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Exploring the perception of decision-makers towards a marine renewable energy project on the island of Cozumel, Mexico

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Abstract

New Marine Renewable Energy (MRE) technology to harvest energy from the ocean is being developed worldwide, including in Mexico, and it will probably increase in the future. Importantly, as new technologies for MRE electricity production develop, it is necessary to assess the societal perception and the acceptance of these new technologies. Ignoring these is an error that could result in the opposition and interruption of these projects, even if they benefit the environment and society. Thus, this study aimed to explore local authorities' perceptions of the development of a marine energy project off the coast of Cozumel. The approach was qualitative, and the methodology consisted of conducting open interviews with key actors to inquire about the perceived challenges to developing a marine energy project. The results show that the main perceived limitations are social, highlighting the resistance of various groups towards external projects. The resistance to changes in the environment results from previous experiences where the project promoters neither informed adequately the population about the practice of conducting research in the area nor shared the results and did not consider the participation of local actors.

Highlights

- There is a growing demand for Marine Renewable Energy (MRE) especially near the coasts.
- The island of Cozumel in the Mexican Caribbean may be subject to harvesting MRE.
- We explored the authorities' perceptions of society's acceptance of MRE.
- Resistance to new technologies results from misinformation and unclear benefits.
- The participation of local agents and effective communication is essential.

Keywords Marine Renewable Energy (MRE), Sustainable development, Cozumel, Mexico, Social perception

1 Introduction

This study explores the perception of key actors and decision makers living on the Caribbean island of Cozumel (Mexico) regarding their perception and acceptance of a marine renewable energy project, which aims at reducing and eliminating greenhouse gas emissions as actions to mitigate climate change.

Climate change is a global problem and involves many dimensions: science, economics, society, politics, moral and ethical questions (Martínez et al. 2024). Strategies

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such as mitigation and adaptation are society's most urgent challenges for reversing and adapting to climate change. Mitigation involves reducing greenhouse gas emissions. Some options for mitigation of climate change include: protection of natural carbon-sink resources; restoration and afforestation; reduction of the emission of greenhouse gases, and adopting renewable and clean energy technologies (Wang et al. 2023). Adaptation strategies involve society's actions and are essential alongside mitigation strategies that will help address the challenges of global warming (Wang et al. 2023). This is because it will take decades of climate change mitigation efforts to significantly reduce increasing temperatures.

The mitigation of climate change has led to different actions, alternatives, and policies (<https://www.ipcc.ch/>). For instance, many Sustainable Development Goals (SDGs) stated by the United Nations are affected by climate change (Halkos G & Gkampoura 2021), such as poverty (goal 1), hunger (goal 2), health and well being (goal 3), clean water and sanitation (goal 6), economic growth (goal 8), infrastructure (goal 9), sustainable cities (goal 11), life below water (goal 14), life on land (goal 15). Two SDGs are directly related to climate change. Goal 7 seeks affordable and clean energy, and goal 13 calls for climate action (Wang et al. 2023). Ensuring access to affordable, reliable, sustainable and modern energy lies at the heart of the Agenda for SDGs and the Paris Agreement on Climate Change (<https://sdgs.un.org/topics/energy#description>). Countries that have signed these agreements are committed to take actions to halt climate change and achieve the SDGs.

Based on this premise, interest in using renewable energy has boomed in many countries. However, there is still public debate about the costs and benefits of these alternatives compared with fossil energy (Holechek et al. 2022). On one hand, energy production with the new technologies may be more expensive and less efficient in the short term. However, on the other hand, the environmental impact of renewable energy production is expected to decrease, especially regarding the emission of greenhouse gases and climate change (Chapman et al. 2018). Nevertheless, despite the relevance of acting to slow climate change and developing new technologies, the transition towards renewable energies is occurring at a relatively slow pace. The 2024 Statistical Review of World Energy (Energy Institute 2024) reported that in 2024, renewables' share of total primary energy consumption reached 14.6%, representing a 0.4% increment compared with the previous year. Together with nuclear, they represented over 18% of total primary energy consumption. In addition, fossil fuel consumption as a percentage of primary energy dropped 0.4% to 81.5%. Such reduced percentages of renewable energy production

show how far behind in advancing energy production technologies that can help halting or slowing climate change owing to fossil fuel consumption.

Interestingly, PF Nexus (2024) (<https://www.pfnexus.com/top-10-energy-storage-investors-in-latin-america-and-caribbean>) recognizes Latin America as a global leader in renewable energy, with 60% of its electricity sourced from renewables—double the global average. The region is rapidly advancing its wind and solar capabilities while enhancing energy efficiency. Solar PV systems, wind turbines, and hydropower are the most widely utilized technologies, with Brazil, Mexico, and Chile leading large-scale projects. In November 2023, the Renewable Energy Country Attractiveness Index (RECAI 2023) ranked these three Latin American countries 19, 16 and 35 respectively, as countries that were attractive for renewable energy production (<https://www.ey.com/content/dam/ey-unified-site/ey-com/en-gl/insights/energy-resources/documents/ey-recai-62-v9-final.pdf>). In Mexico, the government reported that in 2023 the production of renewable energy represented 26.5% of the total energy produced (SENER 2024).

Marine renewable energy (MRE) is one of the incipient renewable energies being developed worldwide (Copping et al. 2024). It involves the generation of energy (electricity) from the movement of seawater including tides, waves, and persistent ocean currents, as well as from the gradients of temperature and salinity in the oceans. Some countries also include energy generation from the open waters of large rivers and offshore wind energy as part of MRE. Each MRE resource requires a different type of device to harvest that energy and transform it into electricity. Depending on the type of energy, the devices are placed in the appropriate portion and depth of the ocean or large river and secured to the seabed (or riverbed) either by weight or by anchors. Compared with its potential, the efficiency of transforming ocean energy into electricity still needs to be improved. It is a promising renewable energy alternative, especially in countries with a long shoreline.

The above means that MRE still has little market penetration because technology development is in progress and, therefore, the prices and efficiency are less competitive compared with fossil fuels and conventional renewables, such as solar or wind energy production (Holechek et al. 2022). Despite the high investment and consumption costs, there is already relevant progress in MRE production in some countries. For instance, in the United Kingdom and Chile, production costs decreased by 40% after ten years of installation of devices. The estimates of 2023 revealed the following costs: US\$1,325 per MWh for wave farms; 150 US\$ per MWh for tidal energy (tides), 10,000 to 20,000 US\$ per MWH for OTEC and

1325 US\$ per MW for oscillating water column (Rehman et al. 2023). These were very high if compared to those of fossil energies for 2024, which fluctuated between 45 and 108 US\$ MWh (Lazard LCOE 2024).

In the case of Mexico, which has 11,122 km of coastline, MRE has a high potential for ocean energy electricity production, even if only some of its coasts are suitable for this (Hernández-Fontes et al. 2020; Gorr-Pozzi et al. 2023; Sánchez & Mendoza 2024). Different studies identify sites where the physical conditions are adequate for ocean energy production. For instance, Ocean Thermal Energy Conversion is available in Cozumel, Jalisco, Oaxaca, and Baja California Sur. Ocean currents are also available in Cozumel and the large islands in the Gulf of California (Alcérreca-Huerta et al. 2019) and, also, off the coasts in southern Mexico (Hernández-Fontes et al. 2020; Garduño-Ruiz et al. 2021) (Fig. 1).

Besides the theoretical possibilities of ocean energy production, before deploying new ocean energy devices, project promoters must assess the environmental impacts and take actions to keep them at a minimum possible (Chapman et al. 2018; Copping et al. 2024). In addition, it is relevant to consider how modern technologies affect human activities such as fishing and tourism. Indeed, the installation of new technologies in a territory (intervention processes) can be complex and entail social conflicts that make it difficult to launch new projects. The above may occur even when these new technologies have a positive social effect and reduced environmental impact, as is the case of MRE production.

In Mexico, the island of Cozumel, in the Mexican Caribbean, is expected to have an increased electricity demand because of the sustained population growth and rapidly growing massive tourism over the last decades

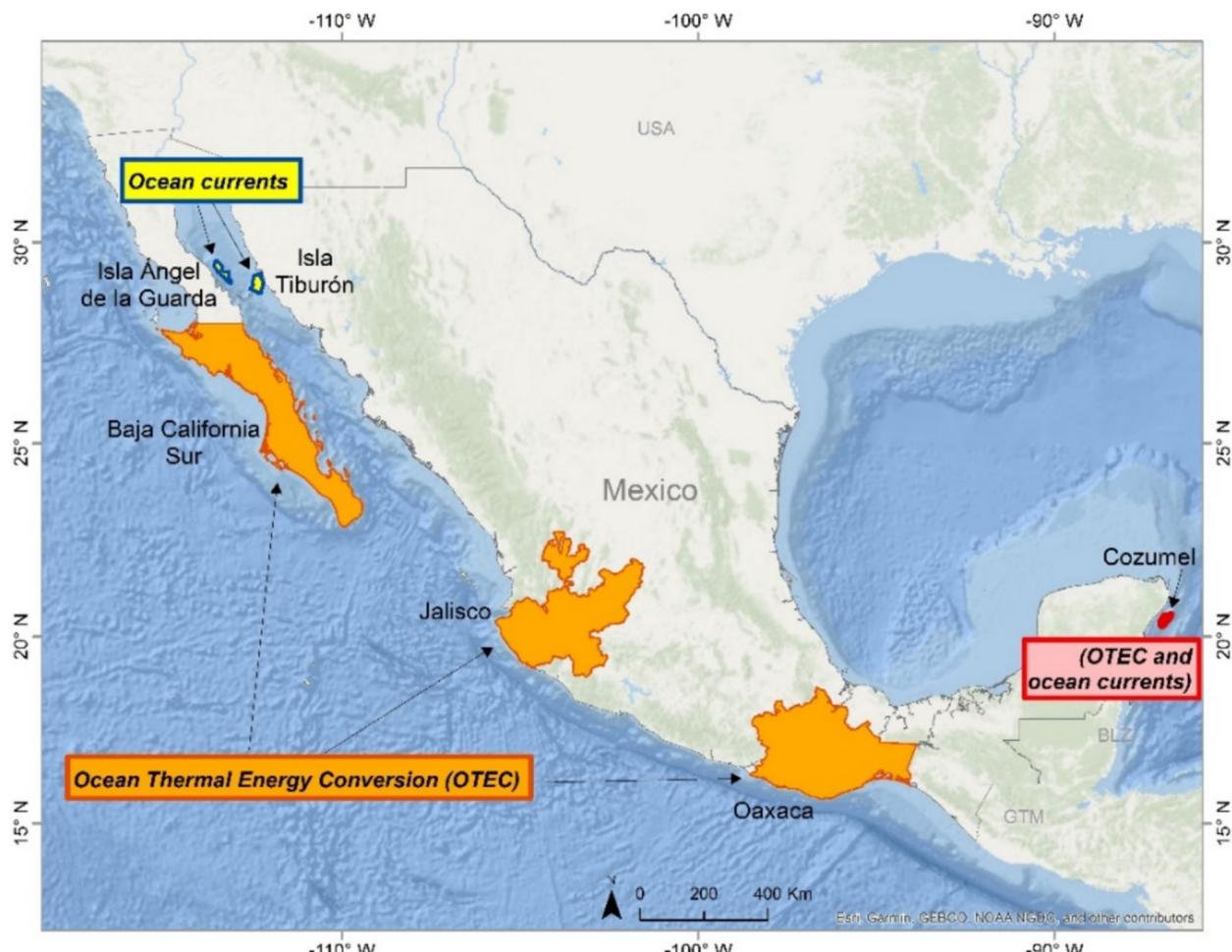


Fig. 1 Regions where the physical conditions are adequate for ocean energy production from different sources, such as Ocean Thermal Energy Conversion and Ocean Currents. Map created based on information from Alcérreca-Huerta et al. 2019; Garduño-Ruiz et al. 2021; Hernández-Fontes et al. 2020; Gorr-Pozzi et al. 2023; Sánchez & Mendoza 2024)

(SECTUR 2013; 2014). Such intense tourism activities typically consume a formidable amount of electricity and water. For instance, the touristic industry of Cozumel consumes more than 1.2 million m³ of water a year (Programa Marco Cozumel 2018). In the Yucatan Peninsula, water consumption by tourists is more than double that of residents (Lima-Vargas et al. 2024). There is no public information regarding the yearly electricity consumption in Cozumel, but it is likely to be very high, considering the 4,687 hotel rooms with air conditioning (INEGI 2018). Energy consumption increases with the arrival of tourists, as was determined by Pablo-Romero et al. (2023) in the ten most visited countries in the world (Mexico ranking 7th worldwide).

To compensate for and reduce such environmental impact and achieve a more sustainable tourism scenario, the World Tourism Organization seeks to promote energy reconversion in this sector (TURISCOM 2014; SEMARNAT 2017). In this sense, recent studies are exploring the possibility of harvesting ocean current energy from the Cozumel channel to provide the island with electricity. Located along the island's western shore, in front of the continent, the Cozumel channel reaches a maximum of 400 m in depth and 18 km in width. The Yucatán current flows through the Cozumel channel, and thus, harvesting MRE is possible in the area (Alcérreca-Huerta et al. 2019; Maslo et al. 2023). Since 2017, the Mexican-based CEMIE-Oceano project has been developing modern technology to harvest energy from ocean currents while assessing environmental impacts and social responses. The above implies both the evaluation of the ecological settings of the area and the social conditions of the human settlements, which includes the position and acceptance of citizens and local authorities regarding the installation of these devices in their territory. Assessing the public perception of Marine Renewable Energy in Cozumel Island is relevant because the project may fail when public opinion is ignored (van de Grift & Cuppen 2022). Such problems already occurred in the past in Cozumel with the promotion of a wind farm in the island's center (Caballero 2013). The local inhabitants halted the project because of fear of alterations to their natural environment and the absence of local benefits since the project planned to transport the energy produced to the hotels of the Mayan Riviera on the continent (Valdivieso 2012).

Indeed, public opinion is a central element in territorial intervention projects for using energy resources, whether conventional or not. The resistance of residents towards the deployment of renewable energy-producing devices is likely to occur even when the environmental impact of renewable energy production is less than that of fossil fuels. There are several aspects that influence the

opposition that residents have, such as the need to know the benefits and harms of the project, so it is essential to pay attention to the particularities and characteristics of each site (Wolsink 2000; Ek 2005; Qazi et al. 2019). Considering this framework, this study aimed to explore the perception of local authorities regarding the development of a marine energy project off the coasts of Cozumel, possibly in the Cozumel channel.

2 Methods

2.1 Study site: the island of cozumel

The study took place in the city of San Miguel Cozumel, with 85,000 inhabitants. The city is on the island of Cozumel, located in the Mexican Caribbean area, 17 km off the eastern coast of the Yucatan Peninsula, Mexico (20°3'N and 87°3'W; Fig. 2). The climate is warm sub-humid with a mean annual rainfall between 800 and 1500 mm and a temperature of 26–27°C. The driest months are March and April, with the highest rainfall in September (Castillo-Campos et al. 2023). Tropical cyclones (e.g. tropical storms or hurricanes) hit the island from June 1st. to November 30th), making landfall on the Caribbean part of the island. Human settlements and infrastructure are located on the other side of the island, facing the continent, where the protection from storms is better than on the eastern coast.

Cozumel is an important tourist site in the Mexican Caribbean and receives nearly 6 million tourists every year (<https://www.lajornadamaya.mx/quintanaroo/229238/cozumel-recibio-1-6-millones-de-turistas-los-tres-primeros-meses-de-2024#:~:text=Cozumel%2C20la%20isla%20m%C3%A1s%20grande,hoteles%20fotantes%20y%20ocupaci%C3%B3n%20hotelera>). This is significant, considering the size of the island (894 km²) and relatively small permanent population (85,000 inhabitants) (Sánchez-Crispín and Propín-Frejomil 2003).

Several island characteristics drive the tourism industry, such as the infrastructure for docking cruise ships, making the island one of the leading destinations worldwide for this modality (SEGOB 2017). Furthermore, its white beaches, bathed by the beautiful Caribbean Sea and the second largest barrier reef in the world, the Mesoamerican reef system, attract many tourists yearly. Cozumel is one of the best places in the world to go diving (Palafox-Muñoz & Rubí-González 2021).

The island has beautiful dune scenarios along the east coast intertwined with caverns and small bays (Sánchez-Crispín & Propín-Frejomil 2003). The combination of the dunes and caverns with the iconic Caribbean blue ocean make the landscape particularly captivating. Several eco-tourism parks (such as Chankannab and Punta Sur) receive thousands of visitors every day. These parks offer nature-related activities,

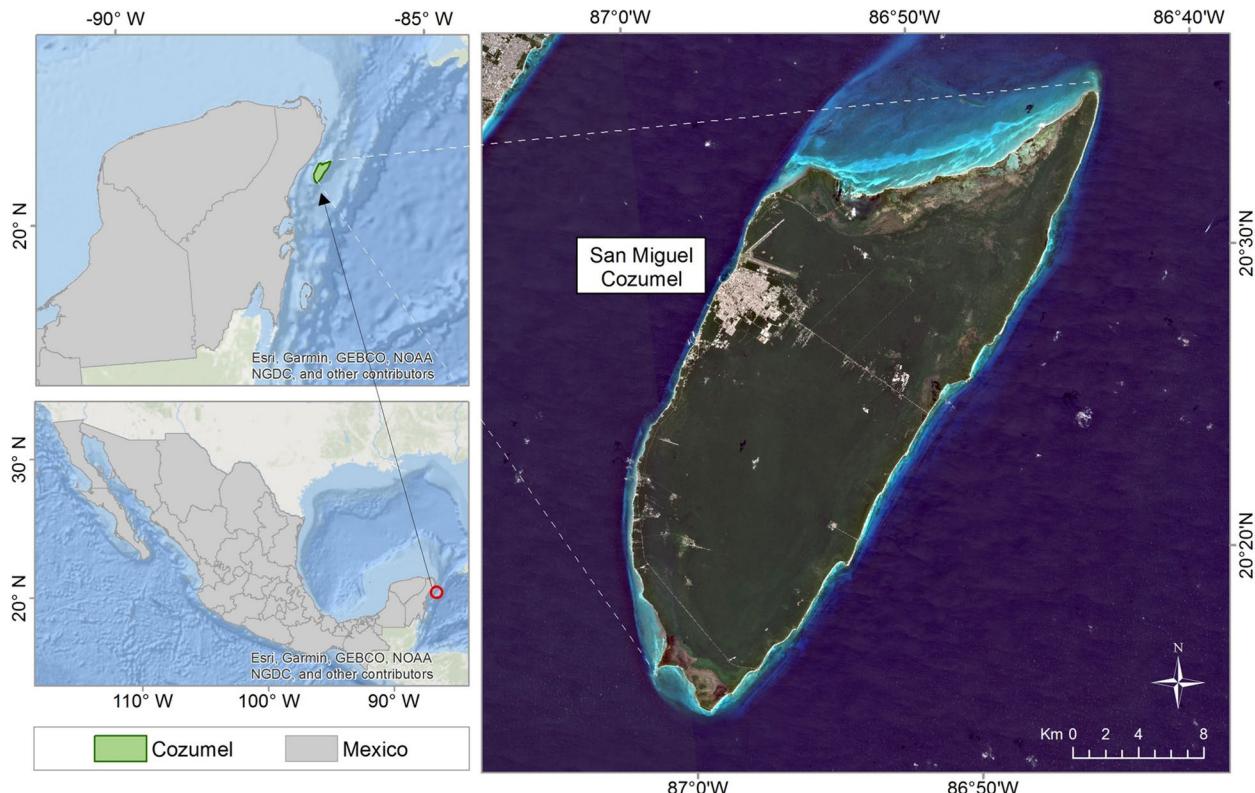


Fig. 2 The location of the study site is the Island of Cozumel in the Mexican Caribbean

such as snorkeling and observing areas of fauna and flora. Chankannab contains the lagoon of Chankannab which is a protected area. The eco-touristic park Punta Sur is the largest reserve of Cozumel and hosts a high diversity of species of plants and animals. It also contains archaeological remains and a lighthouse from which the views are spectacular (Cozumel Parks 2017).

Besides its natural wealth, Cozumel has 35 archaeological sites, of which San Gervasio is the largest. The Mayan culture populated Cozumel about 1,700 years ago. It flourished thanks to its commercial port and a ceremonial center dedicated to the goddess of fertility, Ixchel, which called for pilgrimages from the continent (Antowich 1991).

Cozumel's biocultural attributes have led the island to the limit of its carrying capacity (Segrado et al. 2008; Pavón 2023), both in terms of local inhabitants and mostly tourism. This overexploitation increasingly affects the island's natural ecosystems, the most relevant assets that drive tourism. Thus, actions are necessary to maintain this fragile island (Alvarado-Herrera et al. 2020; Segrado-Pavón 2023).

2.2 Interviews

Before this study, a Likert scale survey was applied on the island to investigate citizens' general opinions about renewable oceanic energies (Wojtarowski 2020). In that research, the sample comprised 50 adults residing in Cozumel who were randomly selected through opportunity sampling. The only requisite was that the interviewees were local residents over 18 years old, and who were willing to answer. The study by Wojtarowski (2020) revealed that a significant majority of respondents (82%) had a positive assessment of renewable energies. At the same time, it was evident that 32% had little information on the subject.

Despite the tendency to positively value renewable energies and an inclination and interest in their use, previous experiences on the island of resistance to territorial intervention projects inclined us to investigate more deeply among key actors in the locality. To obtain a more in-depth description of society's perception of MRE, we searched for key actors from the different institutions dealing with environmental issues of the island of Cozumel. Some of these actors had a previous understanding

of renewable energies and experience in public service; others had operational positions within the tourism industry. In this way, we aimed to have a more complete vision of what it could mean, from a social perspective, to carry out an ocean energy project in Cozumel.

Prior to visiting the selected actors, we contacted them through electronic mail or phone calls to explain to them the purpose of the interviews. We thus confirmed whether they would be interested in being interviewed or not. If the answer was positive, date and time were programmed.

The key actors interviewed worked in different relevant institutions of Cozumel that participate in environmental and decision making (Table 1). The names of the interviewees are omitted for confidentiality.

We considered that the most appropriate inquiry tool was an open interview, as it promotes a dialogue where the informant can freely express their opinion on a topic (Vasilachis de Gialdino 2006; Izcara 2014). The interviews took place at the work centers of each informant in Cozumel in February 2020. The central topic of the interview was the informants' position on the degree of acceptance that a marine energy project would have on the island and the main challenges that the project could face. In some cases, such as the Chankanaab lagoon, the eco-touristic park Punta Sur, and the archaeological site San Gervasio, we were invited to walk around the installations and talk with the workers besides the people in command. In all cases, the interviews took place relaxed and respectfully. The interviewees freely expressed the degree of acceptance a marine energy project would have on the island and the main challenges the project could face.

It is important to note that two interviews, those aimed at the Municipal Tourism Directorate and the National Commission of Protected Natural Areas (CONANP), did not take place because it was impossible to reconcile agendas with the officials of both institutions. In this

case, despite the absence of the voice of these two institutions, it is possible to offer relevant and valuable information to meet the objective of the research, which is to show the challenges that the development of a marine energy project in Cozumel would entail from the perspective of experienced actors, whether in public service or in key positions in the functioning of the island.

Before the interviews, all participants were fully informed of the project's aims. They were guaranteed that their responses would remain anonymous and that their private personal information would not be shared or published. After ensuring that the participants understood the study's goals, all agreed to have their responses published. We closely followed the Mexican laws regarding the ethics of studies with humans: "Ethics Code of the Public Administration" (https://www.gob.mx/cms/uploads/attachment/file/706145/Co_digo_de_E_tica_de_la_Administracion_Publica_Federal.pdf) and the General Law of private information (<https://www.diputados.gob.mx/LeyesBiblio/pdf/LGPDPPSO.pdf>). Similarly, the institutional Ethics Committee of INECOL verified that the study was performed respectfully, honestly, and without discrimination or harassment (<http://normateca.inecol.edu.mx/normateca/documentos/0407.pdf>).

The interviews were recorded with a portable recorder and then transcribed by one of the authors (AW). Later, the transcribed interviews were analyzed to search for common patterns of similarities and differences between the interviewees. Once the study was finished, we shared the results with the interviewees, by sending them electronic copies of the reports to their electronic mail directions.

3 Results and discussion

Several trends help us understand Cozumel's specific circumstances from the participants' perception of MRE. Among the most notable are the following:

Table 1 List of interviewees, institution and position

ID	Institution	Position
1	Cozumel Military Fortress	General Commander
2	Cozumel Secretariat of Ecology and the Environment	Sub-director
3	Cozumel Secretariat of Ecology and the Environment	Assistant of the Subdirector
4	Port Captaincy	Captain
5	Secretariat of Urban development of the county of Cozumel	Director
6	Secretariat of Culture of Cozumel	Sub-director
7	Eco-Park Chankanaab	Sub-director
8	Punta Sur State Eco-Park	Director
9	Archeological site San Gervasio	Director

- 1) *Intervention of the territory*.- The interviewees consider that the citizens' main concerns associated with the territory's intervention are environmental. There is a strong concern regarding the possible deterioration of the island's ecosystems due to implementing projects that use or affect the natural environment. The residents of Cozumel are aware of their natural heritage and its fundamental relevance to carrying out their main economic activity and source of income: tourism.
- 2) *Resistance towards outsiders*.- There is a shared perception of the resistance on the island towards projects that come from abroad and do not consider local institutions or actors. They also perceive a disagreement among actors and groups on the island, who state that it is a common practice among those conducting research in Cozumel to keep their results private.
- 3) *Distrust*.- Linked to the previous element is planning projects to exploit the natural environment, of which the population is not informed or is informed in a limited way. In addition, citizens' opinions should be considered when carrying out such projects.

Based on the above, we performed a horizontal analysis of the interviews, synthesizing the most relevant responses. The results of the interviews were analyzed and interpreted according to different approaches: social conflicts and renewable energy; the conflicts of extractivism; communication opportunities; socialization of the project; public consultation and recommendations.

3.1 Social conflicts and renewable energy

A fundamental element on which all the participants agreed was that, to carry out a project to harness marine energy in Cozumel, the most significant challenge would be the resistance of society towards new technologies. To express this opinion, they base themselves on the island's previous experience with other projects, such as the one narrated by the following informants:

"There is a precedent of a wind farm project canceled by social opposition due to the absence of consultation. There was a generalized social resistance to implementing this project" (ID 5).

"I remember the cancellation of the wind farm, where organizations like Citymar and other groups opposed the project because they considered it would not benefit society" (ID 06).

The wind farm to which the interviewees refer and briefly mentioned before was a project promoted by the North American company Mexico Power Group, which intended to install 114 wind turbines in the island's

center. It turned out that the population found out they would not receive any benefits since the project planned to sell energy generated to the hotels in the Riviera Maya in the continent (Valdivieso 2012). In addition to the theft of resources by intervening in its territory without receiving any benefits, a series of protests by the local inhabitants took place owing to the fear of suffering severe impacts on the island's water table because of the placement of the towers. The company canceled the project due to the significant local public opposition (Cabalero 2013).

3.2 The conflicts of extractivism

The local opposition to the intervention of the territory is not only associated with energy projects. There are other sensitive factors for the population and for the activists of Cozumel, who, according to the opinion of some informants, usually resist external projects. Several opinions coincided on the matter:

"Some territorial defense organizations and other groups have recurring complaints regarding those visitors who perform research activities on the island and do not share their data or do not collaborate with local actors, such as with the academic and scientific staff of the local University of Quintana Roo, for example" (ID 03).

"The link with local people and institutions is important since there is high sensitivity to projects that come from external agents. The opposition to external actors occurred when updating the Local Ecological Planning Program since the government hired an external consultancy to prepare it. The Ecological Planning Program elaborated externally caused suspicion in the population" (ID 8).

The informants' opinion shows the population's particular sensitivity towards the development of external projects. The term extractivism comes from the physical extraction of materials, generally associated with deterioration and high environmental, economic, and social costs, in mining and the oil industry (Szeman & Wenzel 2021) that render little or no benefits to the local population. This concept is also transferred in language and is used as a metaphor to explain the subtraction of material and knowledge or internal data from a region, which are then used to benefit private interests, whether academic, economic, or of any other type.

This type of exploitation of territory, both in its material and intellectual form, usually causes discomfort among citizens and reduces the possibility of them presenting a positive attitude or agreement with the projects. A long history of Latin American extractivism is associated with population resistance and social

conflicts. Several examples illustrate this: the classic hydrocarbon industries in Ecuador and Peru (Picq 2020; Svampa 2021); mining companies in Chile, Mexico, and Ecuador (Smart 2020); the energy sector in Bolivia; neo-extractivist, linked to progressive governments in Argentina, Brazil, Bolivia, Ecuador, Uruguay, and Venezuela. Although the latter present different forms of legitimacy, they have yet to solve the socio-environmental damages of their operation (Szeman & Wenzel 2021).

Often, decision-makers consider that natural resources benefit the territories that possess them. However, in Latin America, on countless occasions, they have not positively impacted the development of states and nations. On the contrary, they have instead represented a kind of curse known as "the paradox of abundance" (Karl 1997; Afzal et al. 2023) that has eroded them environmentally and socially. Resources are plundered, and territories become suppliers of raw materials to enrich countries in other latitudes with greater economic power. Alternatively, resources concentrate in the lands of elite groups. This centuries-long history has generated suspicion and distrust, which has penetrated the collective memory of some groups and populations.

3.3 Communication opportunities

Despite the depth of mistrust, communication and relationship strategies with the population help mitigate the lack of trust. In that sense, some informants contributed valuable ideas to develop a MRE project in Cozumel, considering the position of citizens. An open dialogue is necessary for transmitting truthful information through a transparent process, and any doubts and concerns the local population may have are identified and explained. Examples of these alternatives are shown below, with opinions on this topic issued by various public officials:

"It is essential that the project is fully known and understood and made public by truthfully informing the population and asking for their opinion, as well as that of the ecology sub-directorate. In addition, adequate project communication is needed, probably through worktables or workshops" (ID 3).

"The project proponents must adequately and accurately inform the population about the project. There must be a benefit for the island, and this must be clear to the population, and a public consultation must be carried out" (ID 5).

"It is important to socialize the project and inform the population about it before carrying it out. Otherwise, a negative predisposition occurs...Having some control over what will happen in the future is important. Therefore, it is necessary to disseminate and share information sincerely and to fore-

see whether it will be necessary to take preventive or precautionary measures" (ID 6).

3.4 Socialization of the project

The emphasis of those interviewed on the importance of socializing the project before carrying it out is clear. The project's socialization should be done transparently and provide the most significant amount of information so that the benefits for the local population are known, as well as the potential risks if they exist. Below is the opinion of another informant who supports this position:

"It would be important to organize conferences or workshops demonstrating how conventional energy sources (fossils) affect the environment and how Cozumel obtains its electrical service from these sources. It is necessary to demonstrate that ocean energy is clean and why its use is convenient for Cozumel. The local inhabitants need to see what the devices look like and how they work. It is also necessary to demonstrate how this project can economically benefit the island's population. The characteristics of the project should be presented with truthful information and in coordination with the participation of local actors" (ID 8).

The interviewees emphasized the need for effective communication before deploying MRE devices. Local and international experiences suggest the importance of transparently communicating these projects' possible economic, landscape, or ecological effects. The socialization of the project helps reduce the perception of the population, and actors involved that the project has hidden agendas or that their participation is only a justification for decisions previously made.

Previous and similar experiences both in Mexico and in other countries have demonstrated the relevance of the socialization of these projects: the wind farm in Cozumel and the marine wind farm in Trafalgar, Cadiz (southern Spain), both canceled because the intense social opposition (González & Estévez 2005; Ide et al. 2021). The Spanish case demonstrated that an abstract public position favoring alternative energies is not enough since it is not inherent to accepting a specific project in the territory. Residents define their positions based on their experiences with similar issues and how project promoters and authorities communicate. The perception of authentic participation and transparency in the management of the plan influences the population to have a positive attitude toward a specific project (Devine-Wright et al. 2020; Hooper et al. 2020; Quirapás & Taeihagh 2021).

3.5 Public consultation

Besides the socialization of the project, it is necessary to perform public consultations regarding the deployment of new projects in the territory, seeking broad participation from society and ensuring that communication strategies have been implemented and are effective. When an intervention has not arisen from a concern or request from the locality itself, social participation through a public consultation is necessary so that the project becomes part of the community. Although it is true that, for decades, there have been efforts and many success stories in Latin America to replace conventional planning with a participatory one, the former is still present in countless territorial intervention projects, sometimes under different versions of participation (Cantarero 2020; Martínez & Komendantova 2020).

This conventional model, where the community does not participate and only adjusts its behavior to the decisions of the authority or the group that implements the project, has proven ineffective in Latin America. Indeed, in its rationalist technical vision, the technocratic paradigm ignores the turbulence resulting from the interactions of a diversity of social actors—among which is the citizenry—involved in the project. Social resistance arises when the model promotes a reality based on their interests, which are not always concordant with society's opinion (Cantarero 2020; Martínez & Komendantova 2020).

3.6 Recommendations

Some appropriate steps, derived from the context of participatory methodologies, include strengthening links with society. The project is viable when the relationships with the most critical actors among the project's beneficiaries are promoted. Due to their decision-making capabilities, other critical actors, such as public organizations and institutions, are deemed indispensable during the process (Cantarero 2020). In this sense, the interviewees made the following recommendations:

"Adequate communication of the project is essential, probably through working groups or workshops where business chambers, civil environmental organizations, civil organizations of Cozumel, and environmental institutions participate" (ID 3).

"It is necessary to work with the graduate school of the University of Quintana Roo, Campus Cozumel, which has experts in geography, limnology, and sustainable tourism management, among other areas or specialties. Linking with local people and institutions is important since there is high sensitivity to projects that come from external agents" (ID 8).

"A public consultation is necessary, and it must clearly show the benefits for the island to the population" (ID 5).

The opinions converge on the importance of diverse actors' participation and doing so through an effective communication strategy that offers clarity and certainty.

3.7 Limitations of the study

This study shows the responses and perception towards MRE of nine key actors who worked in different relevant institutions of Cozumel. They participated in environmental and development decisions on the island of Cozumel at the time of the interviews and thus, had detailed information of society's perception toward renewable energy. Because of the detailed in-depth interviews that we performed, and the amount of time invested in each (during the interview and processing the information) there was a limit on the number of people we could approach. Nevertheless, because the interviewees were key actors in Cozumel, we consider that their viewpoints are representative of the perception of the decision makers of the study site. In depth interviews with key actors provided detailed information on the topic addressed (Osborne and Grant-Smith 2021).

In addition to the above, it is important to acknowledge that there will be some differences not only between interviews (because of differences between the interviewees) but also between interviews conducted by different interviewers. Interpersonal dynamics come into play in this form of interviewing and can influence results (Osborne and Grant-Smith 2021). Nevertheless, in our case this was not a problem because the interviews were all performed by a single person (AW).

Finally, the perception of people towards the deployment of new technologies can be time- and context dependent. People's opinions and perceptions may change over time. Thus, exploring social perception towards the deployment of renewable energy devices needs to be performed in tandem with the development of technology. Furthermore, longitudinal research may also be appropriate to follow actors over time and consider the passing of time. In quantitative research a longitudinal study with measurements at several points in time is the favored pathway for assessing changes according to the social and cultural context (Hollstein 2021).

4 Conclusions

The results show a convergence in the perception of the interviewees. They identified that the main challenges in Cozumel for developing a MRE project are social, highlighting the resistance of various groups towards external projects. The resistance to changes in the environment

and social conflicts with the development of new technologies for renewable energy extraction derive from previous experiences on the island. These previous experiences aimed at the exploitation of the island's natural resources for the benefit of outsiders (extractivism). Furthermore, communication of the promoters with society was poor. The socialization of projects were overlooked and public consultation and recommendations were ignored. Local actors did not participate either. The result is mistrust and strong opposition.

For these reasons, the interviewed key decision makers propose collaborating with local actors, communicating the research results in the territory, truthfully showing the project's particularities, and sincerely addressing the potential environmental effects. Finally, those interviewed agree that holding a public consultation, not as an administrative requisite but as a decision factor, is a fundamental element to consider for the success of an intervention process in Cozumel. The conclusions of this study can serve as a guide for any project in Cozumel. The social benefits need to be clear, but the participation of local agents and effective and sincere communication of each project is essential.

Finally, future research considerations could involve a) evaluation of participatory governance models that integrate decision-makers and local community members into all stages of territorial intervention projects; b) analysis of effective participation and communication strategies to assess which communication methods are most effective in adequately communicating the characteristics of marine energy projects in particular; c) studies on social acceptance and perception that involve a wide variety of local stakeholders (residents, fishermen, tourism service providers, authorities, NGOs); d) performing a longitudinal study with measurements at several points in time is the for assessing changes according to the social and cultural context.

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Authors' contributions

Conceptualization AW, Data curation AW, Formal analysis AW, Funding acquisition MLM, Investigation AW, Methodology AW, Project administration MLM, Visualization MLM, Writing – original draft AW, Writing – review and editing MLM.

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

Institutional review board statement

The study closely followed the Mexican laws regarding the ethics of studies with humans: "Ethics Code of the Public Administration" (https://www.gob.mx/cms/uploads/attachment/file/706145/Co_digo_de_E_tica_de_la_Administracio_n_Pu_blica_Federal.pdf) and the General Law of private information

(<https://www.diputados.gob.mx/LeyesBiblio/pdf/LGDPSSO.pdf>). Similarly, the institutional Ethics Committee of INECOL overviews that the study was performed according to the institution's ethics code: respectfully, in honesty, without discrimination or any harassment (<http://normateca.inecol.edu.mx/normateca/documentos/0407.pdf>).

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Data availability

Due to the confidentiality of the information gathered from the interviews, data cannot be made freely open. However, we can make the data available upon request.

Declarations

Competing interests

The authors declare no conflicts of interest.

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