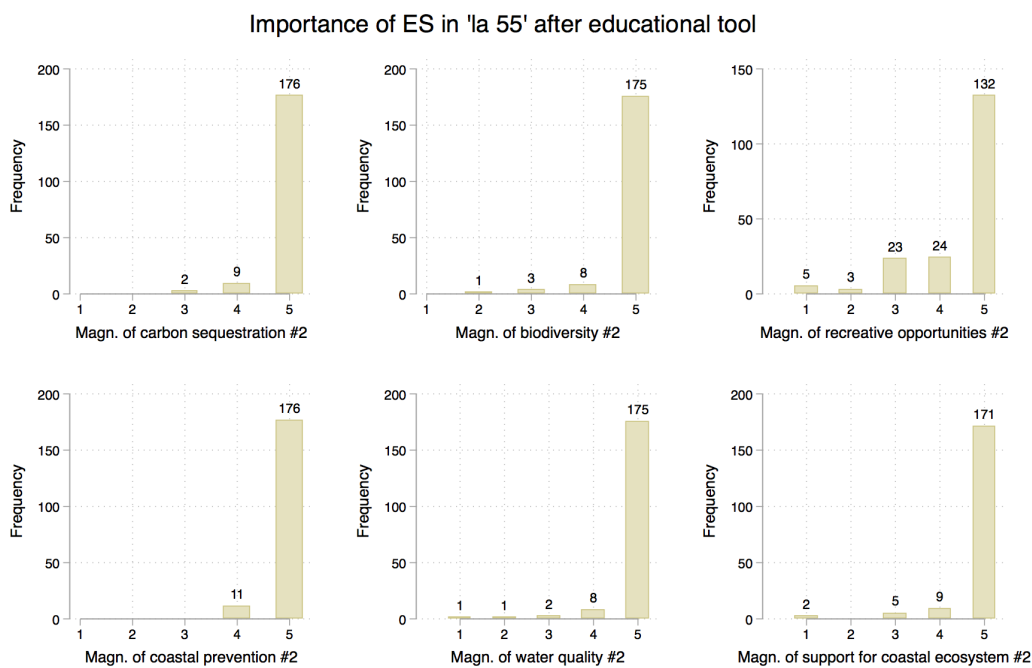
Figure 29: Importance of ecosystem services for 'La 55'

3.2.3. Local Economic valuation of ecosystem services

In the questionnaire, a part involving economic values was presented to respondents. The answers the survey benefitted from are valuable for a future research project aiming at computing the economic value of ecosystem services. While it is not the first objective of this report, main results are nonetheless presented below to understand the willingness to pay and contribute of the residents.

Concerning the ecosystem service classified in the project as coastal prevention (erosion, natural disasters, floodings and storm prevention), it was first asked to the respondents if they knew by how much their house or business had been affected by the Dean hurricane. In figure 30, the meaningful observation is that all respondents from 'El Sur' were victims of important destructions, while respondents residents of 'Casitas' were the least affected. 'El Pueblo' and 'La 55' are more nuanced. The hypothesis behind the heavy difference between on one side 'Casitas' and on the other side 'El Sur' and 'El Pueblo' is that houses from 'El Sur' and to a lesser extent 'El Pueblo' are directly in front of the ocean, while 'Casitas' and 'La 55' are protected by a natural mangroves barrier. Results from 'La 55' nonetheless tend to a higher level of destruction. This may be due to the greater fragility of houses in the area.
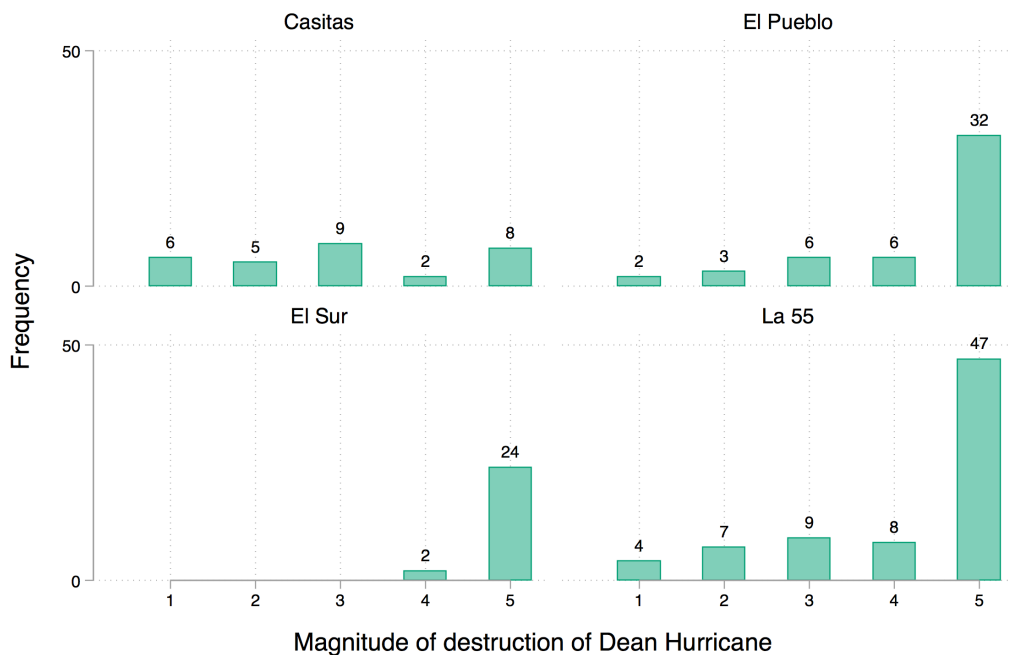
Figure 30: Magnitude of the effect of hurricane Dean on the local community

Figure 31 summarises descriptive statistics for the willingness to pay of the community as whole regarding various concepts. While standard errors are big, the median is also taken into account.

Looking at home protections, inhabitants are on average willing to pay an amount close to 600MXN pesos per month to protect their house or business from natural disaster or flooding. The willingness to pay for erosion is lower, close to 262. As erosion is a natural disaster having impact in the longer run, it illustrates the fact that the community projects itself less easily into the long term, and perceives the imminent damage greater.

Concerning the willingness to pay for mangroves conservation, reef conservation and ecotourism development, the average per inhabitant is equal to more or less 230MXN pesos, 307MXN pesos and 214MXN pesos respectively[17].

It can be observed that the number of people not willing to contribute financially to the three environmental causes is important[18]. In order to nonetheless collect data allowing to measure the willingness to contribute to conservation thematics, the same question was asked in terms of hours of work. It seemed to be a relevant way to measure the willingness of the community to participate to coastal ecosystem conservation, as an important part of the community lives below the minimum wage[19]. It can be observed that the amount of respondents willing to contribute in terms of time is higher than when paying with money. On average, respondents are willing to dedicate 8 hours per month to mangroves conservation and reef conservation, and close to 7 hours per month for the development of ecotourism[20].

The table also illustrates in the last column the addition of contribution of all respondents. In terms of money contribution, reef conservation is the highest (70765MXN pesos), followed by mangroves conservation (52693.7). However in terms of hours, mangroves conservation gathered more than reef conservation (4201 and 3851 respectively).

These data collected not only will be useful for any future research project based on the economic valuation of coastal ecosystems, but also support favorably a potential future

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[17]The value for ecotourism development does not take into account one respondent who would have been willing to contribute with a million MXN pesos, since it inflates all results. It is nonetheless kept in the database and is part of the analysis.

[18]407 respondents did not want to contribute financially to mangroves conservation, 403 to reef conservation and 421 to ecotourism development.

[19]The minimum wage in Mexico is equal to 123.22MXN pesos per day.

[20]Thanks to the willingness to contribute in time and the wage of the respondents, it will be able to proxy a variable illustrating the amount of 'money' the respondents would be able to contribute, even though he did not want to contribute directly with money.

conservation project of the coastal ecosystem since it seems that the community would support it.

Willingness to pay for (in MXN pesos/months)	Mean	Standard Deviation	Median	Min	Max	25th percentile	75th percentile	90th percentile	95th percentile	99th percentile	Number of people not willing to pay/contribute	Sum of WTP
Protect home / business from potential natural disasters	633.622	2206.238	200	0	30000	0	500	1000	2000	10000	190	343450
Protect home / business from erosion	262.156	1192.189	0	0	16666.7	0	100	500	1000	5000	372	142089
Protect home / business from flooding	623.066	3064.663	0	0	50000	0	300	1000	2000	12000	280	337702
Mangroves conservation	230.103	570.691	41	0	5000	0	200	500	1000	3333.33	407	52693.7
Reef conservation	307.673	1143.491	66.3	0	4000	0	200	500	1390	4000	403	70765
Ecotourism development	214.9721	626.0695	33	0	3333.33	0	166.67	500	1000	3333.333	421	1048799
Willingness to contribute to (in hours/month)												
Mangroves conservation	8.735	12.713	4	0	80	2	10	24	30	75	126	4201.98
Reef conservation	8.156	11.43	4	0	80	2	10	20	30	60	140	3851.32
Ecotourism development	7.232	12.363	3	0	100	1	8	20	30	75	189	3422.15

Figure 31: Descriptive statistics of the willingness to pay and contribute of the respondents

If the respondent was not willing to contribute to mangroves conservation, reef conservation or ecotourism development with any of the two suggestions (either with money or with time) the research aimed to understand the reason. Figure 32 illustrates the main reasons.
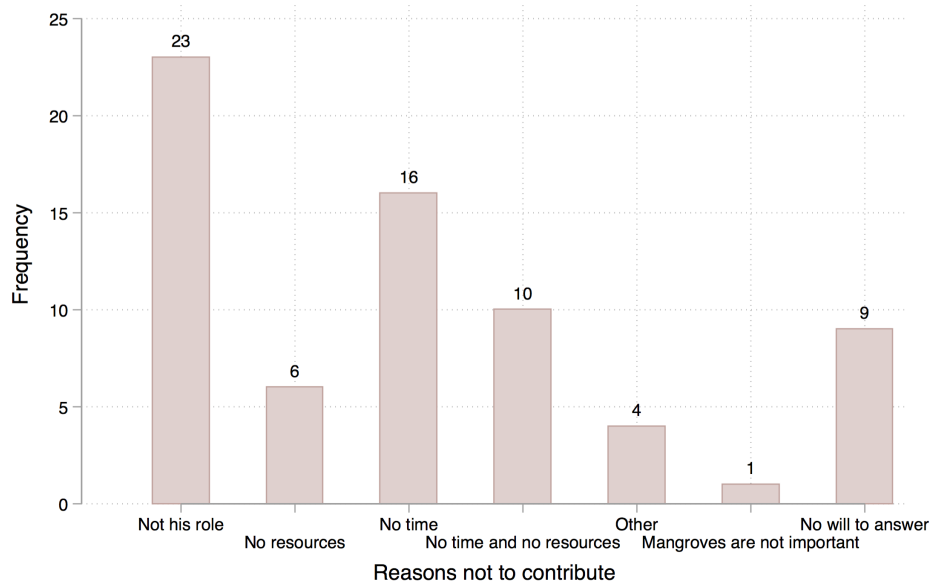

Figure 32: Main reasons to not contribute to conservation or ecotourism

The main one is because respondents believe that it is not their role to contribute to conservation, supposing it should come from the government. It is then followed by respondents explaining they had no time, and then others neither having time nor resources. Further than that, others justified by explaining that they had not the sufficient economic resources to contribute to it. While overall there only are 69 respondents who were unwilling to contribute one of two ways, the majority highlights as a reason the delegation of a task which should come from a governmental level rather than an individual level.

While table 31 summarised economic contributions from the perspective of the village as a whole, table 3.2.3 summarizes means and standard deviations at the zones level, in order to detect any difference of contribution between the four zones[21]. Concerning the willingness to pay to protect its house from potential natural disasters and erosion, residents from 'El Sur' are the ones most willing to invest to protect their house or business, followed by 'El Pueblo', 'Casitas' and last la '55'. This order illustrates the geographical closeness to the ocean and the risk to be affected. For 'La 55', it also may illustrate the lower income of residents living in the zone, as it is illustrated is subsection 3.2.6.

Concerning financial contribution to conservations, 'El Sur' also is the one with the highest hypothetical values of contribution for mangroves conservation, followed by 'El Pueblo', 'Casitas' and finally 'la 55'. For reef conservation and ecotourism, 'El Pueblo' surpasses 'El Sur'. This may be due to the higher economic dependence of 'El Pueblo' to the reef, with the majority of dive centers and touristic businesses being located in the latter.

Looking at time contribution for mangroves conservation, once again 'El Sur' is the zone with the residents who would be the most willing to dedicate time, followed by 'la 55', 'El Pueblo' and last 'Casitas'. Reef conservation follows the same path, with the exception that after 'El Sur', inhabitants from 'El Pueblo' were the ones most willing to dedicate time.

The differentiation of financial and time contribution illustrates from a descriptive approach different behavioural dynamics in Mahahual: overall, people from 'El Sur' are the ones with the highest willingness to pay or to contribute to conservation of mangroves, which may be due to their geographical proximity to the ecosystem. For reef conservation and development of ecotourism, the financial contribution of inhabitants from 'El

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[21]Drivers of willingness to pay are analysed more specifically in section 4.

Pueblo' is the highest[22]. It may be due to the importance of the reef for the economy of businesses in 'El Pueblo', as well as the important number of touristic businesses in the zone. In terms of time, inhabitants from 'Casitas' where the least willing to contribute, even though in terms of financial contribution residents from 'La 55' remain last. Dynamics in 'La 55' illustrate inhabitants not willing to contribute financially as much as other inhabitants to conservation programs, but willing to dedicate hours of work to it.

Table 1: Mean and standard deviation of willingness to pay of respondents per zone

	Casitas Mean (SD)	El Pueblo Mean (SD)	El Sur Mean (SD)	La 55 Mean (SD)
Amount to pay to protect from potential natural disasters	675.56	702.97	967.62	545.57
	(1998.50)	(2219.09)	(2239.81)	(2534.28)
Amount to pay to protect from potential erosion	269.13	534.26	565.72	73.41
	(1204.93)	(2007.26)	(1171.07)	(175.98)
Amount to pay to protect from potential flooding	764.92	617.60	913.34	472.23
	(3916.71)	(2233.18)	(2250.45)	(2555.60)
Money contribution for mangroves conservation	248.19	253.17	521.11	78.89
	(605.02)	(586.17)	(945.42)	(141.21)
Money contribution for reef conservation	264.71	578.63	504.44	104.80
	(658.54)	(2250.96)	(932.83)	(211.10)
Money contribution for development of ecotourism	234.49	21972.11	451.11	74.39
	(702.16)	(147408.01)	(944.42)	(145.21)
Time contribution for mangroves conservation	7.81	9.40	17.32	9.91
	(9.24)	(12.01)	(29.55)	(16.75)
Time contribution for reef conservation	8.28	8.74	12.69	8.57
	(9.36)	(12.26)	(15.41)	(14.95)
Time contribution for development of ecotourism	7.12	7.23	11.90	8.13
	(11.32)	(9.32)	(17.93)	(15.75)
Observations	216	97	37	187

Means of variables. Standard deviations in parenthesis

After the section on willingness to pay or participate to conservation thematics, next section presents descriptives concerning the vision of the residents on the development of the village.

3.2.4. Sustainable development of Mahahual

The aim of this section is to understand the vision of the local community concerning the development of the village. Figure 33 illustrates the importance[23] of preferences of the local community as a whole concerning different actions for Mahahual. The most favoured action (with the majority of respondents who chose the highest value of importance) is to develop conservation and restoration programs of coastal ecosystems, and the least favoured action is to maintain the current mass tourism activities or in other

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[22]In terms of time dedicated to reef conservation, El Sur remains the same.
[23]Once again, the importance is on a scale from 1 to 5.

words, the cruiseship industry[24]. This result is comforting for any future sustainable development for Mahahual with an economic model depending more on local ecotourism rather than on the cruiseship industry.

After the development of conservation and restoration programs, the most favoured action is to improve urban infrastructure. As described above, there are various urban necessities lacking or failing in the village. The most important one collected during interviews are sewage system and access to freshwater. It is then followed by the implementation of new economic activities such as art and culture, community gardens, and scientific research. Conserve artisanal fishing follows with 406 respondents giving it the highest importance. The penultimate is the attraction of different tourists than the cruiseships. It can nonetheless be observed that the gap between the latter and the maintenance of current mass tourism activity is the biggest. As such, it confirms the fact that mass tourism is the least preferred development for the current residents of Mahahual.
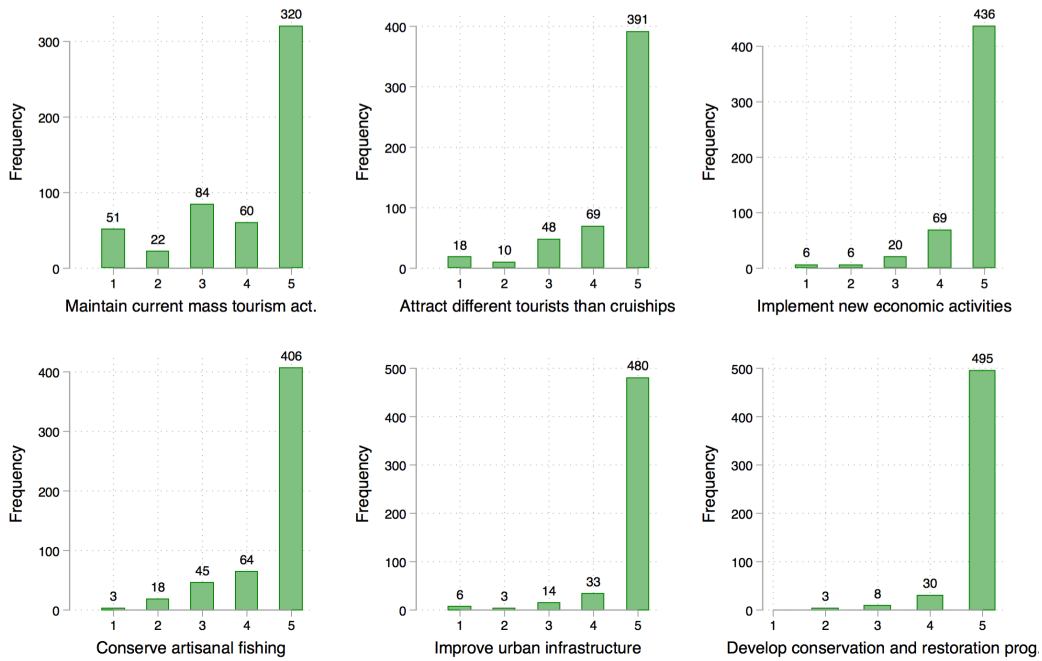
Figure 33: Main actions wanted for the development of Mahahual

Next figures present results for each zones. For Casitas in figure 34, responses follow the same direction as the global responses. For 'El Pueblo' in figure 35, the order is slightly

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[24]It remains important to highlight that as the port closed, many workers financially depending on it left the village. As such, the will of local development depending on the cruiseship industry may be underestimated in the paper.

different: the moss important activity is to improve the urban infrastructure, closely followed by the development of conservation and restoration programs. The third place is attributed to attracting different tourists than cruiseships. It is a surprising result, knowing that 'El Pueblo' is the zone with constant and direct contact with tourists from the cruiseships. On the fourth place is found the implementation of new economic activities, followed by conserve artisanal fishing and last the maintenance of mass tourism activities. Artisanal fishing as it used to be in Mahahual 20 years ago is not seen as very important for the community, and not either for people living in 'El Pueblo' where many fishermen are located.

Concerning 'El Sur', the first place is attributed to conservation and restoration programs, then followed equally by urban infrastructure, artisanal fishing, new economic activities, attract different tourists than those from the cruiseship industry, and then the maintenance of mass tourism.

For 'La 55' in figure 37, the main caracteristic to highlight is that the gap between the importances of each action is smaller than for other zones, which highlights less straight preferences. Second of all, the maintenance of mass tourism activities is not at the last position, but at the before last. 'La 55' is thus the zone in Mahahual which is the most attached to the cruiseship industry. It is justified by the fact that the majority of residents in 'La 55' previously worked fort the port. The favoured action nonetheless remains the development of conservation and restoration programs.

As a whole, questions about the future development of Mahahual highlight two facts: the cruiseship industry is not the less important activity the community would like to see developing more in the future, since a sustainable development is preferred. It is a comforting results for futures conservation projects which could involve the local community and diversify the local economy.

Another question concerning specific types of activities was also asked to the community. Figure 38 illustrates favoured activities: the most favoured one for 'Casitas' and 'El Sur' is scientific and environmental research. For 'El Pueblo', it is the development of ecotourism, while for 'La 55', it is the development of medicinal research. Details of all preferences can be observed in the figure.
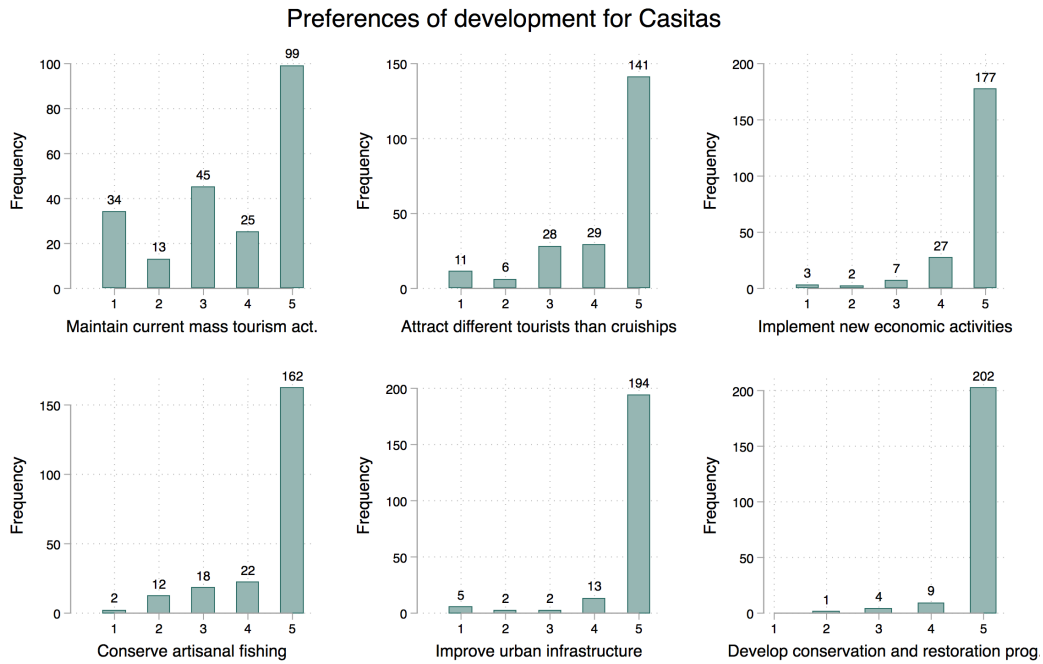
Figure 34: Main actions wanted for the development of Mahahual, by Casitas
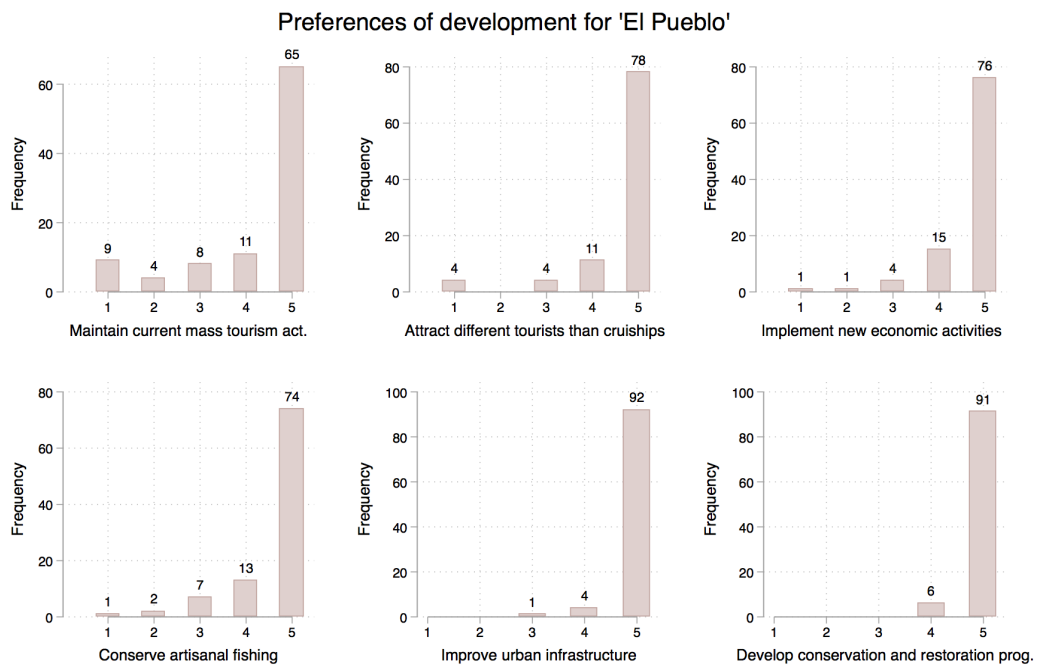
Figure 35: Main actions wanted for the development of Mahahual, by El Pueblo

Preferences of development for 'El Sur'
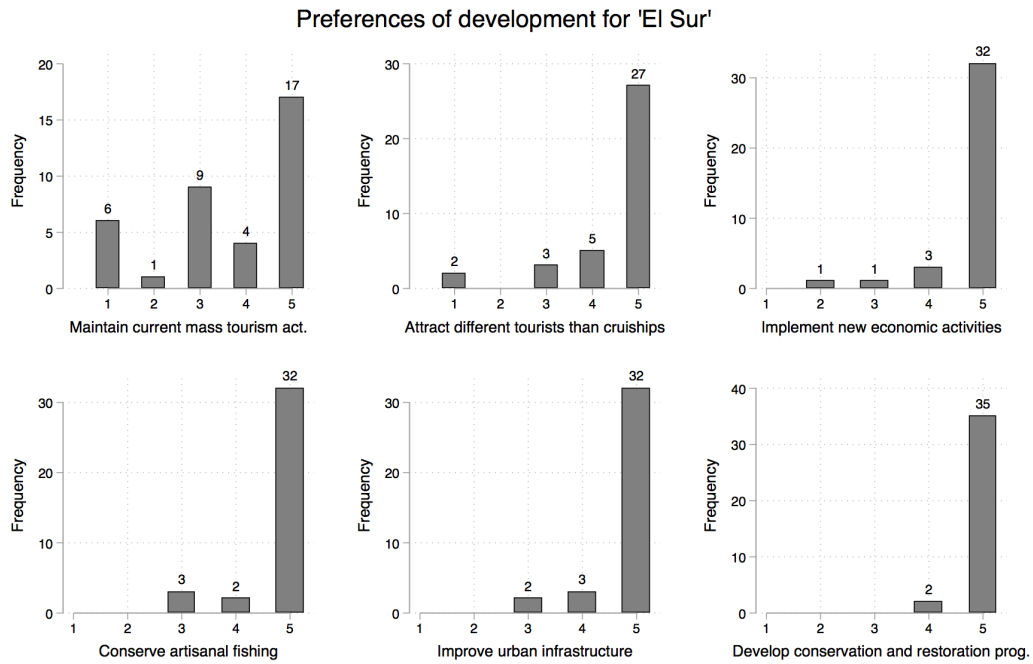
Figure 36: Main actions wanted for the development of Mahahual, by El Sur

Preferences of development for 'La 55'
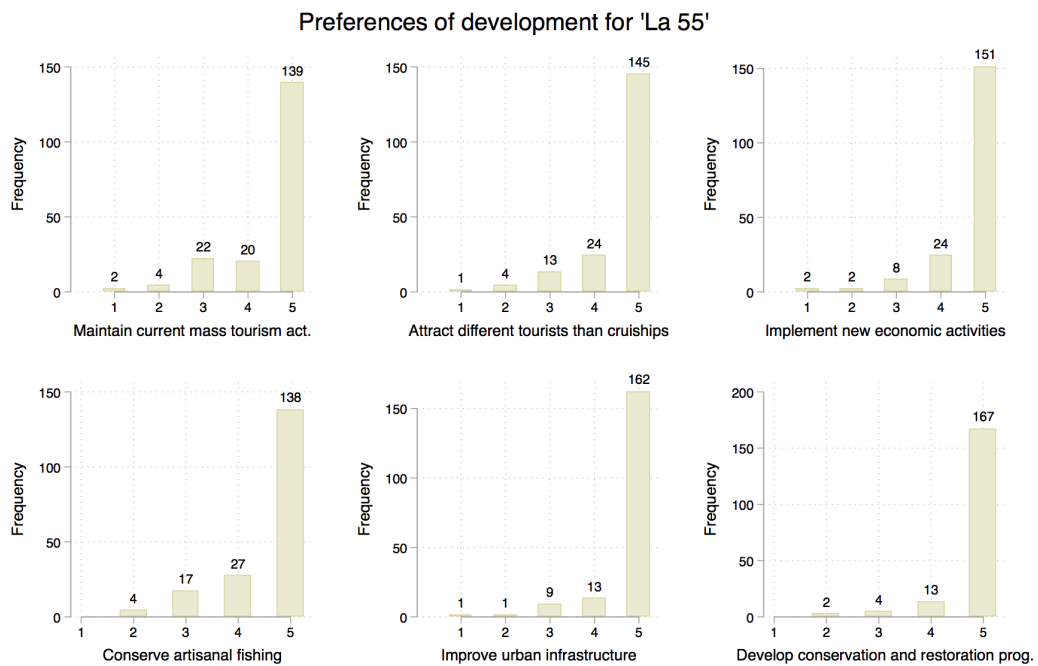
Figure 37: Main actions wanted for the development of Mahahual, by La 55

Preferences of future activities for 'the four Zones'
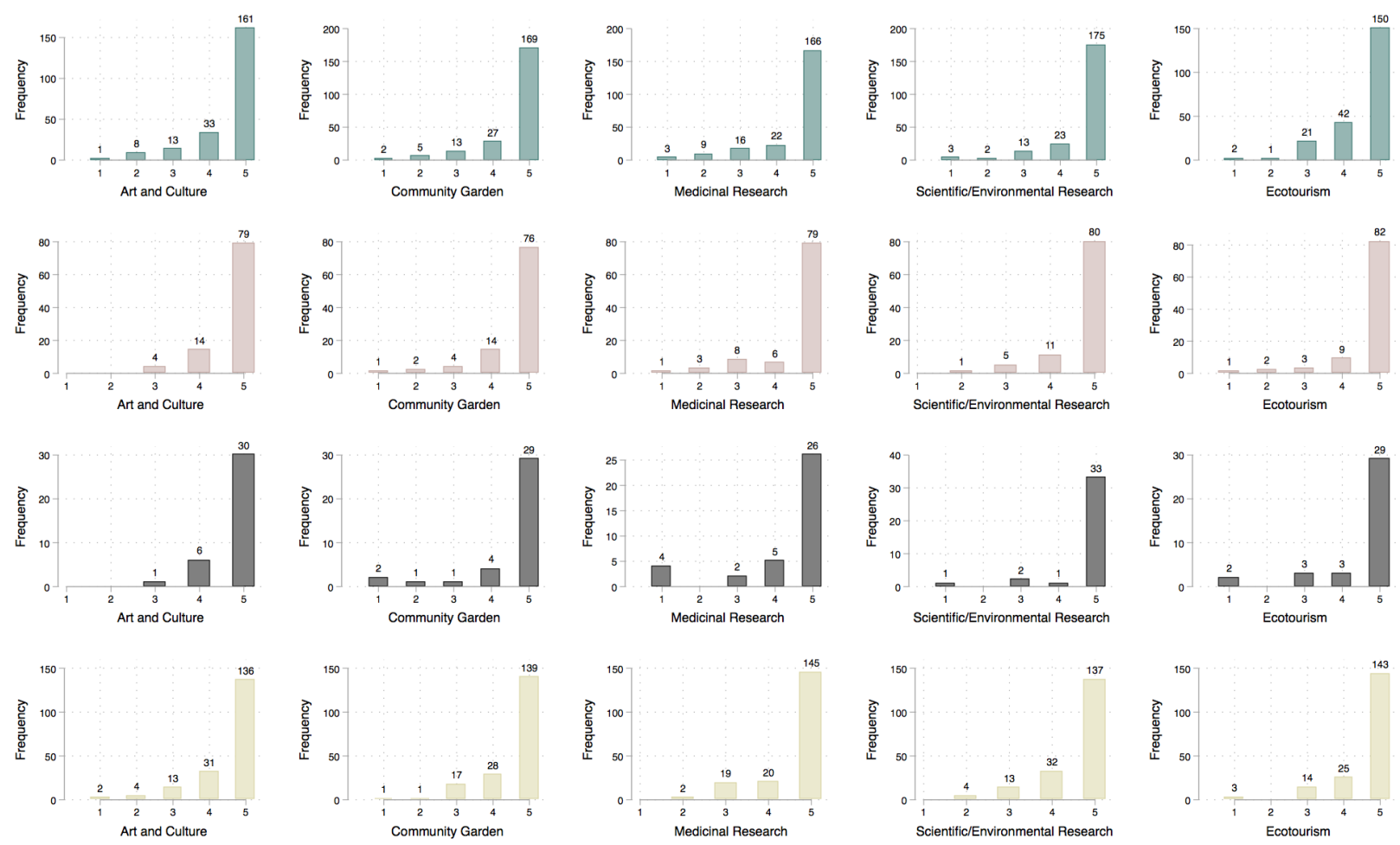
from the top to the bottom: Casitas, El Pueblo, El Sur, La 55

Figure 38: Main activities wanted for the development of Mahahual, by zones

In the sustainable development part of the questionnaire, a question was turned to residents living or owning a business directly on the beachfront to know their potential interest to replant mangroves in front of their property. Out of the 126 respondents considered, 91 identified themselves to be interested to replant mangroves plantules if there would be any replanting project in the future. This proportion of 72% of people concerned in favor of seeing mangroves in front of their establishment is a comforting result from a sustainable development approach. For any future conservation project which would need the exact businesses and owners interested, please contact the research centre Takata[25] to have access to the database.

While the questionnaire is mostly quantitative, a few questions remained open. As such, it gave the possibility to respondents to suggest activities they would like to see more in the development of Mahahual. The following ideas are the ones which were evoked directly by the community, classified in six families: sustainable tourism, conservation of the environment, education, art and culture, infrastructure, and cleanliness of the village. All ideas are illustrated in page 38 of the report.

Another open question directly asked respondents if they had any suggestion for a mangroves conservation project involving the community. Stated proposals are observed in page 39, and also classified in four subgroups: ecotourism, education, direct impact in the mangroves, and potential entities to be created.

Ideas put forward by the community demonstrate the will of residents to diversify the economic model of the village, and while it is hypothetical, it shows diversity of responses from the current development.

As a whole, the sustainable section of the questionnaire highlights the fact that while Mahahual is a village still depending majoritaly on the cruiseship industry, other types of development could be considered, since the local community seems interested and eager to benefit from other types of development.

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[25]research@takataexperience.com

IDEAS OF ACTIVITIES

Sustainable tourism

- Mangroves Museum

- Photographic exhibitions and competitions

- Recreational bike routes

- Etnotourism

- Natural reserve

- Stable for horses in order to implement horse trips

Conservation of the environment

- Organize days to plant trees

- Spirituality classes to get closer to nature

- Nature surveillance by volunteers

- Campaigns for conservation and cleaning of coastal ecosystems

- Rainwater collection

- Laboratory of water samples and microbiology

Education

- Ecology classes at school

- Information and education on waste separation

- Ecotourism workshops

- More environmental education for all ages

- Language center (ex: Mayan)

Art and Culture

- Muralism and carnivals

- Open air concerts

- Teaching of crafts

- Crafts with plastic, reusable material

- Theatre

Infrastructure

- Improve health infrastructure

- Mall

- Local market

- Second hand clothing store

- Playroom for kids

- Animal refuge

- Cinema

- Reactivate the Heliport

- Bank

- Urban hydraulic engineering facilities

- Public hospital

Cleanliness of the village

- More recycling programs

- Separate garbage cleaning competition for recycling

- Recovery of domestic residues such as oil

40

SUGGESTIONS FOR A MANGROVES CONSERVATION PROJECT

Ecotourism

- Ecological beach[26] for ecotourism
- Make an ecotourism park with mangroves as in Florida, managed by the community
- Recreational activities for mangrove care

Walks with tourists in mangroves to generate an economic activity

Organize a festival during Mangrove day (26th of July)

Education

- School excursions with workshops
- Group in social networks for the development of community education
- Training camps to know and take care of mangroves
- Mangrove conservation programs that are paid for in exchange for mangroves conservation work
- Print out mangrove conservation/ecosystem services posters
- Awareness of the community: outings to mangroves in small groups for education

Direct impact in mangroves

- Reforestation programs with the community (volunteering)
- Community cleaning
- Create a mangrove farm and nursery

Entities created

- Creation of a protection committee
- Weekly cleaning brigades with the community with economic payment (temporary employment)
- Protection campaigns

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[26]An ecological beach would be a beach where the harmony of coastal ecosystems would be observed and where tourists have the opportunity to learn about their importance.

Last, and idea in terms of a way to finance sustainable projects was to charge a percentage as a lodging tax[27] as in hotels and tourism businesses to finance any mangroves conservation program[28]. There is however no current testimony that this funding idea was used in other conservation programs.

Next section presents economic results occurring from the fishing industry, which was also one of the objectives of the research.

3.2.5. The fishing industry

In order to put a future economic value on mangroves ecosystem, this research project also collected information about the fishing industry. While computing the economic value of mangroves is part of a future research paper, descriptive statistics remain valuable to present: out of the 542 persons interviewed, 201 are fishermen. Among these 201, only 24 have an income depending on fishing. When summing income from fishing, the result is 99.500MXN pesos/month generated by the fishing industry from the side of fishermen.

The other perspective to take into account are fish buyers. 342 respondents indicated they are buying fish every month, with an average of 815 pesos/month[29]. The total amount spent on fishing from the 542 interviews is equal to 319.645MXN pesos/month. The fishing industry is thus a consequent sector for the local economy, and the fact that mangroves are needed to preserve a healthy reef and to benefit from a sustainable stock of fish allow to use these data in order to measure part of the economic value of the biodiversity ecosystem services of the mangroves [30].

The last part of the questionnaire consisted of demographics collection, in order to understand precisely residents interviewed and their characteristics.

3.2.6. Demographics

Number of residents

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[27]A lodging tax is when property owners and managers are required to pay lodging tax for renting out a room or property.

[28]In general, most of lodging taxes are collected for local tourism promotion, school support and infrastructure.

[29]This high value is due to the few responses of hotels and restaurants buying a consequent amount of fish.

[30]information about places where individuals fish was also collected during the survey, and is available upon request.

The sample accounts for 246 women and 296 men[31]. In figure 39 the distribution by zone is illustrated. The highest share of respondents were from 'Casitas', followed by 'La 55', 'El Pueblo', and finally 'El Sur'. This is justified by the size of each zone and the number of residents in each one, and is also justified by previous demographics showing the bigger size of Casitas.
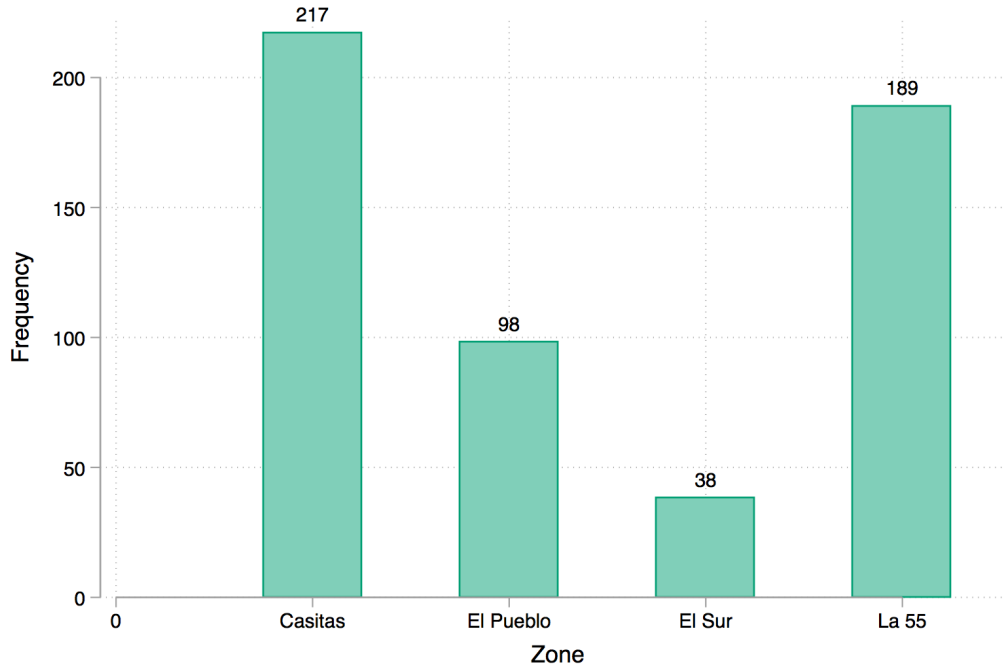
Figure 39: Frequency of the respondents by local zone

On average, each respondent has two kids. In total, 844 children from respondents were identified, even though it does not illustrate whether or not these children live with their parents. In terms of the number of people living under the same roof of respondents, the following descriptive statistics illustrate it: the average of inhabitants per house is 2, as it can be seen in figure 40. Adding up responses, this data collection found that except the 524 persons interviewed, there also are 1118 additional residents in Mahahual (992 being part of the family of the respondents and 126 not). It can thus be stated that at the moment, 1642 persons have been identified in the village[32]. This census is closed to the one made by the Health Centre in January 2020 as shown in figure 4, nevertheless with a higher number.

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[31]During the fieldwork, we tried to balance as most as possible the gender parity. However, interviewing women was sometimes harder due to the fact that most of the time the head of the household is the man and the latter prefers to answer the survey.

[32]Details about the gender and age of additional persons than the respondent can be found in the database and are available upon request.

Out of the 542 respondents, 117 stated they economically depended on someone, while 289 highlighted that other individuals were depending on them. On average a person who has to economically take care of others has to financially help a bit more than 2 individuals.
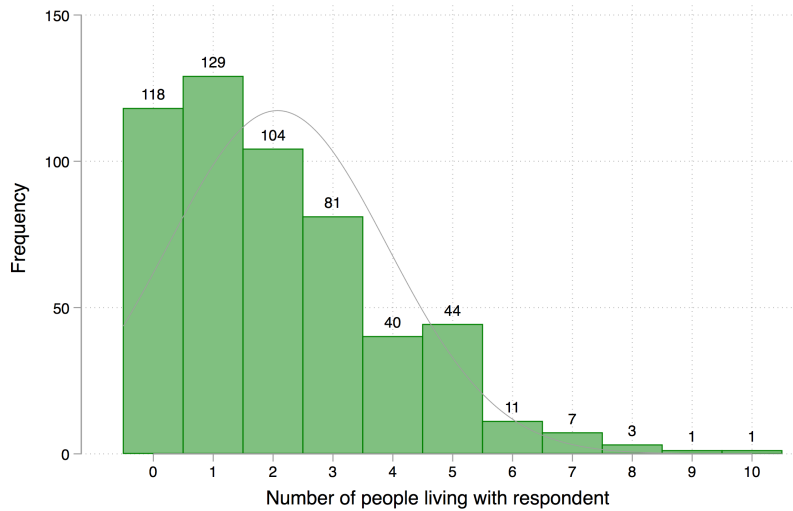
Figure 40: Distribution of number of people living with respondents

Age and Civil Status

Figure 41 illustrates the distribution of the age of respondents. The mean is more or less between 30 and 40 years old, and age seems to follow a normal distribution[33]. Concerning the civil status in figure 42, the majority of respondents are single, followed by married, free union, separated, and widowers.

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[33]Normal distribution, also known as the Gaussian distribution, is a probability distribution that is symmetric about the mean, showing that data near the mean are more frequent in occurrence than data far from the mean. In graph form, normal distribution will appear as a bell curve.
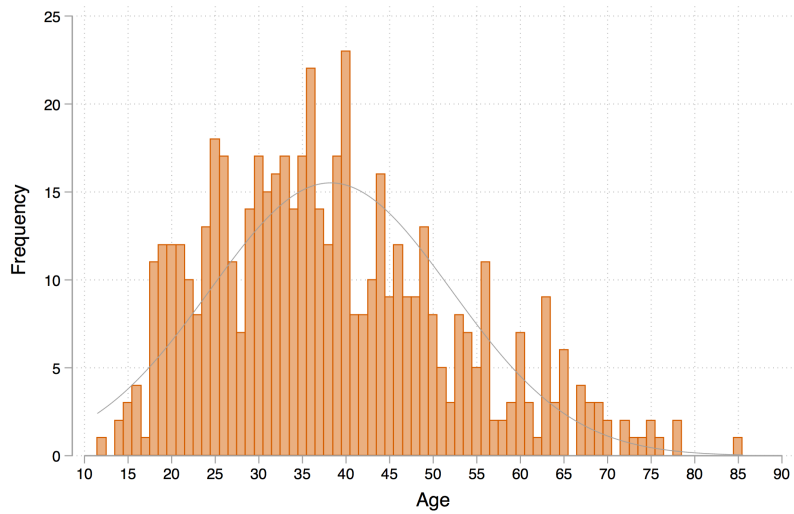
Figure 41: Age distribution of respondents
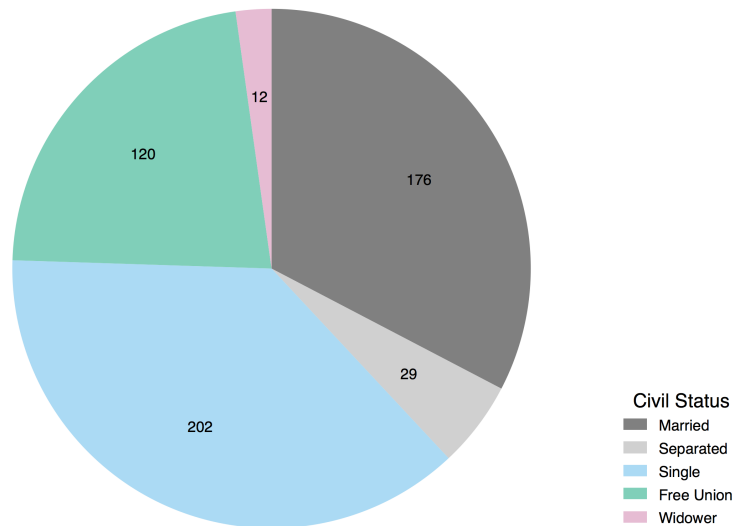
Figure 42: Civil Status of respondents

Scolarity and Activities
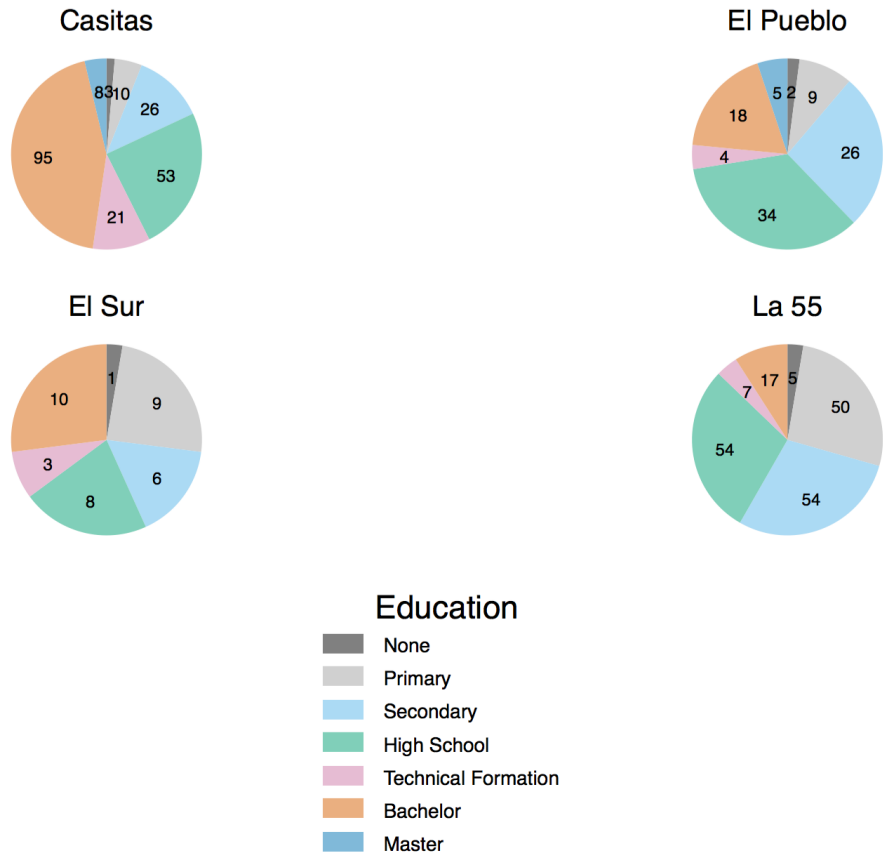
Figure 43: Education of respondents

Difference of education depending on zones is observable in figure 43. 'Casitas' has the highest levels of educations. It has the highest proportion of academics (bachelors and masters included) compared to the three other zones, followed by 'El Sur', 'El Pueblo', and then 'La 55'. 'La 55' has the highest proportions of respondents only having a primary school or a secondary school degree.

Among the other sectors and activities mentioned by respondents, we have the following: administrators of properties, housebuilders ('albaniles'), architect, veterinary, accountants, fotograph, doctor, pharmacists, captains, sailers, hair dresser, yoga teacher, and musicians.
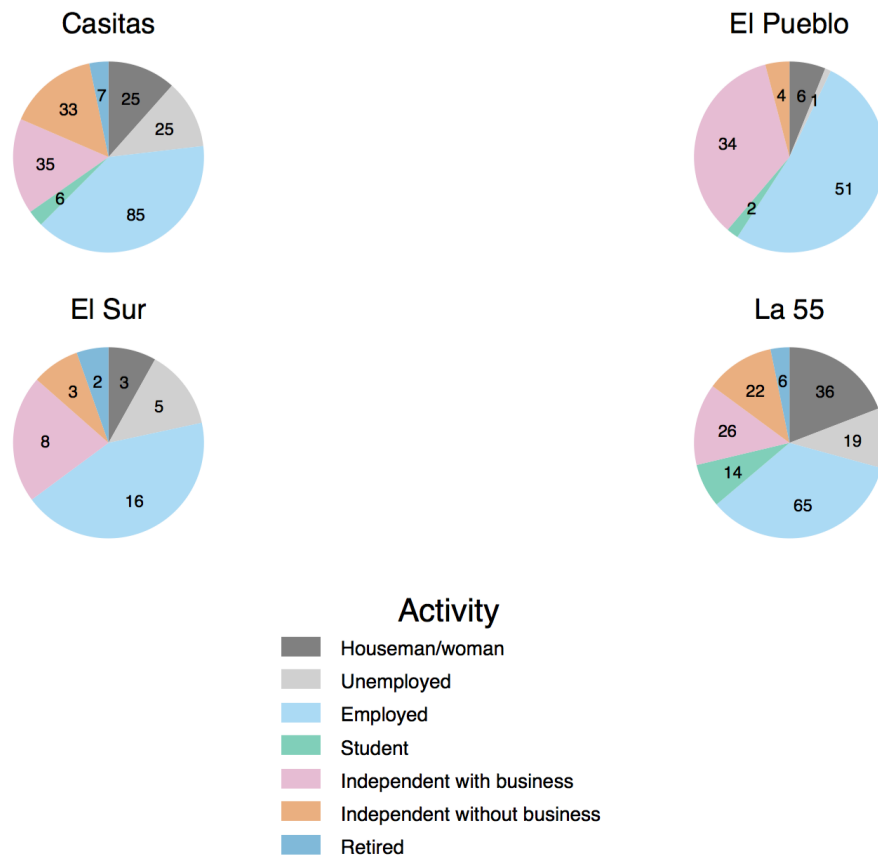
Figure 44: Main activities of respondents by zones

Concerning activities of respondents, figure 44 illustrates differences among zones. Most of people are employed, with the highest proportion in 'El Pueblo'. There are more housewomen and men in 'La 55' compared to other zones, and more independent with a business in 'El Pueblo'. 'El Pueblo' is also the zone with the lowest amount of unemployed people, with the majority in 'Casitas'. Last, most of students live in 'La 55'.
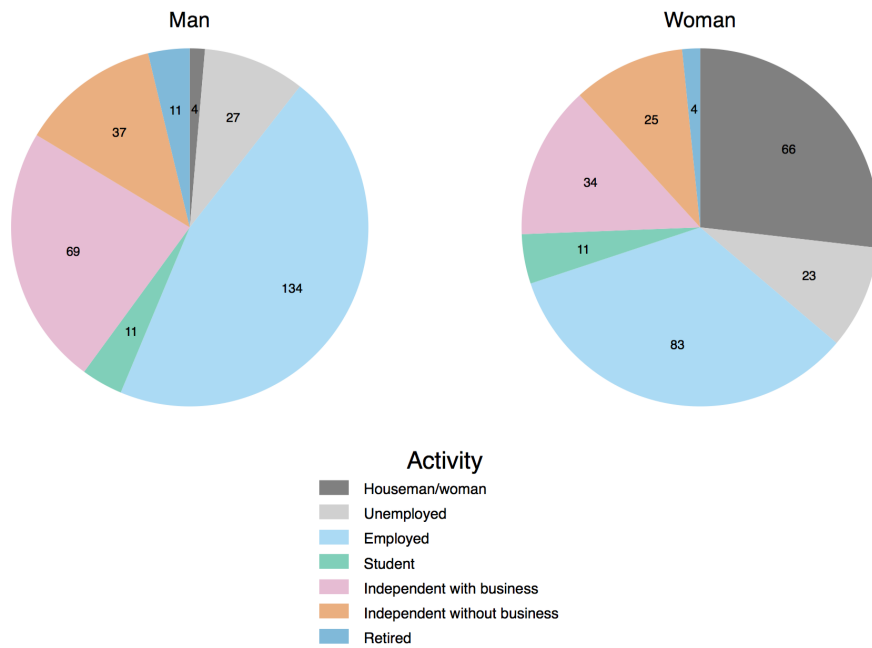
Figure 45: Main activities of respondents by gender

The notable differentiation is when analysing activities by gender. Figure 45 shows that women account for most of housewomen in the sample. There also are less women having the independent status with or without business, or even being employed.

Concerning the sector of activities, the fieldwork and data collected allows to evaluate the impact of the COVID-19 crisis on the employment of people from a descriptive approach. Figure 46 represents employment status before and during the COVID-19 crisis. Jobs which decreased after the start of the crisis are the following in the order of the importance of the negative effect: employees from the port, artisans, taxi drivers, aquatic guides, touristic guides, and massage therapists. The most important impact have been for the employees of the port, due to the fact that cruise ships were not arriving anymore.

Concerning the positive impact on change of employments and activities of people[34], the change of number of unemployed people is the highest: before crisis, 15 people of the sample were unemployed, and it reached 55 during the crisis. Other small positive impacts are for fishermen, other activities, and surprisingly in the restaurants/hotel

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[34]It is important to highlight that the change of employment cannot be attributed only to the COVID-19 crisis, as these are only descriptive statistics. A regression analysis would be needed to detect any significant impact of the crisis.

industry. The increase of other activities may be due to the reorientation of the local job market in order to adapt from the crisis[35].

Sectors of Activity	Number before COVID-19 crisis	Number after COVID-19 crisis
Hotel/Restaurant	122	125
Taxi driver	19	12
Artisan	43	29
Massage therapist	16	12
Aquatic activities	43	38
Touristic guide	25	19
Costa Maya Port	75	29
Public sector	11	12
Fisherman	13	22
Student	31	28
Unemployed	15	55
Other	228	243

Figure 46: Education of respondents

The number of people who stated they had a job before the crisis but not at the time of the survey is equal to 44 out of the 542 people interviewed. As such, the impact of the COVID-19 crisis on the local employment affected 44 persons of the sample, who did not manage to redirect their employment to adapt to the crisis.

Origins and geographical affiliation

Out of the 542 persons interviewed, 50 consider themselves to belong to an indigenous group. Figure 47 summarises the geographical origins of respondents. It can be observed that Chetumal is the city where most of current residents of Mahahual are from, more than Mahahual itself. It is then followed by the state of Mexico. While most of the answers were censored at the state or country level, it was collected at the city level for agglomerations close to Mahahual, such as Bacalar, Cacchoben, Chetumal, Felipe Carrillo Puerto, Limones, Noh-Bec, Tulum, and Xcalak.

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[35]Another research project would be to evaluate the impact of the COVID-19 crisis at different points of time, and this database is a baseline for it.

Origin of the respondent	Freq.	Percent
.	1	0.19
Argentina	9	1.67
Bacalar	10	1.85
Belice	1	0.19
Campeche	22	4.07
Canadá	1	0.19
Cancún	15	2.78
Chacchoben	3	0.56
Chetumal	76	14.07
Chiapas	13	2.41
Chihuahua	4	0.74
Chile	1	0.19
Chunjuju	2	0.37
Cozumel	4	0.74
Croacia	1	0.19
Europe	28	5.19
Felipe Carrillo Puerto	4	0.74
Guadalajara	2	0.37
Guadalupe Victoria	1	0.19
Guanajuato	2	0.37
Guatemala	4	0.74
Guerrero	20	3.70
Honduras	2	0.37
Jalisco	7	1.30
Limones	14	2.59
Mahahual	45	8.33
Mexico	66	12.22
Michoacán	11	2.04
Noh-Bec	4	0.74
Nuevo Leon	3	0.56
Nuevo esperanza	1	0.19
Oaxaca	9	1.67
Playa del Carmen	3	0.56
Puebla	9	1.67
Quintana Roo	17	3.15
San Luis Potosí	1	0.19
Sinaloa	1	0.19
Tabasco	28	5.19
Tamaulipas	2	0.37
Tlaxcala	2	0.37
Tulum	1	0.19
USA	11	2.04
Uruguay	3	0.56
Venezuela	1	0.19
Veracruz	45	8.33
Xcalak	2	0.37
Yucatán	28	5.19
Total	540	100.00

Figure 47: Origins of respondents

Figure 48 illustrates the years spent by the respondents in Mahahual. On average, respondents have been living in the village since 1O years. The distribution is skewed to the right side: there are people living in the village since many more years distributed differently, and also many living there since 1 or 2 years.
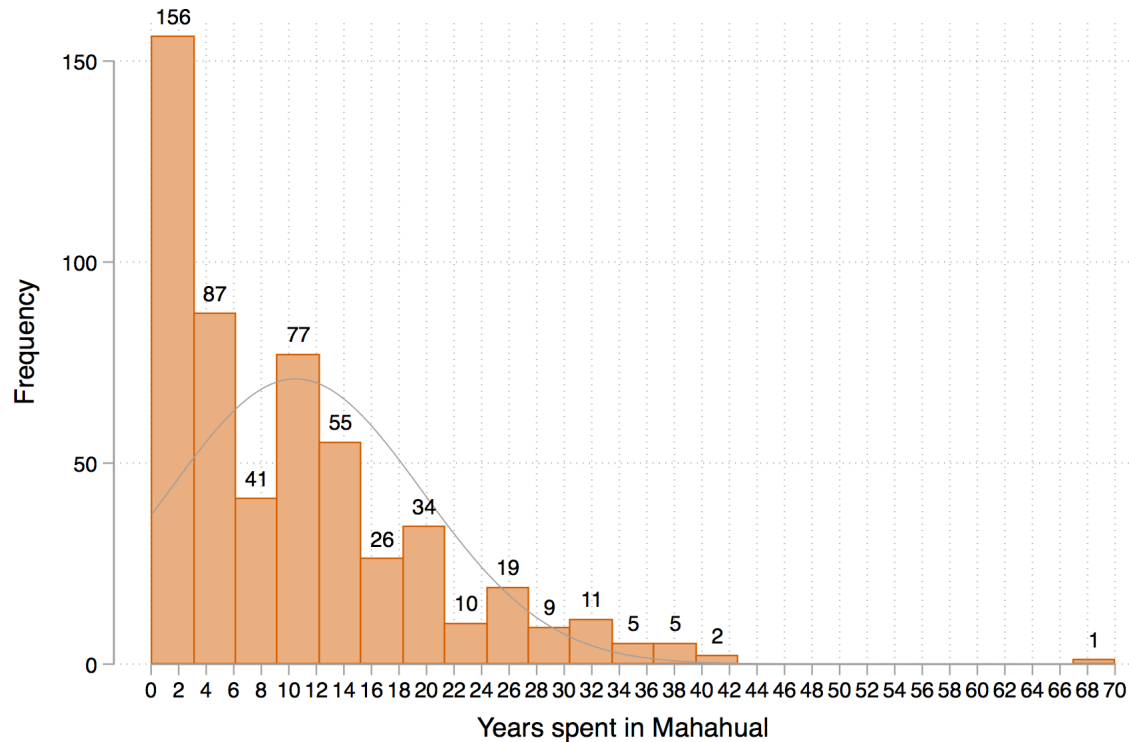
Figure 48: Years spent in Mahahual

The majority of people interviewed are full-time residents of Mahahual as shown in figure 49(518 full-time residents and 19 part-time residents). The majori†y of part-time residents live in 'Casitas'.

Q53	Zone				Total
	Casitas	El Pueblo	El Sur	La 55	
Here all year	203	96	36	183	518
Going away in low sea	13	2	0	4	19
Total	216	98	36	187	537

Figure 49: Full-time or part-time residents of Mahahual

51

Housing and urban infrastrucure

Owning or renting the house	Zone				Total
	Casitas	El Pueblo	El Sur	La 55	
Renting	162	60	19	66	307
Owning	54	38	18	122	232
Total	216	98	37	188	539

Figure 50: Owners and tenants

The sample interviewed consists of 307 house tenants and 232 owners, as observed in figure 50. The majority of 'Casitas' and 'El Pueblo' are tenants, while it is the opposite for 'La 55'. For 'El Sur', it is almost equal. The access to potable water and sewage system with CAPA (cfr figure 51) is also different depending on the zone: while 'Casitas', 'El Pueblo' and 'El Sur' mostly have access to it, the majority of 'La 55' does not[36]. It also may explain why the water quality ecosystem service of mangroves has been favoured by inhabitants of this zone, as well as a better development of urban infrastructure of the village.

Q57	Zone				Total
	Casitas	El Pueblo	El Sur	La 55	
No	5	5	6	56	72
Si	211	93	31	131	466
Total	216	98	37	187	538

Figure 51: Connected houses to CAPA[a]

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[a]Comisión de Agua Potable y Alcantarillado - Quintana Roo

A better access to potable water and direct connection to CAPA in 'La 55' would be the next step for the urban development of Mahahual.

Income of the community

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[36]The zone 'El Sur' has been interviewed until 'Punta Tam', 200 meters after Takata Research Centre. After Takata Research Centre, connections to CAPA still do not exist.

Questions about income of respondents were asked, before the start of the COVID-19 crisis, and after[37].
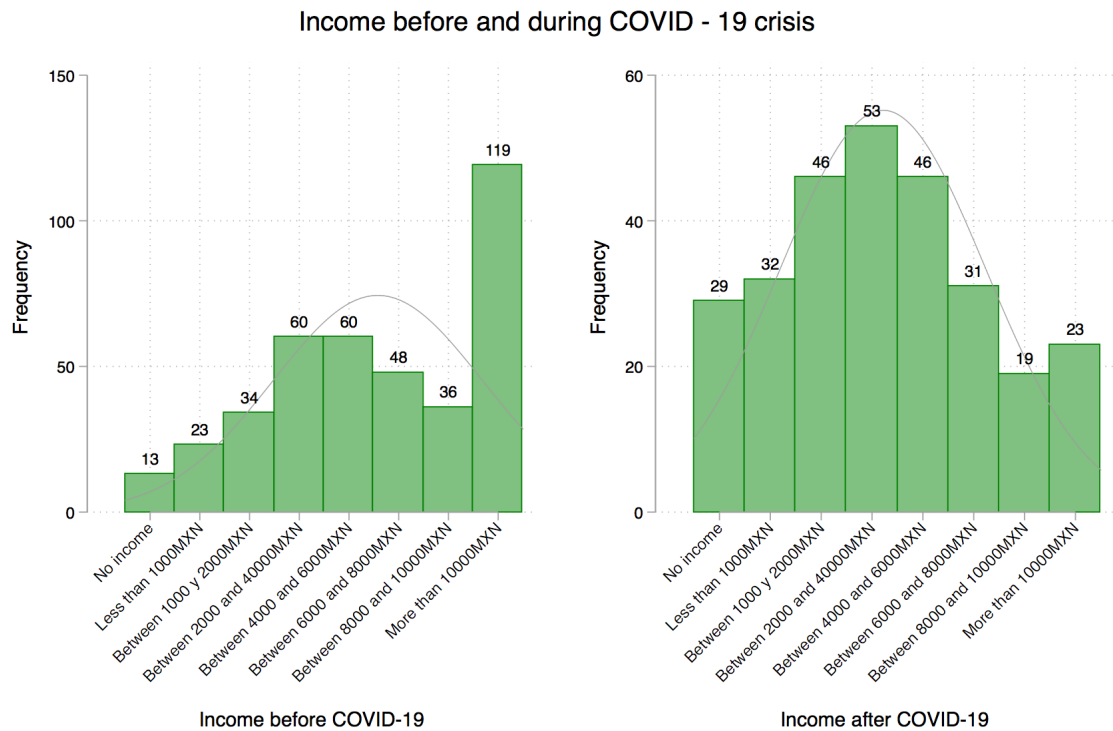
Figure 52: Evolution of income before and during the COVID-19 crisis

Figure 52 illustrates the shares of income before and during the COVID-19 crisis. The difference is directly observable: while the average was around 6000 pesos per month before crisis, it is close to 3000 pesos during the crisis. People earning more than 10.000MXN pesos a month are now a minority of the community, compared to before the crisis. Figure 53 differentiates these results by gender. Before the crisis, women earned on average between 4000 and 6000MXN pesos, while men between 6000 and 8000 pesos. During the crisis, women are now earning around 3000MXN pesos, while mean are earning around 4000MXN pesos. The question on whether the crisis has started to be an instrument decreasing gender inequalities remains open, but what is sure is that the COVID-19 impact significantly income of the local community.

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[37]While the first week of the fieldwork did not include the income question during the crisis but only the income the respondent used to benefit from before the crisis, the amount of observations for the income during the crisis has not been answered by all respondents.
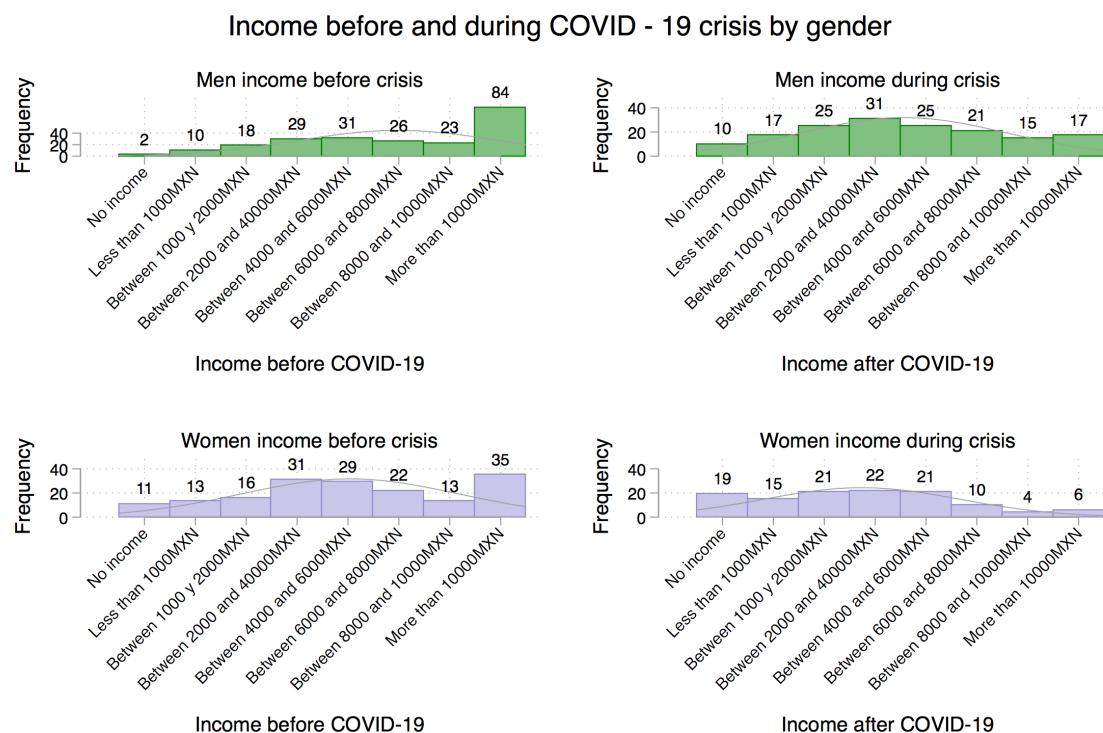
Figure 53: Evolution of income before and during the COVID-19 crisis, differentiated by gender

Figure 54 and figure 55 illustrate income differentiated by zone, before and during the COVID-19 crisis. 'Casitas' is the zone with the highest nimber of residents benefitting from a income higher than 10000MXN pesos per month. It is then followed by 'El Pueblo', 'El Sur', and finally 'La 55'[38]. Looking at figure 55, results change considerably during the crisis, and the number of people benefitting from more than 10000MXN pesos decreased. The question on whether the crisis has started to be an instrument decreasing zone inequalities in terms of income is also to be considered.

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[38]It remains important to mention that it may not be representative of the whole community, since there were various respondents who did not want to provide information about their income. They are not taken into account in the income analysis.

Income of different zones before COVID - 19
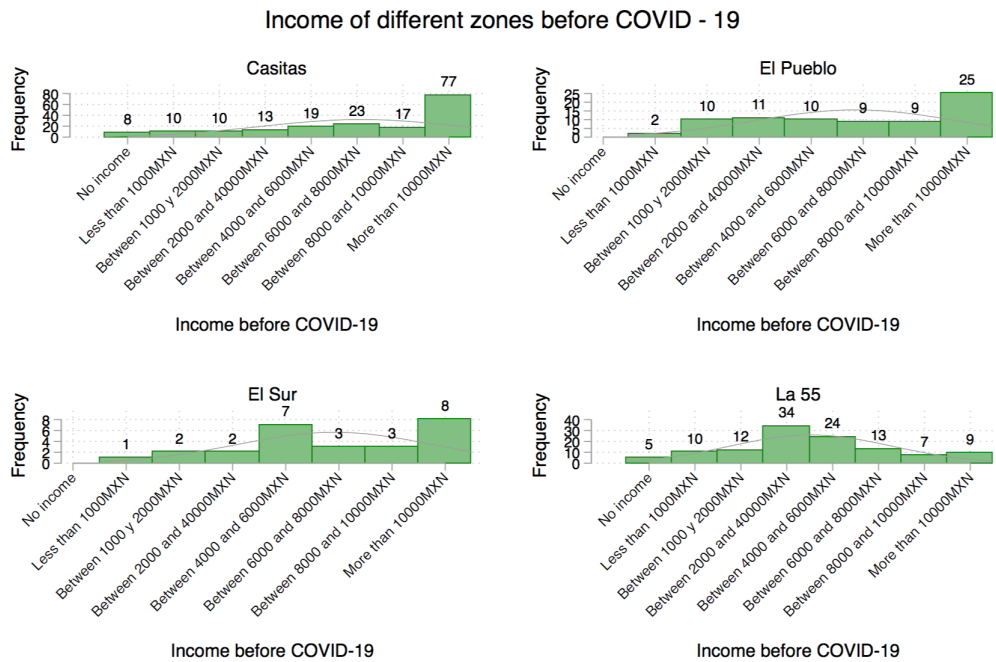
Figure 54: Evolution of income before the COVID-19 crisis, differentiated by zones

Income of different zones during COVID - 19
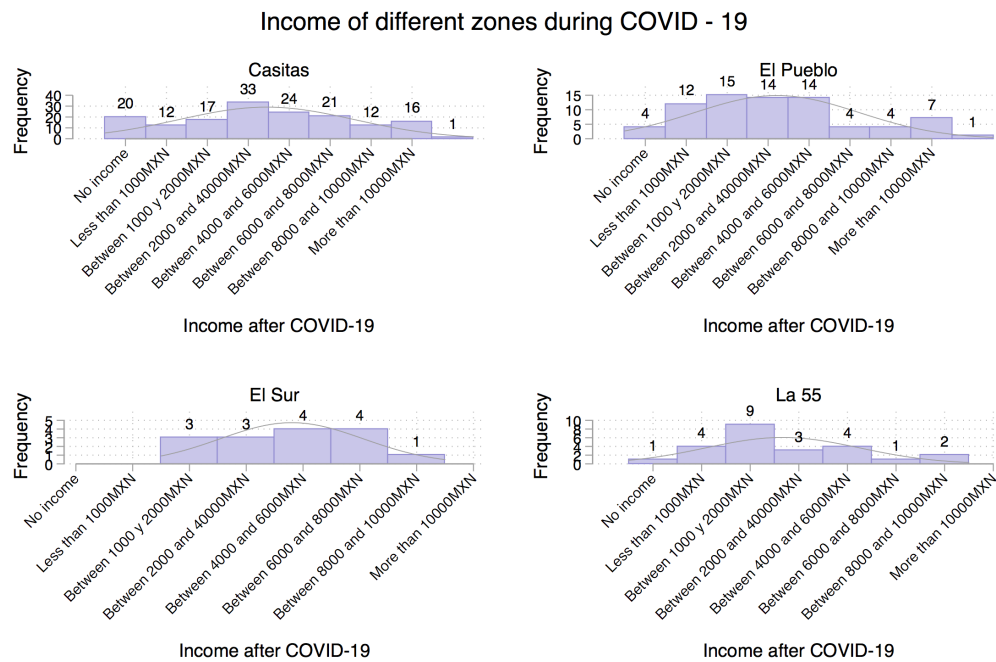
Figure 55: Evolution of income during the COVID-19 crisis, differentiated by zone

Next section introduces an approach more quantitative to determine factors determining significantly the willingness to pay of respondents[39]. Section 4.1 can be skipped for lecturers not interested in econometrics.

4. Quantitative framework

4.1. Methodology to understand the willingness to contribute to mangroves conservation

In order to determine drivers of any potential contribution to mangroves conservation, a regression analysis is used. While this report is mainly about descriptive statistics and principal trends of data collected, it opens the way for more quantitative research. An OLS (ordinary least squared) approach is applied[40] to investigate the impact of characteristics of respondents on their willingness to contribute to mangroves conservation. The following regression model is run:

$$Willingness\ to\ contribute\ to$$
$$Conservation_i = \beta_0 + \beta_1 Zone_i + \beta_2 Time_i + \beta_3 Activity_i + \beta_4 Sector_i + Controls_i' + \epsilon_i$$

with $Conservation_i$ being either the willingness to pay of the respondent for mangroves conservation in MXN pesos per month or the willingness to contribute to any future conservation project in terms of hours of work per month. The second variable is used due to low salaries received by part of the local population. As such, the willingness to work also illustrates the ability and will of the respondent to participate into conservation of the coastal ecosystem.

$Zone_i$ represents the zone in which the respondent lives ('Casitas', 'El Pueblo', 'El Sur', 'La 55'), $Time_i$ represents how many years the respondent has lived in Mahahual, $Activity_i$ represents his activity (unemployed, employed, student, independent with business, independent without business, retired), $Sector_i$ is the sector in which the respon-

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[39]It nonetheless is a basic introduction to the type of research which can be done with data collected during the project.

[40]The OLS estimator requires that the explanatory variables are exogenous and there is no perfect multicollinearity. Furthermore, OLS is optimal in the class of linear unbiased estimators when the errors are homoscedastic and serially uncorrelated. Under these conditions, the method of OLS provides minimum-variance mean-unbiased estimation when the errors have finite variances. Under the additional assumption that the errors be normally distributed, OLS is the maximum likelihood estimator.

dent works (touristic guide, artisan, aquatic activities,...), and $Controls_i$ controls for gender and income of the respondent.

4.2. Results

Main results are available in the 5 tables below. All first three columns use the willingness to pay in MXN pesos per month as dependent variable, and the last three use the willingness to contribute in terms of hours of work per month.

In table 2, it can be observed that inhabitants from 'El Sur' overall would be willing to contribute more than Casitas in terms of money and in terms of hours of work (on average 318 pesos more per month and 9.43 hours more per month in the most specified regression models in columns (3) and (6))[41].

Table 3 shows that years spent living in Mahahual only influence the willingness to contribute to conservation in terms of hours of work per month, rather than in terms of MXN pesos per month. According to the table, any additional year spent in Mahahual increases the willingness to work by 0.16 hours, in the most specified regression in column (6).

The effect of the activity of the respondent on the willingness to contribute to conservation is illustrated in table 4. Main effects are detectable in the last three columns, when considering the hours of work as the contribution to conservation. Unemployed respondents seem to be the ones most willing to contribute in terms of hours of work for conservation compared to housemen and housewives (11 hours more per month). They are followed by independent people owning a business, and then employees[42]. In the specification of column (6), gender also has a positive effect on contribution to conservation.

Zooming on the type of sector in which the respondent is working in, table 5 illustrates in column (1) (2) and (3) that in terms of financial contribution, only people working in the public sector have a higher detectable motivation to contribute more to mangroves conservation than unemployed respondents (on average 735 MXN pesos more.) Focusing

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[41]For categorical variables such as the zone, the type of activity and the type of sector, coefficients are interpreted comparing it to the omitted category of the variable. For the variable 'zone', it is Casitas. For the variable 'activity', it is the housemen/wifes activity. For the sector, it is the unemployed category.

[42]There is no detectable effect for student, retired or independents without business.

on the willingness to work for conservation, students and fishermen would be willing to contribute more per month.

From the findings from the four tables above, main characteristics influencing positively the willingness to contribute to mangroves conservation are the following: living in 'El Sur' increases the willingness to contribute both in terms of financial contribution or hours of work. Seniority at Mahahual increases the willingness to work for any mangroves conservation project. Unemployed people are also more enclined to dedicate their time, as well as independents with a business, students and fishermen, who seem to be the ones more willing to help working for any future protection and conservation project. Last, women should also be considered as important parts, since they also appear to be willing to contribute more in terms of hours of work for mangroves conservation than men.

Table 2: Ordinary Least Squares regressions of Willingness to Pay on Geographical Zones

				OLS		
	WTP	WTP	WTP	WTC	WTC	WTC
El Pueblo	4.98	52.26	45.06	1.59	2.13	2.35
	(98.178)	(101.479)	(101.951)	(2.072)	(2.093)	(2.103)
El Sur	272.92*	338.46**	318.45**	9.51***	9.04***	9.43***
	(154.829)	(158.957)	(161.000)	(2.782)	(2.789)	(2.812)
La 55	−169.30*	−137.79	−144.62	2.10	2.03	2.22
	(95.311)	(101.649)	(102.082)	(1.635)	(1.785)	(1.793)
Woman			−63.88			1.58
			(79.066)			(1.459)
Control income	*No*	*Yes*	*Yes*	*No*	*Yes*	*Yes*
Observations	229	229	229	441	440	440

Dependent variables are willingness to pay (in MXN pesos per month) to mangroves conservation in the first 2 columns and willingness to contribute in terms of time (in hours per month) in the last 2 columns. Standard errors in parenthesis. Significance: * ($p < 0.10$), ** ($p < 0.05$), *** ($p < 0.01$).

Table 3: Ordinary Least Squares regressions of Willingness to Pay on Years Spent in Mahahual

				OLS		
	WTP	WTP	WTP	WTC	WTC	WTC
Years spent in Mahahual	−4.20	−5.25	−5.42	0.18**	0.15*	0.16**
	(4.781)	(5.002)	(5.009)	(0.077)	(0.079)	(0.080)
El Pueblo		77.85	71.10		1.47	1.69
		(104.347)	(104.713)		(2.118)	(2.124)
El Sur		366.35**	346.17**		8.18***	8.58***
		(161.129)	(162.962)		(2.822)	(2.837)
La 55		−124.35	−131.11		1.64	1.82
		(102.431)	(102.802)		(1.800)	(1.804)
Woman			−67.39			1.86
			(79.102)			(1.467)
Control income	*No*	*Yes*	*Yes*	*No*	*Yes*	*Yes*
Observations	229	229	229	440	439	439

Dependent variables are willingness to pay (in MXN pesos per month) to mangroves conservation in the first 2 columns and willingness to contribute in terms of time (in hours per month) in the last 2 columns. Income and zones are controlled for in columns 2, 3, 5 and 6, while gender is controlled for in column 3 and 6. Standard errors in parenthesis. Significance: * ($p < 0.10$), ** ($p < 0.05$), *** ($p < 0.01$).

Table 4: Ordinary Least Squares regressions of Willingness to Pay on Type of Activity

				OLS		
	WTP	WTP	WTP	WTC	WTC	WTC
Unemployed	331.33*	260.95	247.52	10.73***	9.66***	11.00***
	(169.351)	(174.562)	(180.171)	(3.064)	(3.074)	(3.154)
Employed	243.99**	212.78*	200.01	5.41**	4.82**	6.29**
	(116.541)	(123.536)	(130.413)	(2.309)	(2.357)	(2.487)
Student	98.77	98.29	85.39	3.53	4.21	5.66
	(223.550)	(248.760)	(252.709)	(4.053)	(4.245)	(4.309)
Independent with business	292.34**	217.09	199.77	6.12**	4.89*	6.56**
	(125.340)	(137.678)	(148.754)	(2.591)	(2.650)	(2.799)
Independent without business	68.21	55.84	44.72	3.05	2.75	4.20
	(148.753)	(150.153)	(154.647)	(2.922)	(2.900)	(3.002)
Retired	113.94	−30.42	−53.26	−1.66	−2.87	−0.81
	(236.052)	(241.581)	(252.951)	(5.126)	(5.116)	(5.229)
El Pueblo		−6.77	−6.32		1.77	2.06
		(109.868)	(110.114)		(2.139)	(2.140)
El Sur		296.01*	290.29*		8.69***	9.34***
		(161.524)	(162.909)		(2.781)	(2.797)
La 55		−148.88	−151.48		1.98	2.35
		(102.744)	(103.302)		(1.781)	(1.788)
Woman			−27.03			2.80*

Dependent variables are willingness to pay (in MXN pesos per month) to mangroves conservation in the first 2 columns and willingness to contribute in terms of time (in hours per month) in the last 2 columns. Income and zones are controlled for in columns 2, 3, 5 and 6, while gender is controlled for in column 3 and 6. Standard errors in parenthesis. Significance: * ($p < 0.10$), ** ($p < 0.05$), *** ($p < 0.01$).

Table 5: Ordinary Least Squares regressions of Willingness to Pay on Type of Sector

| | OLS | | | | | |
	WTP	WTP	WTP	WTC	WTC	WTC
Other activity	−67.19	−21.37	−19.70	−1.75	−1.61	−1.62
	(158.681)	(161.030)	(161.258)	(2.478)	(2.478)	(2.479)
Student	−69.67	−20.22	−23.67	5.01	6.24*	6.23*
	(239.314)	(251.081)	(251.457)	(3.599)	(3.685)	(3.688)
Touristic guide	810.00	730.92	713.58	−0.01	0.14	0.51
	(586.197)	(583.772)	(585.064)	(9.616)	(9.546)	(9.566)
Artisan	91.82	148.45	148.52	−2.65	−2.36	−2.27
	(225.307)	(234.620)	(234.926)	(3.550)	(3.582)	(3.586)
Massage therapist	98.89	298.49	331.68	7.23	6.39	5.89
	(274.169)	(280.447)	(284.832)	(5.476)	(5.459)	(5.507)
Aquatic activities	223.86	218.63	201.84	3.05	2.64	2.84
	(219.824)	(221.762)	(223.357)	(3.424)	(3.459)	(3.472)
Hotel/Restaurant	86.58	76.04	80.29	1.33	1.27	1.21
	(166.713)	(171.034)	(171.366)	(2.588)	(2.636)	(2.639)
Taxi driver	−106.67	−114.12	−129.92	1.55	0.45	0.77
	(319.397)	(337.681)	(338.882)	(4.943)	(4.992)	(5.015)
Costa Maya industry	−63.90	−94.56	−86.80	−2.36	−1.98	−1.98
	(259.804)	(260.653)	(261.231)	(3.707)	(3.724)	(3.726)
Public sector	724.29***	743.28***	735.87***	−3.64	−3.95	−3.80
	(259.804)	(260.511)	(261.069)	(4.743)	(4.737)	(4.745)
Fisherman	201.33	136.72	123.29	8.93**	7.34*	7.66*
	(225.307)	(233.277)	(234.377)	(3.836)	(3.887)	(3.916)
El Pueblo		46.17	39.59		1.77	1.92
		(110.264)	(110.812)		(1.942)	(1.954)
El Sur		415.26**	401.36**		3.58	3.76
		(172.474)	(173.850)		(2.612)	(2.627)
La 55		−97.95	−104.89		2.34	2.46
		(108.148)	(108.746)		(1.648)	(1.657)
Woman			−58.29			0.96
			(83.734)			(1.359)
Control income	No	Yes	Yes	No	Yes	Yes
Observations	221	221	221	428	427	427

Dependent variables are willingness to pay (in MXN pesos per month) to mangroves conservation in the first 2 columns and willingness to contribute in terms of time (in hours per month) in the last 2 columns. Income and zones are controlled for in columns 2, 3, 5 and 6, while gender is controlled for in column 3 and 6. Standard errors in parenthesis. Significance: * ($p < 0.10$), ** ($p < 0.05$), *** ($p < 0.01$).

5. Policy recommendations and conclusion

The awareness campaign implemented during fieldwork in parallel with data collect confirms one thing: the community realises the state of local mangroves has been heavily deteriorated in the past years. It also understands better the importance of this ecosystem post-interviews, after being introduced to all mangroves ecosystem services. The

importance of these latter increased after the educational part, which illustrates the positive impact of the awareness campaign.

From a geographical zone differentiation, inhabitants from 'El Sur' seem to consider mangroves with the highest importance in all answers. They are also the ones willing to contribute more to future mangroves conservation programs, if they were to be set up. It may be due to their geographical closeness to the coastal ecosystem, linked to their vulnerability to any natural disaster. These inhabitants also differentiated most the order for ecosystem services, favouring more support for coastal ecosystem than others. It may be due to the proximity of this zone to the reef.

Among all ecosystem services presented to respondents, recreative opportunities are by far the least valued by the local community. It has also been the ecosystem service with most change of importance before and after the educational part. It illustrates previous community views of the mangroves, initially not perceiving the ecosystem as a recreative place that could generate direct income. It gives room to diverse future ecotourism projects, providing a direct significant economic value to the village.

Concerning the sustainable development of Mahahual, the cruiseship industry does not seem to be the most favoured option for the future of the village. While an important part of the community initially depended financially on the port, it gives hope for a different development more focused on sustainability and ecotourism.

Mahahual is still a place with gender inequalities in terms of activity and responsibilities. Women seemed to be more willing to contribute to mangroves conservation than men, according to the econometrics framework. As such, an ideal situation with a conservation project predominantly managed by women in order to empower them more than the current situation would be a new ambition for the sustainable development of Mahahual, as well as for a reduction of gender inequalities.

The question on whether the COVID-19 crisis has started to be an instrument decreasing gender inequalities and zone inequalities would be to investigate in more details, but what is sure is that the COVID-19 has impacted significantly income levels of the local community.

This project is valuable for further research focusing on ecosystem services and conservation of the environment. The number of hours respondents offered to dedicate to the conservation of coastal ecosystems is close to 8 hours per month for mangroves and also for the coral reefé. This favorably supports any future conservation project which

would involve the community and put them as first stakeholders. The objective of the research which aimed to assess whether the community would be ready to take part in a conservation project and contribute to the sustainable development of Mahahual is fulfilled post survey.

Understanding the local community and its needs also helps to be able to implement any future local ecotourism initiative, such as relaxing walks through calm and pristine mangrove forest, with resting points for a view of mangroves, birds, primates, crabs and other attractions (Runya et al. 2019). This kind of project which is not developed at the moment would help to bring the local community closer to mangroves, as well as to preserve this ecosystem.

The efforts that could be made to conserve mangroves through ecotourism and suggested by the community include the creation of mangroves nursery[43], planting of mangroves in degraded areas, planting of mangroves in new areas where there was no mangroves before, educating the community on the importance of conserving mangroves forest, and offer security to mangrove forest through surveillance and monitoring.

Raising awareness of the community increases chances of protecting this ecosystem, with measures taken at the local level. The fieldwork and answers concerning importance of ecosystem services demonstrated that the educational part at the individual level has had a detectable effect on the responses and thus knowledge of the community. While it was only an introduction to the services provided by mangroves, a bigger impact could be achieved by a bigger awareness campaign, and thus gives room for future projects of this kind.

Solutions to mangroves deterioration and tools for mangroves conservation could star developing at the local level: as it has been observed in the answers, most favoured solutions are related to education, raising knowledge and awareness. Local and direct solutions seem to be preferred at first glance rather than solutions coming from federal authorities. It also supports the idea of a conservation project with the community as main actors.

In Mexico, mangroves are theoretically the government property. Centrally planned natural resource management systems have often suffered from faulty design in absence of a co-management structures with local people's participation and partnership. Hence,

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[43]During her months spent in Mahahual, Julia Jadin planted mangrove seedlings from scratch in order to evaluate the feasibility to create a nursery, and results are more than favourable. For any questions about mangroves seeds, please contact the author.

this top-down management have been marked by inefficiencies and even corruption. A model where mangroves ecosystem and responsibility would be shared between the government and local resource dependent communities in an applied co-management structure would potentially attain resource sustainability and livelihood outcomes.

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Appendix

A. Questionnaire

Cuestionario de bosques de manglar de Mahahual

Este cuestionario anónimo tiene como objetivo obtener información de la percepción de la comunidad sobre el estado de los manglares de Mahahual. El objetivo final es identificar y proponer soluciones colectivas y locales que benefician a la comunidad, a través de los usos y relaciones que tienen con este ecosistema. Es importante enfatizar que todas las preguntas de la sección que involucra valores monetarios son hipotéticas y no involucra recaudación de dinero.

1. Nombre del entrevistador: …………….………..
2. Fecha: …………….
3. Ubicación de la entrevista:.………..……………

4. - ¿Dónde vive en Mahahual?
   > El Pueblo
   > 55
   > Casitas
   > El Sur
   > Otro: ……………
   - ¿En qué calle y número?
   > ……………

Parte 1: Sensibilidad a los problemas de conservación

5. En una escala de 1 a 5, ¿Qué tanto contribuye a la conservación del medio ambiente? *(1=no contribuye, 5=contribuye mucho)*

1	2	3	4	5

6. Entre las siguientes opciones, ¿cómo percibe los manglares*? *(selección múltiple)*
   1.Un lugar lleno de mosquitos
   2. Un lugar para desechos
   3. Un área fresca
   4. Un lugar que es difícil para construir
   5. Un lugar importante para el medioambiente y la comunidad
   6. Otro: ……………

7. Desde que vive en Mahahual, ¿Cómo ha percibido el cambio del estado general de los manglares?
   > Degradado
   > Sin alterar
   > Mejorado
   > No sé

8. En 5 años, ¿Cómo cree que percibirá el cambio del estado general de los manglares?
   > Degradado
   > Sin alterar
   > Mejorado
   > No sé

9. ¿Visita los manglares?
   > Si (*Pase a 10*)
   > No (*Pase a 11*)

10. ¿Aproximadamente, con qué frecuencia?
    > Más de una vez por semana
    > Una vez por semana
    > 2 veces por mes
    > Una vez por mes
    > Una vez al año

11. ¿Considera que la degradación de los manglares lo afecta a usted directamente?
    > Si (*Pase a 12*)
    > No (*Pase a 13*)

12. ¿Cómo lo afecta?

    …………………………………………….………
    …………………………………………….………
    …………………………………………….………
    …………………………………………….………
    …………………………………………….………

13. En una escala de 1 a 5, indique la magnitud de cada amenaza para los manglares *(1=no importante, 5=muy importante)*

Amenaza	Importancia
1. Desarrollo costero	
2.Contaminación	
3.Sobrepesca	
4.Cambio climático	

14. ¿Cree que se deberían proteger los manglares?
    > Si
    > No
    > No sé

15. Según usted, ¿Cómo podría lograrse la mejor protección de los manglares?

    …………………………………………….………
    …………………………………………….………
    …………………………………………….………
    …………………………………………….………
    …………………………………………….………

16. En una escala de 1 a 5, indique la importancia de cada acción para la protección de los manglares *(1=no importante, 5=muy importante)*

Acción	Importancia
1. Fortalecer el manejo de los manglares por parte del gobierno	
2.Educación y participación de la comunidad para proteger los manglares	
3.Un mejor manejo de basura y descarga de aguas residuales	
4.Integración de los manglares en un plan de desarrollo urbano	

Parte 2: Servicios ecosistémicos de los manglares

17. En una escala de 1 a 5, ¿qué importancia tienen los manglares para usted? *(1= no importante, 5= muy importante)*

1	2	3	4	5

18. -Indique que usos da a los manglares.
-En una escala de 1 a 5, ¿qué importancia da a cada uso? *(1= no importante, 5= muy importante)*

Usos de los manglares	Si	No	Importancia
1.Productos forestales			
2.Contemplación de la naturaleza			
3.Caza *(¿qué?)*			
4.Plantas medicinales			
5.Eliminación y depósito de residuos domésticos (tirar basura)			
6.Área de desarrollo urbano			
7.Otro. ¿Cuál?			

19. -Ordene de 1 a 6 los servicios ecosistémicos de los manglares *(1= el primero, 6=el ultimo)*.
-En una escala de 1 a 5, ¿qué importancia da a los servicios ecosistémicos de los manglares? *(1= no importante, 5= muy importante)*

Servicios	Orden	Imp1	Imp2
1.Secuestro de carbono* (mejorar la calidad del aire)			
2.Biodiversidad: hábitat natural para especies marinas y terrestres, cría de especies residentes y migratorias			
3.Oportunidades recreativas (ecoturismo) y culturales			
4.Protección costera (prevención de la erosión* , prevención de desastres naturales: protección contra inundaciones y tormentas)			
5.Retención de sedimentos*, absorción de nutrientes* y regulación de la calidad del agua			
6.Soporte para los pastos marinos y arrecifes de coral			

(Empezar la sensibilización del medio ambiente y la importancia de los manglares)

20. Después de conocer los roles naturales que desempeñan los manglares, ¿podría indicar de nuevo la importancia que da a cada servicio? *(Incluir respuesta en Imp2)*

Parte 3: Valoración de los servicios ecosistémicos de los manglares *(REALMENTE explicar que es hipotético)*

21. ¿Sabe si su casa fue afectada por el Huracán Dean?
Si *(pase a 22)*
No *(pase a 23)*
No sé *(pase a 23)*

22. ¿Con qué magnitud? (1=muy poco, 5=mucho)

1	2	3	4	5

23. ¿Cuánto estaría dispuesto a pagar mensualmente para?

	$MEX
1.Proteger su casa/negocio de posibles desastres naturales	
2.Proteger su casa/negocio de la erosión	
3.Proteger su casa/negocio de inundaciones	

(EJ: seguro contra desastres naturales: 800MEX al mes)

24. ¿Cómo estaría dispuesto a contribuir para la conservación de los manglares?
Con dinero *(Pase a 25)*
Con tiempo/trabajo *(Pase a 26)*
Con dinero y tiempo *(Pase a 25 y 26)*
No quiero contribuir *(Pase a 27)*

25. Hipotéticamente ¿Cuánto dinero estaría dispuesto a contribuir al mes para las siguientes acciones?

	$MEX
1. La conservación de los manglares	
2. La conservación de los arrecifes	
3. Desarrollar el ecoturismo* en Mahahual	

26. Hipotéticamente ¿Cuánto tiempo estaría dispuesto a dedicar al mes para? *(Tiempo en horas)*.

	Tiempo(h/mes)
1. La conservación de los manglares	
2. La conservación de los arrecifes	
3. Desarrollar el ecoturismo* en Mahahual	

(EJ: tiempo completo 8 horas diarias = 160 horas mensuales)

27. Si no está dispuesto a contribuir con dinero y tiempo ¿podría darme el motivo? *(múltiple respuesta posible)*
No es mi papel pagar o dar mi tiempo de trabajo, debería provenir del gobierno
No tengo tiempo
No tengo recursos económicos
La protección de los manglares no es importante para mi
No quiero responder
Otro: …………………………..

Parte 4: Desarrollo sostenible de Mahahual

28. ¿Qué tanta importancia le da a cada acción para el desarrollo de Mahahual? *(1= no importante, 5= muy importante)*

Acción	Importancia
1. Mantener las actividades actuales de turismo masivo	
2. Atraer turistas diferentes a la industria de cruceros	
3. Implementar nuevas actividades económicas (arte y cultura, huertos comunitarios, investigación medicinal, investigación científica, …)	
4. Conservar la pesca artesanal	
5. Mejorar la infraestructura urbana (aguas residuales, gestión de residuos, electricidad y construcción de vías)	
6. Desarrollar programas de conservación y restauración de ecosistemas costeros	

29. En una escala de 1 a 5, ¿Qué tanta importancia le da a cada actividad?

Actividades	Importancia
1. Arte y cultura	
2. Huertos comunitarios	
3. Investigación medicinal	
4. Investigación científica/ambiental	
5. Ecoturismo	
6. Otro. ¿Cuál?	

30. ¿Tiene alguna sugerencia para un proyecto de conservación de manglares que involucre a la comunidad?

………………………………………….………
………………………………………….………
………………………………………….………
………………………………………….………

31. <u>Si vive / posee un negocio en el Malecón</u>: ¿estaría interesado en plantar manglares frente a su establecimiento?

        Si
        No

Parte 5: Información sobre el suministro de peces

32. ¿Usted pesca?

        Si *(pase a 33)*
        No *(pase a 35)*

33. ¿Dónde pesca?

        Cerca de Mahahual (1)
        Banco Chinchorro (2)
        Xahuayxol (3)
        Xcalak (4)
        Rio Indio (5)
        Pulticup (6)
        Otro (7):…………………………

34. Si pescador: ¿Qué cantidad de dinero obtiene de la pesca mensualmente?

$MEX	

35. ¿Compra pescado?

        Si *(pase a 36)*
        No *(pase a 37)*

36. En caso afirmativo, ¿cuál es su gasto mensual en pescado?

$MEX	

Parte 6: Información general sobre el entrevistado

37. Género

        Femenino
        Masculino

38. ¿Cuántos años tiene?

…………………..

39. Estado civil

        Soltero
        Casado
        Viudo
        Separado
        Unión Libre

40. ¿Tiene hijos? ¿Cuántos?

…………………………...

41. A parte de usted, ¿con cuantas personas vive?
   - 1.De familia ……………………
   - 2.Otros: ………………………...

42. ¿Qué edad tienen las personas con las que vive? *(especificar parentesco)*

Parentesco	Edad
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

43. ¿Depende usted económicamente de alguien?

        Si
        No

44. ¿Depende económicamente alguien de usted?

        Si *(pase a 45)*
        No *(pase a 46)*

45. ¿Cuántas personas?

…………….

46. ¿Cuál es su nivel de escolaridad?
       Ninguno
       Primaria
       Secundaria
       Bachillerato
       Formación técnica
       Licenciatura
       Posgrado

47. Indique su ocupación ahora *(respuestas múltiples)*
       Empleado (1)
       Independiente (con negocio/sin negocio) (2)
       Jubilado (3)
       Ama/o de casa (4)
       Desempleado (5)
       Estudiante (6)

48. Indique la actividad en la que se desempeña actualmente *(muchas respuestas posibles)*
       Gastronomía/ Hotelería (1)
       Taxista (2)
       Artesano (3)
       Masajista (4)
       Guía acuático (5)
       Guía turístico (6)
       Puerto Costa Maya (7)
       Sector público (bomberos, CAPA, Ejército, Policía, Fiscales, centro de salud, escuelas, capitanía de Puerto) (8)
       Pescador (9)
       Estudiante (10)
       Desempleado (11)
       Otro (12): …………………………………

49. Indique la actividad en la que se desempeñaba antes de la crisis de COVID-19 (*(muchas respuestas posibles)*
       Gastronomía/ Hotelería (1)
       Taxista (2)
       Artesano (3)
       Masajista (4)
       Guía acuático (5)
       Guía turístico (6)
       Puerto Costa Maya (7)
       Sector público (bomberos, CAPA, Ejército, Policía, Fiscales, centro de salud, escuelas, capitanía de Puerto) (8)
       Pescador (9)
       Estudiante (10)
       Desempleado (11)
       Otro (12): …………………………………

50. ¿De dónde es?
       …………………………………

51. ¿Dónde nació?
       …………………………………

52. ¿Desde hace cuantos meses/años vive en Mahahual?

       …………………….……………

53. ¿Vive en Mahahual todo el año o se va en temporada baja?
       Estoy aquí todo el año
       Me voy en temporada baja

54. ¿Dónde vivía hace?
       1 año ………………………
       5 años …………………..
       10 años……………………

55. ¿Pertenece usted a alguna comunidad indígena?
       Si
       No

56. ¿Es propietario o arrendador?
       Propietario
       Arrendador

57. ¿Está usted conectado al sistema de CAPA*?
       Si *(Pase a 59)*
       No *(Pase a 58)*

58. ¿Qué tipo de sistema utiliza?

 …………………………………..

59. ¿En cuál de los siguientes rangos se ubica su ingreso mensual antes y después de la crisis? *(con propinas)*
       No ingreso
       Menos de 1000 al mes
       Entre 1000 y 2000 al mes
       Entre 2000 y 4000 al mes
       Entre 4000 y 6000 al mes
       Entre 6000 y 8000 al mes
       Entre 8000 y 10000 al mes
       Más de 10000 al mes
       No responde

60. ¿Está usted interesado en participar en un programa de educación y conservación de los bosques de manglar de Mahahual, y/o ayudarnos con un siguiente cuestionario? En caso afirmativo, podría darnos su contacto:
    1.Nombre: ………………………………………
    2.Teléfono: …………………………………........
    3.Correo: ………………………………………..
    4.Facebook: ……………………………………..

61. ¿Tiene alguna observación o comentario que le gustaría compartir, que no pudo ser expresado a través de este cuestionario?
………………………………………….………
………………………………………….………
………………………………………….………
………………………………………….………
       ¡Muchas gracias por su participación!

B. Follow-up of the research

This paper will be valuable for further research focusing on ecosystem services and conservation of the environment. It is the starting tool for future projects which would evaluate the economic value of each ecosystem services, and put an economic value of mangroves ecosystem as a whole.

If a conservation project of mangroves were to be designed, a cost-benefit-analysis of it would require valuable information which has been collected throughout the questionnaires completed during the fieldwork. Data concerning the willingness to pay to protect against natural disasters, erosion and floodings can be used to measure the economic value of related ecosystem services. Economic values from the fish industry also evaluate part of the biodiversity ecosystem service. The willingness to pay of the residents could also be used to measure the mangroves economic value as a whole, without differentiating per ecosystem service.
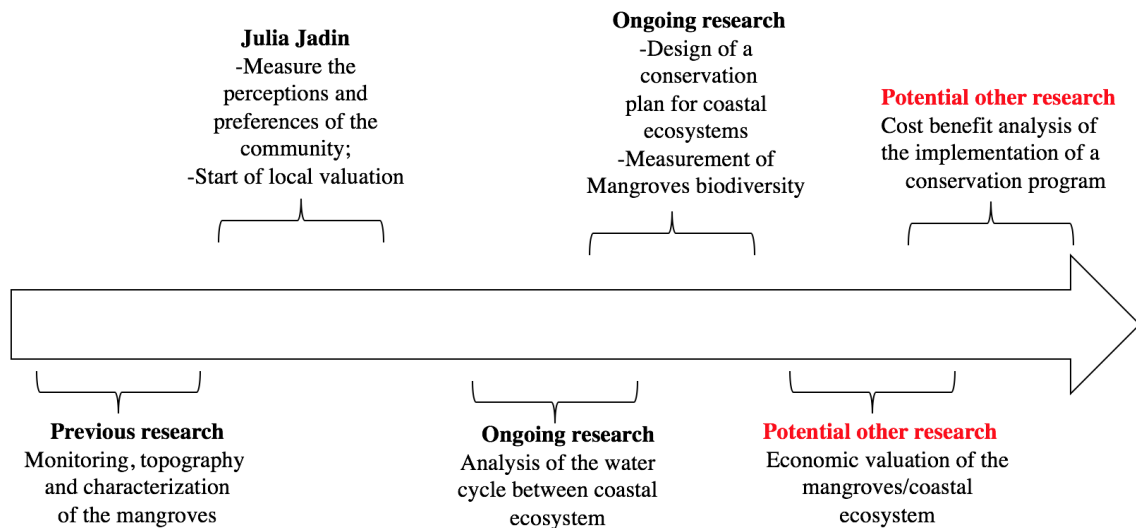

Figure 1: Timeline of projects for Takata Research Centre

Figure 1 illustrates the importance of this project on the timeline of Takata Research Centre. While the mangroves conservation project is constantly evolving and growing, future projects will be needed in order to put a more accurate value on the mangroves or coastal ecosystem. Furthermore, if a conservation plan were to be designed, a cost-benefit analysis of the latter would be the natural step to undertake for any interested party specialised in environmental economics. The CBA would need in a first step

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the economic valuation of the mangroves ecosystem, and then compute all costs of the project.

Appart from the economic valuation of the ecosystems, there are also various other research opportunities which can be based on the collected database on which this paper is based on. Using econometrics such as the introduction from section 4, the following research questions could be investigated, among others:

- What is the economic impact of the COVID-19 crisis on the job market and income of the community?

- Did the COVID-19 crisis decrease gender inequalities in Mahahual?

- What are the socioeconomic variables influencing the willingness to pay of respondents concerning conservation, and is there a difference between mangroves and coral reef preferences?

While these three questions are examples from the author's thoughts, many other research questions can be designed from the collected database. Mahahual has the opportunity with its small size to be a advantageous field of research for any economist interested in doing field research and apply its applied microeconometrics skills.

C. How to germinate red mangroves shoots

During my 7 months in Mahahual, I collected mangrove shoots in order to try to germinate them and start a nursery. Below is a picture of the evolution of the stages.
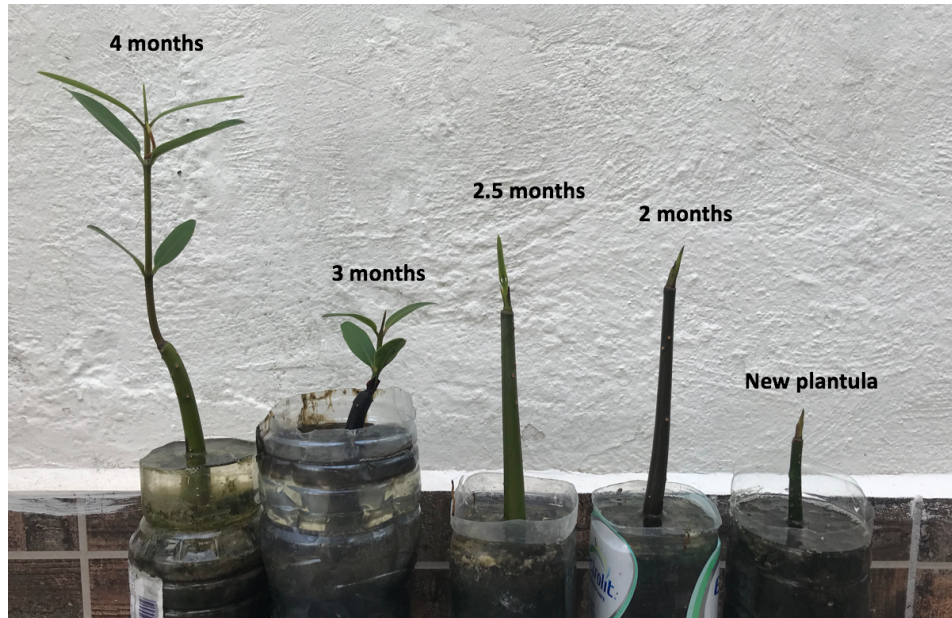

Figure 2: Evolution of mangrove shoots

Below are the steps to follow to germinate mangrove shoots:

1. Collect mangrove plantules in the mangroves (do not take it from the threes!); take it from the ground in case noticing they are not placed in a manner that would have allowed it to grow in its natural environment (*example: I collected mines on the wooden bridge in the mangroves; they would have not been able to grow there*)

2. In a cut bottle (do not make holes under the pot), put half of mud from mangroves, and half of potting soil

3. Fill half of the bottle with freshwater, and the other half with salt water

4. Make sure the soil is never dry

5. Add fresh water anytime there is water missing, and saltwater once a week

6. When the plant will be strong enough to be replanted (more or less 6-7 months I would say), take it out of the pot and place it in the mud or in the ocean directly, making sure the soil is fertile (*It is fertile wherever there are plants, and better where there are plants from the same specie)*

Figure 3: Picture of the start of the red mangroves nursery