INTEGRATING STAKEHOLDERS IN MANGROVE ASSESSMENT AND MANAGEMENT PLANNING

A MODEL BASED ON COLLABORATIVE PLANNING IN VERACRUZ, MEXICO

FINAL REPORT REPLICABLE MODEL
OCTOBER 2018

Contract #CSD/RND-ME-T1313-SN1/17

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Suggested Citation: IDB 2018**.** Mexico: Integrating stakeholders in mangrove assessments and management planning: A model based on collaborative planning in Veracruz, Mexico. Washington, DC

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EXECUTIVE SUMMARY

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The purpose of this document is to present a replicable model for mangrove ecosystem management based on collaborative planning efforts in the mangrove forests of the Ramsar designated Alvarado Lagoon System (ALS), Veracruz, Mexico. The specific objectives were to (i) engage stakeholders in ecosystem assessment activities and management planning; (ii) integrate both ecological and economic measures for valuing and enhancing the resilience of mangrove forest natural capital and its underlying biodiversity and; (iii) produce a replicable mangrove ecosystem management model which can be applied elsewhere in Latin America and the Caribbean.

The project was funded by the Inter-American Development bank (IDB) in support of the IDB Country Strategy with Mexico, which includes reducing vulnerability and enhancing adaptation to climate change and improving conservation and sustainable use of ecosystem services. This strategy is aligned with the Convention on Biological Diversity's (CBD) Strategic Plan for Biodiversity (2011-2020) and Aichi Biodiversity Targets, which emphasize the participation of indigenous communities as an essential component for the conservation of ecosystems and associated livelihoods (Target 14). Broad goals of this project included supporting the government of Mexico in the implementation of its National Biodiversity Strategy (CONABIO 2000), and efforts to develop a program of long term, systematic monitoring of mangroves in Mexico, along with Mexico's National Climate Change Strategy and sustainable forestry goals.

This guide presents the results of collaborative management planning with La Mojarra, an approximately 130 member community within the Poza Honda Ejido in the ALS. Planning efforts were a collaboration among three NGO's: NatureServe, the hub of the 86 member NatureServe network connecting science with conservation, Pronatura Veracruz, a non-profit organization that for 12 years has blended scientific research and community sustainability to restore and manage mangroves in the ALS; and Conservation Strategy Fund an international NGO sustaining natural ecosystems and human communities through conservation economics. The project consisted of four components conducted between February 2017 and October 2018, and building off of Pronatura Veracruz's decade of work with communities in the ALS. The components were:

1. Stakeholder engagement and assessment using participatory appraisal methods

2. Assessment of mangrove ecological condition within La Mojarra in the context of the ALS

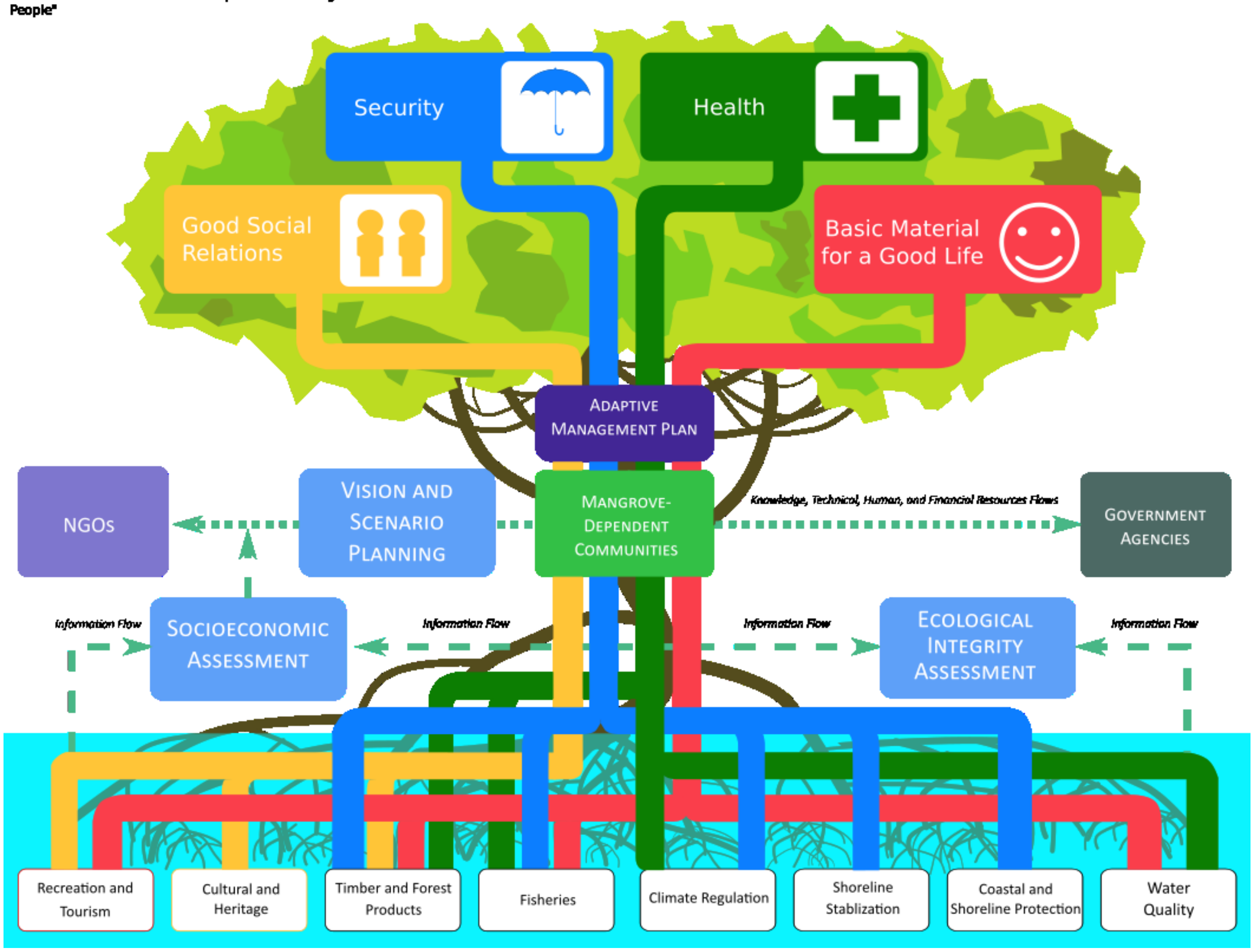
3. Socioeconomic & socioecological assessment of mangrove with participatory activities

4. Workshop with stakeholders to develop a collective vision for future sustainable mangrove use and incorporate that vision in a management plan

We share methods used in our collaborative planning with the community of La Mojarra and other stakeholders in the ALS system in an effort to present a replicable model for efforts to develop mangrove management plans with local stakeholders that can be applied with other communities in Latin America and the Caribbean.

GLOBAL CONTEXT OF MANGROVE CONSERVATION AND MANAGEMENT

Modified from UNEP 2014 "The Importance of Mangroves to All People"



This guide presents a model for enhancing community management of mangrove ecosystems based on a case study from Veracruz, Mexico. We present community-based mangrove management as centered around the many ecosystem services mangroves provide (figure adapted from UNEP 2014). Communities benefit in multiple ways from these ecological services, including from direct consumption of fish and wildlife, extraction of building materials, sales of goods, as well as socially through the cultural heritage of mangrove use in communities. Services with increasingly appreciated global values include carbon sequestration related to climate change mitigation and appreciation for the intrinsic biodiversity of mangrove forests via ecotourism. The components of the model we present (Stakeholder Engagement; Ecological Integrity Assessment; and Socioeconomic Assessment;) come together through collaborative planning workshops to develop management plans for mangrove resources. Roles for additional stakeholders and interested groups such as regional NGOs and government agencies are also identified as key to supporting successful community based management of mangrove ecosystems.

GLOBAL STATUS OF MANGROVES

Situated at the interface between land and sea, mangrove forests provide a suite of ecosystem services critical to human well-being across the globe. They support an exceptional array of biodiversity, of which a high proportion is classified as threatened or in danger of extinction (Polidoro et al. 2010, IUCN, 2018). Mangrove forests are the site of both commercial and subsistence production of fish, shellfish, timber, fuel wood, and a litany of other non-timber forest products (NTFPs; Walters et al. 2008). The key ecosystem services they provide include shoreline stabilization, buffering of storm effects, sediment trapping, nutrient cycling, and protection against wind and wave erosion (e.g. De Groot et al. 2012, Barbier 2015). The 2004 Indian Ocean Tsunami elevated the conservation of mangrove forests and other coastal wetland ecosystems as a global issue for their potential to buffer and mitigate wave and storm damage (Danielsen et al. 2005; Dahdouh-Guebas et al. 2005). It is estimated that 210 million people live within 10 km of mangrove forests and directly benefit from or depend on mangrove forests and the services they provide (Hutchinson et al. 2014).

Mangrove forests will play an increasingly important role in global climate change mitigation and adaptation efforts as they are one of the most carbon-rich tropical forest types, and can moderate the effects of extreme weather events in coastal zones. It is estimated that mangrove forests contain between 600 - 1,000 Mg of carbon per hectare on average, approximately four times that of upland tropical forests. Consequently, mangrove forests contribute up to 10% of global carbon emissions stemming from deforestation despite representing only 0.4 - 0.7% of total tropical forest area (Donato et al. 2011; Van Lavieren et al. 2012). One of the important roles of mangroves and other coastal wetlands in the context of climate change is their potential to sequester large amounts of carbon in soil. In areas where sedimentation allows soil formation to keep pace with sea level rise, these systems can act as continuing carbon sinks in the face of climate change.

Mangrove forests and coastal wetlands became the topic of increasing conservation efforts in the 1970s, beginning with the signing of the Ramsar Convention on Wetlands of International Importance in 1971. As of August 2018, the Ramsar Convention has designated 2,315 wetlands of importance covering over 245 million hectares (Ramsar Secretariat 2018). Besides the Ramsar Convention, mangrove forests are also target ecosystems for numerous international biodiversity and climate change organizations and treaties such as the Convention on Biological Diversity (CBD), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), International Tropical Timber Organization (ITTO), the Food and Agricultural Organization of the United Nations (FAO), and many others.

Despite widespread recognition of the invaluable services they provide, mangrove forests are among the most threatened tropical ecosystems in the world (Gilman et al. 2008). Their global extent is estimated to have decreased by over 25% between 1980 and 2005, a loss of approximately 50,000 square kilometers (Carter et al. 2015). At an ongoing 1% annual deforestation rate estimated by the FAO, mangrove forests could functionally disappear in as little as 100 years (FAO 2007). As deforestation rates vary greatly across regions, countries, and even provinces, functional loss of mangrove ecosystems has already occurred in localized areas (Thomas et al. 2015). Globally, the most significant drivers of mangrove deforestation are clearing for agriculture, shrimp aquaculture, wood extraction for timber and charcoal, and coastal development (Thomas et al. 2015; FAO 2007). Like deforestation rates, the most prominent drivers of mangrove forest loss differ from site to site based on a variety of factors including specific species composition, population pressure, existing governance systems, and degree of integration into larger regional and national markets (Thomas et al. 2015). Furthermore, estimates of mangrove coverage widely based on methodology, which has hindered inventorying efforts across the globe (Hamilton and Casey 2016).

STATUS OF MANGROVES IN LATIN AMERICA AND THE CARIBBEAN

As of 2012, Latin America and the Caribbean accounted for approximately 28% of global mangrove coverage (Hamilton and Casey 2016). Tables 1-3 and Figure 1 show mangrove extent and change rates for selected Latin American and Caribbean countries between 2000 and 2012 grouped by subregions. However, the region shows high variability in both mangrove coverage change rates and primary drivers of mangrove loss (Van Lavieren et al. 2012). The most common drivers of deforestation across the region are aquaculture, agricultural expansion, and coastal development (Van Lavieren et al. 2012). Central America and Mexico as a combined region have experienced the most severe mangrove losses at the regional level, having lost 30% of mangroves between 1980 and 2005, while South America and the Caribbean lost 11% and 6.6%, respectively (FAO 2007). Annual change rates decreased significantly from 1980 to 2005, but the region continues to experience widespread mangrove loss (FAO 2007; Hamilton and Casey 2016). Mexico alone accounts for 3-5% of global mangrove extent and is estimated to have lost 300,000 ha of mangrove forest between 1980 and 2005. Although rates of loss have declined in recent years with investment in mangrove conservation, Mexico is at risk of losing 50% of its mangrove extent over the next 25 years without continued protection efforts (ILCP 2015).

Table 1 *Trends in mangrove extents of South American political entities over the years 2000 - 2012, 1980 - 2000 sourced from Hamilton and Casey 2016 and FAO 2007, respectively. Mangrove extent estimates vary widely. We use the Mangrove Forest Watch estimates from Hamilton and Casey 2016.*

Country	2000 (km^2)	2012 (km^2)	Total Change 2000-2012	Annual Change 2000-2012	FAO Average Annual Change Estimate 1980-1990	FAO Average Annual Change Estimate 1990-2000
Brazil	7721.31	7674.94	-0.60%	-0.05%	-0.3%	-0.1%
Colombia	1674.15	1671.86	-0.14%	-0.01%	-1.1%	-0.9%
Ecuador	937.56	935.74	-0.19%	-0.02%	-2.2%	-0.8%
French Guiana[1]	704.45	696.45	-1.14%	-0.09%	0%	0%
Guyana	188.28	187.77	-0.26	-0.02	-0.3%	0%
Peru	11.70	11.67	-0.26%	-0.02%	-3.5%	-2.5%
Surinam	523.56	512.01	-2.21%	-0.18	n.a	n.a.
Venezuela	2415.84	2403.83	-0.50%	-0.04%	-0.6%	-0.6%
South America	14176.85	14094.27	-0.58%	**-0.04%**	**-0.7%**	**-0.4%**

[1] ***Values shown for French Guiana include small amounts of mangrove habitat from Martinique, Guadelupe and Mayotte. These were not separated in Hamilton and Casey 2016.***

Table 2 *Trends in mangrove extents of Central American political entities and Mexico over the years 2000 - 2012, 1980 - 2000 sourced from Hamilton and Casey 2016 and FAO 2007, respectively. Mangrove extent estimates vary widely. We use the Mangrove Forest Watch estimates from Hamilton and Casey 2016.*

Country	2000 (km^2)	2012 (km^2)	Total Change 2000-2012	Average Annual Change 2000-2012	FAO Average Annual Change Estimate 1980-1990	FAO Average Annual Change Estimate 1990-2000
Belize	306.19	302.75	-1.12%	-0.09%	0%	-0.30%
Costa Rica	336.38	335.21	-0.35%	-0.03%	1.70%	-2.40%
El Salvador	236.94	236.14	-0.34%	-0.03%	-2.80%	-2.80%
Guatemala	274.69	257.08	-6.41%	-0.53%	-0.70%	-0.10%
Honduras	535.97	525.24	-2.00%	-0.17%	-2.50%	-4%
Nicaragua	557.66	553.51	-0.74%	-0.06%	-1.30%	-1.10%
Mexico	3021.03	2991.83	-0.97%	-0.08%	-2.60%	-2%
Panama	1327.86	1323.94	-0.30%	-0.02%	-2.70%	-0.80%
Central America and Mexico	6596.72	6525.70	-1.08%	-0.09%	-1.52%	-1.22%

Table 3 Trends in mangrove extents of Caribbean political entities over the years 2000 - 2012, 1980 - 2000 sourced from Hamilton and Casey. 2016 and FAO 2007, respectively. Mangrove extent estimates vary widely. We use the Mangrove Forest Watch estimates from Hamilton and Casey 2016.

Country	2000 (km^2)	2012 (km^2)	Total Change 2000-2012	Average Annual Change 2000-2012	FAO Average Annual Change Estimate 1980-1990[2]	FAO Average Annual Change Estimate 1990-2000[2]
Bahamas	35.74	35.31	-1.20%	-0.10%	-2.10%	-0.30%
Cayman Islands	46.05	45.96	-0.20%	-0.02%	-0.60%	-0.40%
Cuba	1660.36	1633.46	-1.62%	-0.14%	-0.10%	-0.15
Dominican Republic	101.35	100.81	0.53%	0.04%	-2.80%	-2.80%
Haiti	37.12	36.87	-0.67%	-0.06%	-1.70%	-0.50%
Jamaica	42.41	42.32	-0.21%	-0.02%	-1.10%	-1%
Puerto Rico	44.59	43.97	-1.39%	-0.12%	-0.80%	-0.70%
Trinidad and Tobago	48.06	47.92	-0.29%	-0.02%	-0.40%	-0.20%
Caribbean	**2015.68**	**1986.62**	**1.44%**	**0.12%**	**-0.50%**	**-0.10%**

[2]FAO estimates include data from additional countries/areas not available in Hamilton and Casey (2016)

Countries within Latin America and the Caribbean are involved in numerous international agreements related to the conservation, restoration, and management of mangrove forests and other coastal wetland ecosystems. All but five political entities listed in the UN Food and Agriculture Organization's (FAO) 2007 report are parties to the Ramsar Convention or have had sites designated through their controlling entities. Table 4 shows examples of key mangrove policies and programs in Latin America.

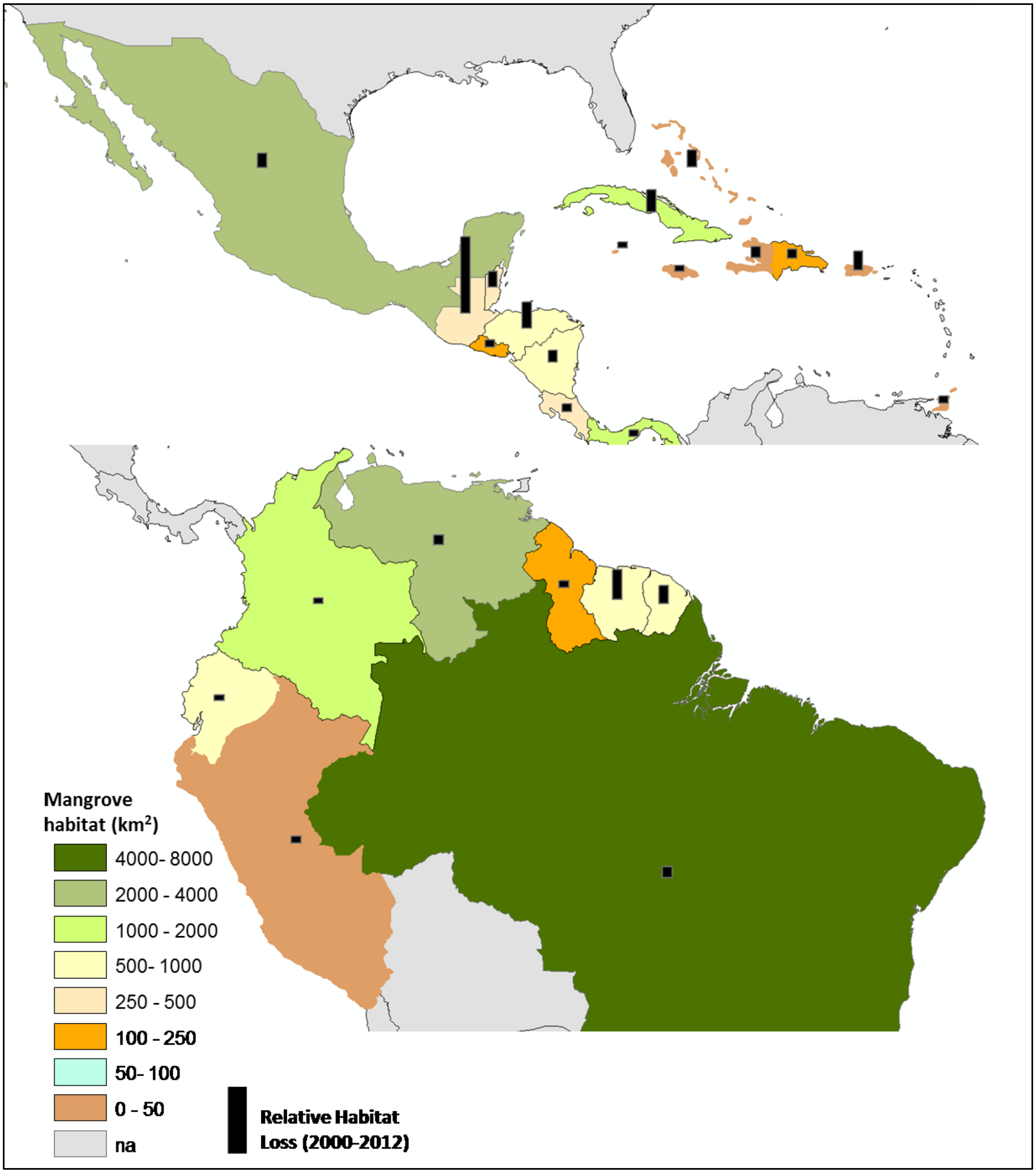


Figure 1. *Mangrove habitat in square kilometers by country across Latin America and the Caribbean, with relative habitat loss shown. Data are from Hamilton and Casey 2016, based on Mangrove Forest Watch (MFW) estimates. Mangrove extent estimates are variable across data sets and methodology. MFW estimates are focused on tree cover and tend to be lower than general habitat based estimates, but are consistent in relative extent and loss by country. Maximum habitat loss from 2000-2012 was 6.4% (Guatemala). All habitat loss is depicted relative to this rate. Data not available for all countries. Data also shown in Tables 1 to 3.*

Table 4 *Examples of national mangrove policies and programs in Latin America.*

Country	International Agreements	National Legislation	Government Institutions	Sources
Costa Rica	Ramsar Convention, ITTO Producer, CBD Ratified,	1940 Wastelands Law: Government approval required for mangrove extraction. 1992 Wetlands defined as public assets with multiple uses. 1996 Updated Forestry Law increased focused on conservation, introduces ecosystem services in forest definitions. 1998 Biodiversity Law: All wetlands defined as protected areas.	Ministry of the Environment and Energy, National System of Conservation Areas	López-Angarita et al. 2016
El Salvador	Ramsar Convention, CBD Ratified	National Program for the Restoration of Ecosystems and Landscapes: Designates mangrove forests as a critical ecosystem	Ministry of the Environment and Natural Resources	Unidad de Medio Ambiente 2012
Guatemala	Ramsar Convention, ITTO Producer, CBD Ratified,	1985 Constitution Art. 122: Considered a public good in state land reserves 1998 Forestry Law: Protection, conservation, and restoration of mangroves declared national interests. The 2009 Policy for the Integral Management of Guatemalan Marine Coastlines, 2006 National Wetlands Policy ,2011 Biodiversity Policy all variously designate mangrove ecosystems as areas that should be protected and managed for the continued benefit of Guatemalans.	National Forestry Institute National Protected Areas Commission in protected areas, Office of Control of State Reserves in state reserves, Municipalities, Office of Fishing and Aquaculture, and Guatemalan Tourism Institute in coastlines with current or potential future tourism development	Recio et al. 2016
Honduras	Ramsar Convention, CITES, CBD Ratified,	1993 General Environmental Law: Mangrove forests are declared fundamental part of sustainable development. 2008 Forest, Protected Areas and Wildlife Law: Provides legal definition of mangroves	National Institute of Forest Conservation and Development, Protected Areas and Wildlife, Agriculture and Livestock Department, Natural Resources and Environment Depart., Honduran Tourism Institute, Armed Forces of Honduras	Recio et al. 2016
Mexico	Ramsar Convention, ITTO Producer, CBD Ratified,	NOM-022-2003, NOM-059-SEMARNAT-2010: Established four common species of mangrove as threatened. The 2010 program launched a series of inventorying and monitoring programs. Mangrove forests are common targets for government-restoration programs.	Secretary of the Environment and Natural Resources, National Water Commission	PROFEPA 2010.
Nicaragua	Ramsar Convention, CBD Ratified,	Act 690: 2009 Law for the Development of Coastal Zones: Delimits zones for coastal development and conservation, defining certain areas as for public use and limiting activities in those zones. DECRETO No. 78-2003 National Wetlands Policy: Formally	National Wetlands Committee, Ministry of the Environment and Natural Resources	Office of the President of the Republic of

Country	International Agreements	National Legislation	Government Institutions	Sources
		establishes wetland conversation as a national interest, recognizes array of ecosystem services supported by wetland ecosystems.		Nicaragua 2003, 2009.
Panama	Ramsar Convention, ITTO Producer	Panamanian Constitution Art. 296: Mangroves recognized as natural resource of national purpose. Law 1, Article 5.5: Also considered a protected forest Law 44, Article 2: Designated as a marine/coastal resource, National Authority of Aquatic Resources (ARAP) is made responsible for management outside protected areas.	National Environmental Authority in protected areas, ARAP outside of designated protected areas, Panama Tourism Authority, Ministry of Agricultural and Livestock Development, Municipal governments	Recio et al. 2016
Brazil	Ramsar Convention, ITTO Producer, CBD Ratified	Forestry Code: All mangrove ecosystems as defined in Code are considered "Areas of Permanent Protection", requiring permits to alter.	Brazilian Forest Service (SFB), Ministry of Environment and Institute of Natural Resources (IBAMA)	Ferreira et al. 2016. Yale School of FES n.d. Borges 2017.
Colombia	Ramsar Convention, ITTO Producer, CBD Ratified,	National Integrated Coastal Zone Management Policy, National Program for Sustainable Use: Management and Conservation of Mangrove Ecosystems: Establishes guidelines for zoning, planning, managing, conserving and restoring mangrove ecosystems. Coastal Environmental and Land Use Unit Plans: Established Coastal Environmental Units (UAC) wherein regional governments can establish management systems with local communities.	National Environmental System (SINA) including Ministry of Environment and Regional Sub-departments (CAR), and various Research Institutes including Marine and Coastal Research Institute (INVEMAR)	Rodríguez-Rodríguez et al. 2016.
Ecuador	Ramsar Convention, ITTO Producer, CBD Ratified,	1985 Revised Fisheries and Fisheries Development Law: Explicitly prohibits the destruction or alteration of mangroves. 1981 Forestry Law Shrimp aquaculture may only take place outside designated mangrove areas.	The National Council for Fisheries Development underneath the Ministry of Foreign Commerce, Industrialization, Fisheries and Competitiveness, Directorate General for Fisheries	D'Andrea, A. 2005.
Guyana	ITTO Producer	National Mangrove Management Action Plan: Series of monitoring, research, and restoration projects across the nation 2010-2013. Guyana Forest Act Regulation 17: Mangroves on state lands decalred 'Protected Trees', creates permitting process for mangrove harvesting on state lands	Guyana Forestry Commission: permitting mangrove removal on state lands. National Agriculture Research Institute: Design and partial implementation of National Mangrove Management Plan	Saywack 2013.
Peru	Ramsar Convention, ITTO Producer	Memorandum 048-2014: Establishes the National Strategy for Wetlands, the country's first Wetland-specific policy.	Ministry of the Environment	MINAM 2014.

Many Latin American and Caribbean countries have enacted policies at the national level recognizing mangrove ecosystems as important national interests (Recio et al. 2016). However, as deforestation rates show, these policies have historically been ineffectual. Table 2 gives a brief overview of national policies in Latin America regarding mangrove use and conservation. Mexico stands out within the region for its leadership in national mangrove conservation policy (Van Lavieren et al. 2012; Carter et al. 2015). Since 2003, Mexico has designated its four dominant mangrove tree species as threatened to aid in their conservation, and in 2010 began to increase mangrove monitoring and inventorying programs (PROFEPA 2010). As will be explored later, Mexico has also taken notable steps towards engaging local communities in mangrove management (CONABIO 2012). Several other countries such as Guatemala and Panama have updated environmental legislation to accommodate for mangroves, but have not created specific programs for them like Mexico (Rotich et al. 2016).

State natural resource management institutions in Latin America and the Caribbean encounter many of the previously-described challenges of centralized mangrove management. Responsibility for mangrove management is often divided across multiple departments, creating jurisdictional ambiguity over responsibilities and policies (Rotich et al. 2016). This ambiguity is often exacerbated by the complexity of land tenure systems in Central and South America (Rotich et al. 2016). Though land tenure is an important issue in mangrove management across the globe, it is regarded as a central topic in Latin America and the Caribbean (Recio et al. 2016). Land reform has previously been the central issue in various civil conflicts, and continues to represent a point of controversy in certain countries including Mexico, El Salvador, and Guatemala. Land tenure is an especially important issue in countries with significant indigenous populations as it is closely related to larger issues of indigenous autonomy movements (Garcia et al. 2014). Similarly, land tenure has also been observed to intersect with gender inequality issues in Latin America (Deere and Leon 2003; World Bank 2001). These same countries and others are attempting to reform cadastral registries in order to clarify property and use rights both generally and with regards to specific social groups, but progress has been slow (World Bank 2001; UN-Habitat 2005). Land tenure ambiguity affects external actors' ability to integrate mangrove dependent communities into financial programs such as Payment for Ecosystem Services (PES) schemes.

Many mangroves forests exist in remote rural areas where state departments simply do not have enough human or financial resources to effectively enforce regulations, if there are any (Recio et al. 2016). Monitoring programs operated through state institutions are resource intensive, requiring significant human and transportation resources in remote areas. Gaps in monitoring and regulation have allowed for illegal logging and aquaculture to continue despite bans.

Resource shortages also impact the ability of state departments to effectively implement restoration projects in remote communities.

As conservation efforts increased in the 1980s, researchers began to connect ecological understanding of mangrove ecosystems with further study of the human populations and institutions that inhabit and manage them. The literature reveals a disconnect between the broad spectrum of use patterns, informal management systems, socioeconomic dynamics, and ideologies that exist within and influence mangrove forests, and the centralized, hierarchical state management systems that have historically managed them. Centralized management systems had, for the most part, not yet recognized and incorporated the diverse suite of regulating, protecting, and cultural services of mangrove forests into their management plans (Carter et al. 2015). As the limitations of centralized management schemes became clear in the mid-to-late 1980s, NGOs and national governments, particularly in South East Asia, began to involve coastal communities in formalized management schemes (Carter et al. 2015).

Community Based Mangrove Management

Community-based natural resource management refers to a spectrum of approaches that engage and empower local communities in resource and conservation planning. One of the central concepts behind community based management is that when local populations dependent on mangrove forests are engaged and empowered in decision-making, the likelihood of sustainable management outcomes is higher for both communities and ecosystems. This may be due to factors such as local knowledge of ecosystems, enforcement processes, familiarity with biological and social aspects of mangrove resource utilization, and the community's perception that their livelihoods are directly impacted by changes in resource management (Walters et al. 2008, Datta et al. 2012). In many cases, communities may have sustainably managed mangrove systems for years, but increasing population and market pressures pushed mangrove social ecological systems away from sustainability. Formalized Community-based mangrove management (CBMM) programs seek to connect mangrove-dependent communities with regional and global actors such as NGOs, state departments, researchers, and industry organizations (Walters et al. 2008; Sattler and Schröter et al. 2016). Decentralized management schemes wherein sustainable development is not the sole responsibility of state actors can help to improve outcomes by drawing in diverse perspectives on the roles and services of specific mangrove ecosystems, integrating conservation and restoration goals into community members' livelihoods, and diffusing responsibility across organizations with differing resources, relative strengths, and relationships to the mangrove ecosystem in question.

CBMM programs have the potential to be tailored to suit any given mangrove-dependent community's situation, thereby giving rise to countless potential program designs. Sattler and Schröter et al. (2016) describe forms of community-based natural resource management (CBNRM) as intersections between hierarchies, i.e. government departments, market-based mechanisms, and community management and offer a manner of visualizing and categorizing the stakeholders commonly involved in CBNRM programs. Despite the fact they may look very different in different places, most CBMM programs ultimately share the two-pronged goal of improving the economic livelihoods of community members through assuring the long-term sustainability of the resource system (Sattler and Schröter et al. 2016). Some communities have specific, long-term end goals such as developing a sustainable ecotourism market, whereas others seek to make simply make existing extraction patterns more sustainable.

CBMM programs commonly employ an exclusion mechanism wherein certain groups are permitted to harvest resources within designated sections of the mangrove system (Sattler and Schröter et al. 2016; Beitl 2011; Pomeroy et al. 1997; Szendro 2016). One's ability to extract resources could be contingent upon membership in a pre-existing association, or through simply agreeing to the terms of the use agreements. These exclusion mechanisms are then backed by monitoring efforts and clarification of extenuating issues such as property rights and land tenure (Sattler

Box 1.1 Costa Rica- Osa: CBMM programs in Latin America are commonly combined with Payment for Ecosystem Services (PES) schemes. Osa is located on the Pacific Coast of Costa Rica and comprises several communities surrounding a conservation area managed directly and indirectly by varied actors and agencies. The actors listed in the study are national and regional government agencies, a regional agricultural association, a local fisherperson's association, and local, regional, and national nonprofits (Sattler and Schröter 2016). The communities surrounding Osa are part of a payment for ecosystems services scheme that is managed through a national nonprofit that connected mangrove forests to purchasers of carbon offset credits, namely Volkswagen and Ford (Sattler and Schröter et al. 2016). The authors note that the program has benefitted from a clear division of responsibilities amongst non-government actors, sufficient knowledge and funding resources, and the existence of both governmental and non-governmental mediaries between local councils and regional government agencies (Sattler and Schröter 2016). However, one article argues that the PES system has had limited effects on mangrove conservation and reforestation (Sierra and Russman 2006). Program participants tend to be those who are already concerned about environmental degradation, and some have continued ecologically destructive behavior underneath the program (Sierra and Russman 2006).

and Schröter et al. 2016; Beitl 2011; Pomeroy et al. 1997). In many of the cases reviewed, previously-existing community councils coordinated primarily with state departments and NGOs to designate zones for various uses and coordinate monitoring efforts within that zone (Sattler and Schröter et al. 2016; Beitl 2011; Pomeroy et al. 1997). This main program design can be supported by educational initiatives, technical capacity-building, micro-loans, and direct funding for restoration projects (Wickramasinghe 2017; Sattler and Schröter et al. 2016; Beitl 2011).

Contemporary Challenges of CBMM

CBMM faces considerable challenges in both its design and implementation. The issues are transdisciplinary in nature and can stem from actors operating at any level of a given CBMM program. As with other forms of community-based natural resource management, CBMM often relies on what Safwaty and Sonia Lin 2018 term as "community-brokers", or those members of the local community who act as their communities' representatives (Shafwaty Sa'at and Lin 2018). These actors help to determine the flow of resources and have more influence over program design. These asymmetric benefits can fall along spatial and demographic lines, with the most pronounced effects being gendered in nature. This inequality often arises through providing benefits to certain activities that have historically been practiced by certain groups within the larger community. Small communities in mangrove forests and other marginal resource systems often demonstrate gendered resource use patterns, meaning that it is important to consider how increases in one activity could affect social patterns. However, one can also use these dynamics to support marginalized demographics within a community. As part of Sri Lanka's national mangrove restoration program in the wake of the 2004 Indian Ocean Tsunami, the Sri Lankan government used targeted micro-loans to support women in establishing sustainable operations in mangrove forests (Wickramasinghe 2017). This particular program has achieved a 96% repayment rate amongst the 2,000 women who are enrolled in the program (Wickramasinghe 2017).

CBMM programs often exist within the bounds of one community or municipality and seldom cover entire ecosystems and the various actors that operate within it (Szendro 2018; Beitl 2011; Iwasaki 2011). Commercial and industrial activities can work to stymie communities' conservation efforts if they are not included in management plans. Similarly, various case studies have reported a potential "Tragedy of enclosures" in CBMM plans that employ exclusion mechanisms (Beitl 2011; Beitl 2014a). Without comprehensive regulations, ecologically degrading activities, if sufficiently mobile, can simply move outside of zones with protections and restrictions (Beitl 2011). The tragedy of enclosures tends to affect a particular demographic within a resource system, and is often intertwined with past conflicts between social groups and occupations (Szendro 2018).

Finally, one of the most pressing challenges facing CBMM is simply the fact that it is still in its infancy as a formalized management style, especially in Latin America and the Caribbean. The framework has only gained traction within the last 25 years, meaning that there are relatively few comparative studies of CBMM programs within certain regions or mangrove forest types. Latin America lags behind South East Asia in both implementation and evaluation of CBMM programs. Beyond the lack of data available for proper program evaluation, some CBMM researchers and professionals claim to observe a concerning disconnect between program evaluations and management decisions (Ceccon et al. 2015).

Community Based Mangrove Management in Latin America and the Caribbean

Though mangrove management is still largely vested in state institutions, formalized CBMM programs have risen to prominence in Latin America and the Caribbean over the last 25 years (Ceccon et al. 2015). CBMM programs in Latin America and the Caribbean often take place in cooperation with existing community organizations such as municipal leaders, trade associations, and communal land councils. The total area covered by the program can either be designated by program designers, as is the case in Ecuador's *Custodias* and Brazil's *Reservas extrativistas,* or already be designated through communal land councils or indigenous governments. NGOs often play considerable roles in the design and implementation of CBMM programs in Latin America, acting as mediators between communities and larger regional and national actors (Sattler and Schröter et al. 2016; Carmona Diaz et al. 2004; Coello et al. 2008). Coastal communities in Latin America and the Caribbean are thought to have inhabited and

> **Box 1.2 Ecuador's *Custodias*** Since 2000, The government of Ecuador has operated a CBMM program wherein coastal communities receive ten-year land concessions to harvest seafood and oversee conservation efforts within their concession, or *custodia*. The community organizations institute customary use agreements including, but not limited to, monitoring programs, exclusion mechanisms, and sanctions for illegal harvesting practices (Beitl 2011). As of 2016, approximately 40% of Ecuador's mangrove ecosystems are managed through agreements between the government and more than 50 community organizations (Lugo et al. 2014). Communities often partner with external actors such as university researchers and NGOs to design customary agreements (Beitl 2014; Beitl 2017, Lugo et al. 2014). *Custodias* provide varying degrees of protection for mangrove forests depending on a variety of factors including use agreements, resources available for enforcement, population density of surrounding communities, and existing social arrangements (Beitl 2011, Lugo et al. 2014). In the El Oro province of southern Ecuador, *custodias* with exclusion mechanisms have been shown to support more productive fisheries that comply with catch regulations than non-custodia open access fisheries, even in cases where customary agreements were not strictly enforced (Beitl 2011).

managed mangrove forests through customary agreements since as early as 4,000 BCE, and many communities continue to do so even without support from external actors (Lacerda et al. 1995). Ecuador, Mexico, Brazil, Costa Rica, and Ecuador have all taken significant steps towards devolving creating multi-level governance system for their mangroves. The programs share goals of restoring mangrove ecosystems, clarifying land tenure, and providing marginalized communities with increased social mobility. Boxes 1.1, 1.2, 3.1 and 3.2 contain descriptions of CBMM programs in Costa Rica, Ecuador, and Mexico that employ differing program designs.

ALVARADO LAGOON SYSTEM AND LA MOJARRA

The Alvarado Lagoon System (ALS) is located in the lower basin of the Papaloapan River in the central coast of Veracruz, México. The system includes over 26,000 hectares of mangrove forest, 15,000 of which is intact and 11,000 of which has restoration potential (Pronatura n.d.). The mangroves are located in four municipalities the ALS: Alvarado – 15,746 ha, Acula - 2,203 ha, Ignacio de la Llave 1, 998 ha, and Tlacotalpan – 475 ha (López et al. 2010). To date, over 2,554 ha of private conservation areas have been established in the ALS, although no federal protected areas have been declared. Despite declaration as a RAMSAR site of international importance and prior designations as a wetland of national priority, this coastal wetland is highly threatened by agriculture, cattle ranching, aquaculture, timber cutting and other activities.

Figure 2 *Mangrove forest habitat and overview from the Alvarado Lagoon, Veracruz, Mexico.*

Approximately 50,000 people inhabit the ALS, including indigenous communities. Resource uses in and surrounding the lagoon include agriculture (especially sugarcane), cattle ranching, fishing, timber cutting, honey production, and other activities. The communities are dependent on mangroves for subsistence, income, and cultural uses, among other ecosystem services. Over a 12-year period, mangroves were lost at rates ranging from 10.9 to 179 ha per year across different sectors of ALS (Silva-Lopez et al. 2014).

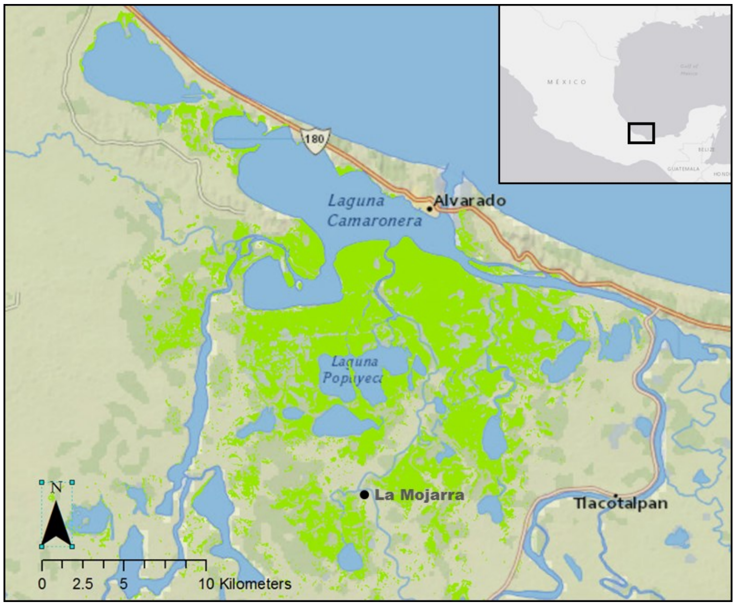


Figure 3 Location of La Mojarra within the Alvarado Lagoon System. Light green indicates approximate distribution of mangrove forest within the lagoon system (Mangrove Data: USGS, Giri et al. 2011).

La Mojarra community is located within the Poza Honda Ejido, inside Acula municipality, adjacent to the Acula river in the southern part of the ALS (see Figure 3). It is also called “Paso La Mojarra” to distinguish it from a homonymous locality just crossing the Acula River, in the Alvarado Municipality. La Mojarra is placed within the Poza Honda ejido (1916 ha), which has been recently expanded towards the west, the new portion being called “La Isleta” (426 ha). According to the last official report (2010), La Mojarra is inhabited by 130 people, whose main activities are small-scale fishing, cattle ranching and sugar cane production (INEGI 2017). The existence of so few productive activities has promoted migration to bigger localities, a trend especially evident from 2000 to date.

INTEGRATING STAKEHOLDERS IN MANGROVE ASSESSMENTS AND MANAGEMENT PLANNING

A Replicable Model for Mangrove Management: the Alvarado Lagoon System and the La Mojarra Ejido

Building off of more than a decade of work on mangrove conservation and restoration in the Alvarado Lagoon System by Pronatura Veracruz, the Inter-American Development Bank supported a project by NatureServe, Pronatura Veracruz and Conservation Strategy Fund to engage in collaborative development of a management plant with the community of La Mojarra. This project, beginning in early 2017 included assessments of the ecological integrity of the mangrove system in the ALS, as well as socioeconomic assessments through participatory economic games. The project comprised three distinct components: i) an Initial Stakeholder Engagement and Assessment, ii) Ecological Integrity Assessment, and iii) Socioeconomic and Socioecological Evaluation. These assessments were integrated in a final set of participatory workshops with stakeholders in La Mojarra in order to create a CBMM plan for La Mojarra. The experiences from this process are presented in this resource guide for those seeking to work with mangrove-related communities in Latin America and the Caribbean.

In each section, we offer detailed descriptions of the methodology used, relevant specific results from the La Mojarra / ALS project, as well as suggestions on how the process can be adapted to locations with differing access to data, funding, and technical resources. Figure 4 shows a simplified flow diagram of the project with key steps highlighted.

As noted previously, the design of specific programs will depend on the ecological, socioeconomic, and cultural dynamics of each mangrove social ecological system. The processes described below are meant to help organizations and communities to identify and incorporate these various dynamics into the management planning process.

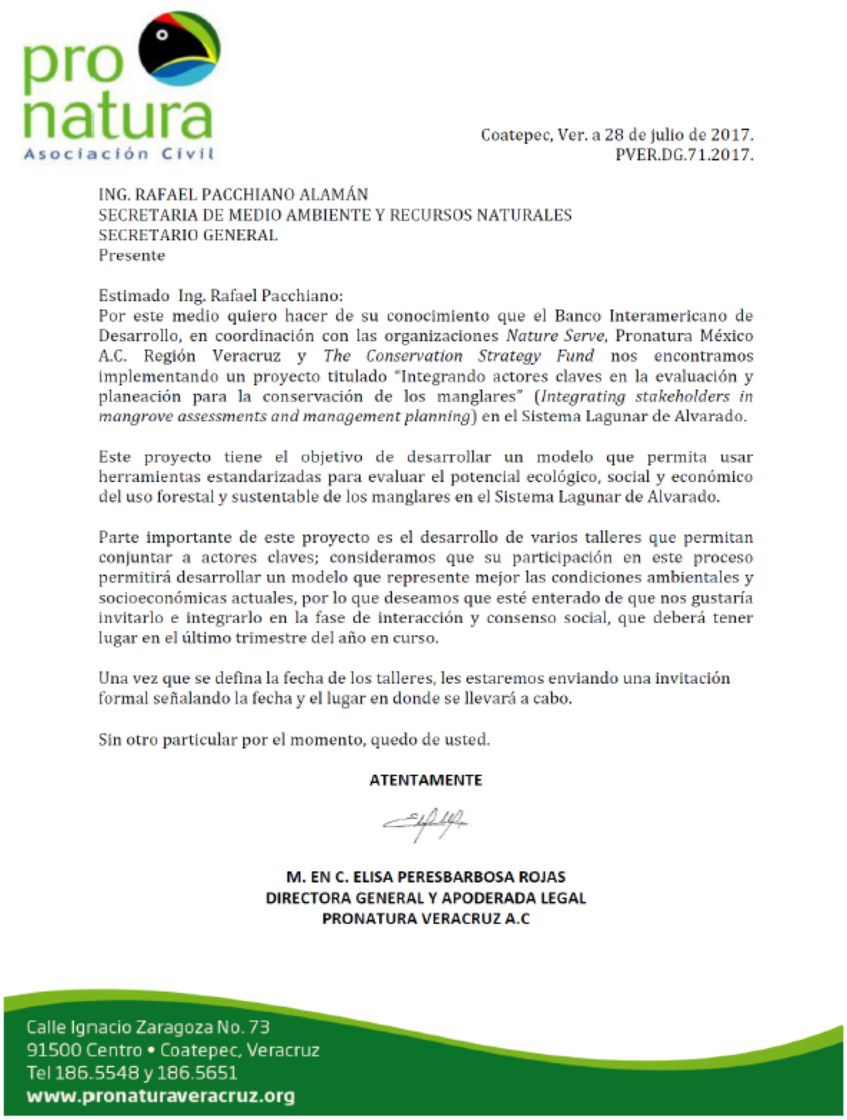
Stakeholder Engagement	**Ecological Integrity Assessment**	**Socioeconomic Evaluation**	**Participatory Management Planning**
• Goals of focal community • Roles of stakeholders • Capacity assessments • Project announcements locally and regionally	• Key ecological attributes • Ecosystem services • Threats and stressors • Scoring ecosystem health • Current conditions • Goals for future conditions	• Demographic surveys • Focal issues to address • Selection of tools for assessment • Collaborative assessments	• Integration of assessments • Visions for the future • Pathways, strategies, actions to achieve vision • Management plan • Implementation & follow-up

Figure 4 Visualization of collaborative planning process.

Component One: Initial Stakeholder Engagement and Assessment

STAKEHOLDERS IN LA MOJARRA

All components of the replicable model and management plan were developed with the support and input of various stakeholders within La Mojarra and the larger ALS. Pronatura Veracruz has worked with a wide swath of communities and stakeholders in the ALS for over 14 years, including a range of government and non-governmental entities. Pronatura Veracruz's presence in the region has created 10 permanent jobs and over 10,000 days of temporary work in various communities. This history of local work by Pronatura Veracruz served to facilitate participation by a range of stakeholders in collaborative planning efforts. As part of this project, Pronatura expanded their relationships within the region, particularly within La Mojarra. Pronatura initially contacted previously-known stakeholders through letters informing them of the project team's objectives and inviting them to participate in the various workshops and studies. A representative letter of invitation is reproduced below.



pro natura
Asociación Civil

Coatepec, Ver. a 28 de julio de 2017.
PVER.DG.71.2017.

ING. RAFAEL PACCHIANO ALAMÁN
SECRETARIA DE MEDIO AMBIENTE Y RECURSOS NATURALES
SECRETARIO GENERAL
Presente

Estimado Ing. Rafael Pacchiano:
Por este medio quiero hacer de su conocimiento que el Banco Interamericano de Desarrollo, en coordinación con las organizaciones *Nature Serve*, Pronatura México A.C. Región Veracruz y *The Conservation Strategy Fund* nos encontramos implementando un proyecto titulado "Integrando actores claves en la evaluación y planeación para la conservación de los manglares" (*Integrating stakeholders in mangrove assessments and management planning*) en el Sistema Lagunar de Alvarado.

Este proyecto tiene el objetivo de desarrollar un modelo que permita usar herramientas estandarizadas para evaluar el potencial ecológico, social y económico del uso forestal y sustentable de los manglares en el Sistema Lagunar de Alvarado.

Parte importante de este proyecto es el desarrollo de varios talleres que permitan conjuntar a actores claves; consideramos que su participación en este proceso permitirá desarrollar un modelo que represente mejor las condiciones ambientales y socioeconómicas actuales, por lo que deseamos que esté enterado de que nos gustaría invitarlo e integrarlo en la fase de interacción y consenso social, que deberá tener lugar en el último trimestre del año en curso.

Una vez que se defina la fecha de los talleres, les estaremos enviando una invitación formal señalando la fecha y el lugar en donde se llevará a cabo.

Sin otro particular por el momento, quedo de usted.

ATENTAMENTE

M. EN C. ELISA PERESBARBOSA ROJAS
DIRECTORA GENERAL Y APODERADA LEGAL
PRONATURA VERACRUZ A.C

Calle Ignacio Zaragoza No. 73
91500 Centro • Coatepec, Veracruz
Tel 186.5548 y 186.5651
www.pronaturaveracruz.org

Figure 5 Example letter sent to national agencies within Mexico as part of initial stakeholder outreach in support of the Alvarado Lagoon planning project.

In total, the project team identified 37 stakeholders, including the La Mojarra Ejido, the Inter-American Development Bank and 35 representatives of various municipal, state, and federal Mexican government agencies. Figure 6 shows a visual ideation of stakeholder relationships, while appendix A1.1 shows a list of stakeholders engaged and brief descriptions of their role. The network of stakeholders observed in La Mojarra exemplifies the complex management landscape commonly associated with mangrove social ecological systems. Actors operate on all levels from local to international, and span government, civil society, industry and commerce. La Mojarra ejido manages and extracts resources. The Inter-American Development Bank stimulates productive, social and territorial development to boost the economy. The municipal, state and federal government agencies variously manage or regulate:

- agriculture
- air pollution
- biodiversity
- climate change
- ecosystems
- environmental economies
- environmental law enforcement
- local development and resources use
- fisheries
- food security and poverty alleviation
- forestry
- marine resources
- sustainable natural resource use
- protected natural areas
- water management
- wetlands

Box 3.1 UMA Conservation Permitting in Mexico

A key link between local sustainability planning and national agencies in Mexico is through Mexico's Unidades de Manejo Para la Conservación de Vida Silvestre (UMAs) program. Since 1997, SEMARNAT (Mexico's Environmental and Natural Resources agency) has operated a system of sustainable use agreements with ejidos across Mexico that promote alternative, sustainable management schemes for individual species of plants and animals.

Poza Honda, to which La Mojarra belongs, has UMA permits for sustainable harvest of several species including white mangrove (*Laguncularia racemosa*) and Green Iguana (*Iguana iguana*). Familiarity with the UMA permit process by La Mojarra was identified as a stakeholder strength, and existing permits were incorporated into management planning where possible.

UMAS provide use rights for individual species to the community and make the communities responsible for administering and monitoring the program with the support of relevant government authorities. Ejidos can elect to designate their lands as extractive, non-extractive, or mixed. They may include active restoration approaches or utilize natural regeneration techniques (CONABIO 2012). Between 1997 and 2008, SEMARNAT and communities created 6,595 UMA agreements, covering over 24,000,000 ha across Mexico (CONABIO 2012). Though they are not as comprehensive as ecosystem-wide management plans, UMAs can help to build the technical capacity of the community to administer more complex programs (Shafwaty Sa'at and Sonia Lin 2018; Pomeroy et al. 1997; Iwasaki 2011; Alhelí Gónzalez and Espejel Ontiveros 2018).

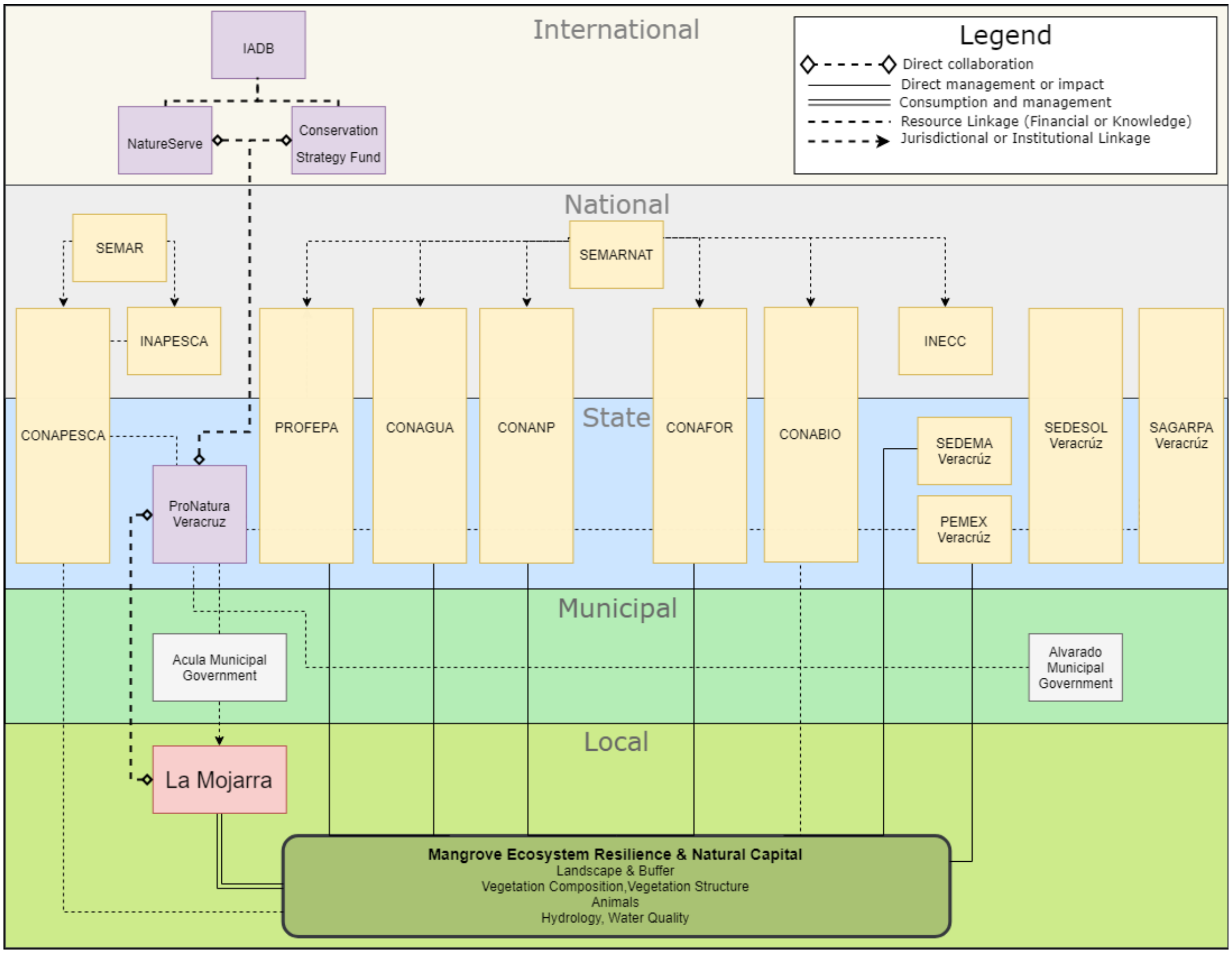


Figure 6 *Visualization of stakeholder relationships adapted from Sattler and Schröter et al. 2016 and using linkage terminology following Shafwaty Sa'at and Lin 2018.*

Prior Work by Pronatura Veracruz in the Alvarado Lagoon System and with La Mojarra

Close collaboration between mangrove-dependent communities and external actors, particularly with non-governmental groups, has been observed to be an important component of project success in case studies across the globe (Pomeroy et al. 1997; Shafwaty Sa'at and Lin 2018). Consistent engagement of community perspectives helps to strengthen resource and knowledge linkages and increase a community's capacity for self-governance by allowing for direct input into all stages of the design process (Delgado-Serrano et al. 2015). This ALS case study in mangrove management benefited greatly from Pronatura Veracruz's established relationship with both the leadership and wider community of La Mojarra. Though Pronatura Veracruz has worked with many communities in the ALS over the last 14 years, it only began to directly work with La Mojarra in a limited capacity through short-term restoration projects in the last five years (Alhelí-Gonzalez and Espejel Ontiveros 2018). Direct engagement with the community on work for larger restoration initiatives such as the German government's International Climate Initiative (IKI) and Pronatura's positive relationships with other communities established the necessary mutual trust to collaborate on the more comprehensive, long-term "Integrating Stakeholders in Mangrove Assessments and Management Planning" (Alhelí-Gonzalez and Espejel Ontiveros 2018). Furthermore, members of the Pronatura Veracruz team noted that an important shift in their relationship with La Mojarra and the region in general came with the increased presence of international NGOs and initiatives (Alhelí-Gonzalez and Espejel Ontiveros 2018).

Box 3.2 Mexico - Marismas Nacionales: Located along the Mexico's Pacific coast, Marismas Nacionales is an estuary system spanning over 220,000 ha in southern Sinaloa and northern Nayarit states, representing approximately 22% of Mexico's total mangrove extent (Lithgow et al. 2017). Marismas Nacionales is a Ramsar Site and portions of it are protected as a biosphere reserve. However, it has still experienced increasing mangrove loss since the 1980s due to a mixture of agricultural expansion, livestock production, infrastructure development, and shrimp aquaculture (Lithgow et al. 2017; Szendro 2018). Numerous ejidos, municipalities, states, and federal departments govern the ecosystem, which has created a complex and overlapping management landscape (Szendro 2018). Some ejidos, such asEjido Los Morrillos and Ejido Mexcaltitán have worked with the National Forest Commission (CONAF), the Secretary of the Environment and Natural Resources (SEMARNAT), timber industry associations, and researchers to design management programs for incorporation into both payment-for-ecosystem services schemes and existing Unidades de Manejo Para la Conservación de la Vida Silvestre (Solís Venegas 2018). Ejidal lands are divided into areas for conservation, restoration, timber extraction, NTFP extraction, and tourism. The communities have placed caps on total harvest of certain mangrove species, and operate a monitoring program to ensure compliance with UMA regulations.

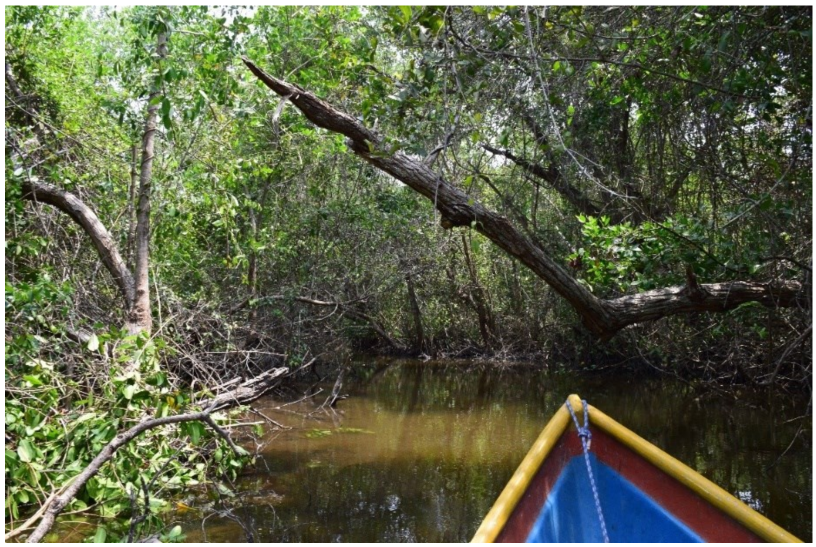
CONTEXT AND ISSUES IDENTIFIED FROM INITIAL STAKEHOLDER ENGAGEMENT

Initial conversations and visits with ejidal and municipal leadership built off prior experience working with Pronatura Veracruz on sustainability issues, and served to identify a range of challenges, ecological threats, and potential community strengths for the collaborative planning process. In terms of threats to the mangrove system in the area, three issues identified early on were 1) water quality degradation from a fertilizer plant in the area, 2) increasing threat of wildfires spreading from burning of agricultural and cattle fields, and 3) direct and indirect effects from the widespread cultivation of sugarcane (e.g. pesticides, land conversion). While additional threats were identified in later stages of the project, these three were initially considered to be the most salient. Through the initial engagement process it also became apparent that La Mojarra and the larger region possessed potential strengths with regards to CBMM. One of these was representation of La Mojarra within the leadership of the local Municipality of Acula. One of the community members holding a leadership role within La Mojarra also held a position equivalent to a Secretary of Natural Resources for the Acula Municipality. This person was an asset to the project and planning process due to his extensive knowledge of the area, but more importantly his position with the municipality facilitated interest and participation from local government representatives during the project. This relationship also represents a strength that could facilitate the success of proposed management actions by the community of La Mojarra, given potential support from the municipality. An additional advantage identified from early engagement with La Mojarra was the community's familiarity with the UMA permitting program for sustainable resource extraction (Box 3.1). This demonstrated both a communal interest in sustainable resource programs and their pre-existing capacity for administering official resource management programs. Early on, community members also voiced a strong interest in diversification of their local economy to supplement and reduce their reliance on income from fishing, citing apiculture and charcoal production as areas they were already working to expand into. Together with the aforementioned issues, these strengths and desires helped shape the design of the ecological and socioeconomic assessments and workshops carried out by project team members.

COMPONENT TWO: ECOLOGICAL INTEGRITY ASSESSMENT

Importance of Ecological Integrity Assessments

The concept of ecological integrity, often defined as the ***measure of structure, function and composition of an ecosystem in the context of its historical range of variation***, provides an essential foundation for managing ecosystems (Lindenmayer and Franklin 2002; Parrish et al. 2003). An assessment of ecological integrity can address questions such as: Is the system in excellent condition with a management goal of retaining that condition? Or is the system highly degraded? If so, what conditions would represent improvements and what actions could be undertaken to move the system toward improved conditions?



Ecological Integrity Assessments (EIA) provide methods for developing standard "biophysical exams" that assess how well an ecosystem is doing, including its component vegetation, soil and hydrology, as well as its interactions with the surrounding landscape. Here we present an overview of the EIA framework and information on conducting EIAs in mangrove ecosystems informed from the assessment of the Alvarado Lagoon System (ALS). The general approach we use is based on NatureServe's framework for Ecological Integrity Assessment methodology (Faber-Langendoen et al. 2016; Comer et al. 2017). We present the assessment methodology and scorecards used in the ALS, which may be applied directly to mangrove sites with similar characteristics in Mexico, along with general examples and guidance for expanding this assessment approach to other locations. The EIA framework uses a 'multi-metric' structure to summarize ecological integrity based on an array of criteria or metrics that can be modified based on specific goals for an assessment. The multi-metric structure encompasses three levels of data collection intensity – remote sensed data for landscape-level assessment (Level 1), on the ground rapid assessment (Level 2), and on the ground intensive assessment (Level 3) in an interactive process that informs - and is informed by - collection of field data from reference locations.

Key Steps

(See also Figure 7)

1. **Assessing EIA capacity:** Based on initial stakeholder outreach, assess data and resources available at the project start. Estimate capacity for data collection on a spectrum from low intensity (remote sensing) to high intensity (detailed collection of field data).

2. **Designing the assessment: Conceptual model and key indicators:** Develop initial conceptual models of ecosystem dynamics and stressors. Identify key ecological attributes and measurable indicators. Identify the range of conditions and sites that will be the focus of the EIA. Identify likely reference conditions.

3. **Designing the assessment: Implementation.** Select specific metrics to measure in the field (e.g. number of trees per hectare) or office (e.g. mangrove extent via remote sensing). Determine detailed protocols for plot data collection, rapid assessment methods and intensive assessments such as water quality sampling. Design preliminary scoring methods.

4. **Analyze and Score:** Place metrics in a framework that estimates conditions from highly disturbed/degraded to excellent condition. Compile and enter data and examine summaries by sites. Revise scoring criteria if needed, based on the range of results documented. Complete assessment scorecards. Rank sites within context of the EIA.

Following the implementation and scoring of the EIA, an ecological assessment can inform development of management plans. Ecosystem state and functions can also be linked to the value of goods and services provided to local communities, and results can inform and enhance ecological monitoring within the region stakeholders.

Subsequent use

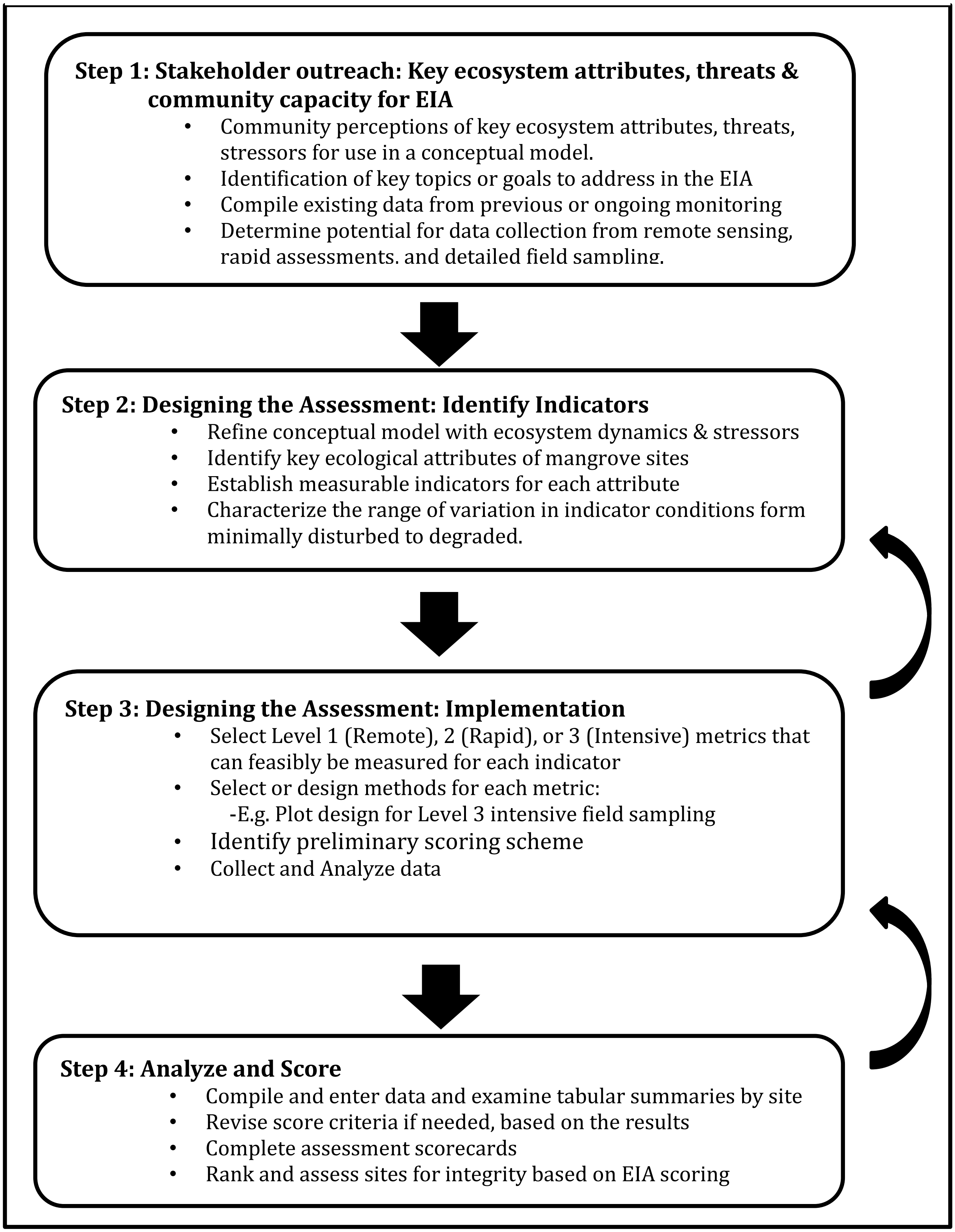
- Incorporation of results into development of management plan and objectives. Use in identification of restoration targets and monitoring objectives.

- Exploration of relationships between ecological attributes and ecosystem services considered through socio-economic assessment. Demonstration of links between ecosystem condition and the value of goods and services provided to local communities.

- Capacity assessment to enhance ecological monitoring capacity for key agencies and research institutes.

Below we present the materials and key information used in steps 1-4 above from the ALS and La Mojarra Ecological Integrity Assessment, along with guidance for generalizing the methods from the ALS to other sites. We provide additional reference materials in appendices, such as EIA results and scorecards.

Figure 7 *Steps involved an EIA for mangrove ecosystems in the context of community based resource management*



Step One: Stakeholder Engagement- Key Ecological attributes, threats, and Community Capacity

Ecological Integrity Assessments typically start with a preliminary conceptual model of the system, with key attributes, threats, and stressors. As this guide focuses on collaborative planning, we present stakeholder engagement as a preliminary planning phase to the EIA, and formal development of a conceptual model at a later stage (see Step Two). As part of initial engagement with stakeholders, views on important aspects of ecosystem function (e.g. productivity of forests or fisheries) as well as factors perceived to be threats or stressors (e.g. fires, pollution) should be identified in discussions with stakeholders. Assessing the capacity of local and regional stakeholders to engage in ecological field assessments, as well as the availability of pre-existing ecological data can then help guide the scope and objectives of the EIA. Where regional or governmental stakeholder participation is high, it may be desirable to plan to integrate an Ecological Integrity Assessment into ongoing management or monitoring efforts, or to adopt specific field methods that are already being utilized. Additionally, the key management, social, and economic issues identified with stakeholders may guide the focus of an ecological assessment. For example, where sustainable forestry is a focus of the community, an assessment that includes quantitative estimates of forest status in terms of mangrove biomass and regeneration rates may be important. Where climate change and carbon sequestration are key issues (e.g. qualifying for payment for ecosystem services such as through REDD+), focused methods that assess the capacity of system to sequester carbon and respond to sea level rise may guide the assessment.

Key Topics and EIA Goals

Although every ecological assessment has the general goal of quantifying the general health and status of the target ecosystem and sites within it, EIA methods provide a flexible framework that can be extended to help answer critical local management questions, or to contribute to regional monitoring efforts. An ecological integrity assessment will be most useful when the data collected from the assessment can directly inform management and economic questions relevant to stakeholders, and be integrated into economic assessments to assist in the development of

Box 4.1 EIA Goals

Core Goals:

- Characterize range of natural variability
- Identify reference sites & conditions
- Ecological health of focal sites
- Guide management targets

Example Optional Goals / Focal Areas:

- Climate change vulnerability
- Payment for Ecosystem Services programs (e.g. carbon stock assessment)
- Quantify forest biomass for timber management
- Status / effects of key invasive species
- Aquatic condition (e.g. detailed water chemistry, sedimentation rates)
- Status of key terrestrial animals (e.g. for extraction or tourism)

management objectives. In the Alvarado Lagoon System, the ecological integrity assessment was designed and implemented primarily by the project NGOs (Pronatura Veracruz, NatureServe, and Conservation Strategy Fund), but incorporated issues known from initial engagement with regional stakeholders. For example, within the focal community of La Mojarra, interest in sustainable forestry was identified as one means to help diversify the economy of the community. In other settings, particular ecosystem services may be identified as important to stakeholders, or the presence of terrestrial or aquatic invasive species may be suspected to have important ecological or economic impacts. Communities may also be interested in qualifying for payment for ecosystem services programs, such as REDD+, which require specific ecological information that should be carefully reviewed and potentially incorporated into the EIA.

Data Collection: Intensity and Capacity

Ecological integrity assessments are designed to be flexible and utilize data collected along a spectrum of effort and intensity. We present this as a spectrum from Level 1 to Level 3 indicators, a standard framework utilized by the U.S. Environmental Protection Agency and the U.S. National Park Service in ecological assessments (Comer et al. 2017; Unnasch et al. 2009; Tables 5, 10). This guide presents additional detail on selecting indicators below, but we introduce the concept here as it is important to assess the capacity of stakeholders and project participants to collect data supporting an EIA. An assessment of capacity may include the availability and interest of stakeholders to participate in training regarding data collection, or their current familiarity with sampling methods. Level 1 indicators are typically aspects of a system that can be measured in an office setting using satellite images or aerial photos. These would include aerial extent of mangroves, level of habitat fragmentation, categorization of surrounding land use, or remote sensed estimates of productivity (e.g. Normalized Difference Vegetation Index, NDVI). For an overview of remote sensed approaches to forest sampling, we refer readers to a recent guide on biodiversity indicators in tropical forests (GOFC-GOLD 2017). These indicators require moderate to expert familiarity with GIS, but can be assessed without visiting sites in the field. Level 2 indicators are rapid assessment field methods. These are typically methods that are designed for quick collection of generalized or target data on ecological condition. Examples include surveys for the presence or relative abundance (uncommon vs. dominant) of an invasive species, or matching mangrove stand condition to a checklist of criteria (or to exemplar photos or drawings) such as presence of seedlings, canopy structure, or diversity of tree species. Level 3 indicators are those requiring more intensive or specialized field sampling, and may include collection of tree diameter data in standardized forest plots, water and soil chemical analysis, or establishment of field data loggers. Not all data collection easily falls into a spectrum of intensity (e.g. drone imagery and wildlife camera traps are increasingly easy to use and are becoming more common in citizen science and community management efforts), but it is worthwhile at the start of an ecological assessment to identify the capacity, or the need, for specialized data collection for the initial assessment and follow up monitoring for ongoing management.

Table 5 Categorization of methods used in Ecological Integrity Assessments, classified along a spectrum of intensity from remote assessments (Level 1) to detailed field assessments (Level 3).

<- Intensity Continuum ->		
Level 1 – Remote Assessment	**Level 2 – Rapid Assessment**	**Level 3 – Intensive Assessment**
General description: Satellite or aerial imagery; GIS-based measurements	***General description:*** Rapid field-based measurements	***General description:*** Intensive field measurements
Example: Analysis of satellite imagery or aerial photos using GIS. Detection of change in cover; fragmentation; Remote detection of conditions: algal blooms, NDVI.	Targeted data collection requiring moderate training and limited equipment. Often qualitative or categorical: e.g. presence of invasive species, grading field conditions based on photos of low to high quality habitat.	Specialized or intensive measurements in the field, such as water quality sampling, measurement of tree diameters, soil sampling.
Requirements: Specialized experience and equipment common within conservation NGOs. Can be performed quickly in an office setting.	**Requirements:** Non-experts may be engaged with moderate training to collect data. Experts may use these methods to collect basic data efficiently.	**Requirements:** Most commonly performed by trained professionals. Requires training and investment to engage non-experts in data collection.

Existing Data

A key component to address from initial stakeholder engagement is the availability of existing data from ongoing or previously occurring monitoring and management activities within the target area. Where pre-existing data is lacking, an ecological integrity assessment should focus on core elements quantifying the current state of the system relative to regional or historical reference standards. However, where pre-existing data is available or previous management activities have been implemented and documented, resources may be directed to collecting data on particular aspects of ecosystem health, or even to establishing whether ongoing management activities are associated with improvements or declines in ecosystem health.

> **Box 4.2 Existing data examples**
> **Alvarado Lagoon System**
> - NGO monitoring data: plant & animal species composition, tidal flux, presence of invasives.
> - Mexican National Mangrove Inventory (CONABIO).
> - Locally proven mangrove restoration methods: Pronatura Veracruz.
> - Land use patterns in GIS files (INEGI)
>
> **General Resource Examples**
> - Global Forest Watch- mangrove extent, forest cover change over time
> - Biodiversity data repositories: GBIF; iDigBio- compiled species data, including from sources below
> - eBird / aVerAves- expert and citizen science avian observations.
> - iNaturalist / Naturalista- citizen science observations with photos.
> - Global mangrove carbon estimates 30m scale (e.g. Sanderman et al. 2018)

Within the Alvarado Lagoon System, baseline data on the structure of the lagoon, as well as information on water quality and species composition was available from regional and national stakeholders and scientists. As a mangrove system recognized as a RAMSAR site of known importance, the ALS was included in a national assessment of mangrove status by CONABIO (National Commission on the Use and Knowledge of Biodiversity) within Mexico (CONABIO 2009). In addition, Pronatura had a long history of conducting ecological restoration and community engagement within the area. As such, background information on the potential for mangrove restoration at the site was known, basic species composition was well documented, and ongoing monitoring activities which included establishment of piezometers for measuring water table levels and flux could be leveraged in the design and implementation of the EIA. Box 4.2. describes local ALS datasets as well as general data available globally for mangrove projects. In addition, global and national datasets from museums or citizen science efforts have the potential to help provide basic data on species composition at all sites or baseline information on mangrove status. These would include Global Forest Watch (information on global forest coverage across time, including for mangroves; globalforestwatch.org), E-Bird (ebird.org; aVerAves in Mexico), iNaturalist (inaturalist.org; Naturalista in Mexico), the Global Biodiversity Information Facility (GBIF.org) or the Integrated Digitized Biocollections project (iDigBio.org).

A Matrix for EIA Capacity Planning.

Below we present a matrix that summarizes potential approaches to an ecological integrity assessment based on the availability of pre-existing data, capacity for data collection, and identification of key questions and goals identified with stakeholders.

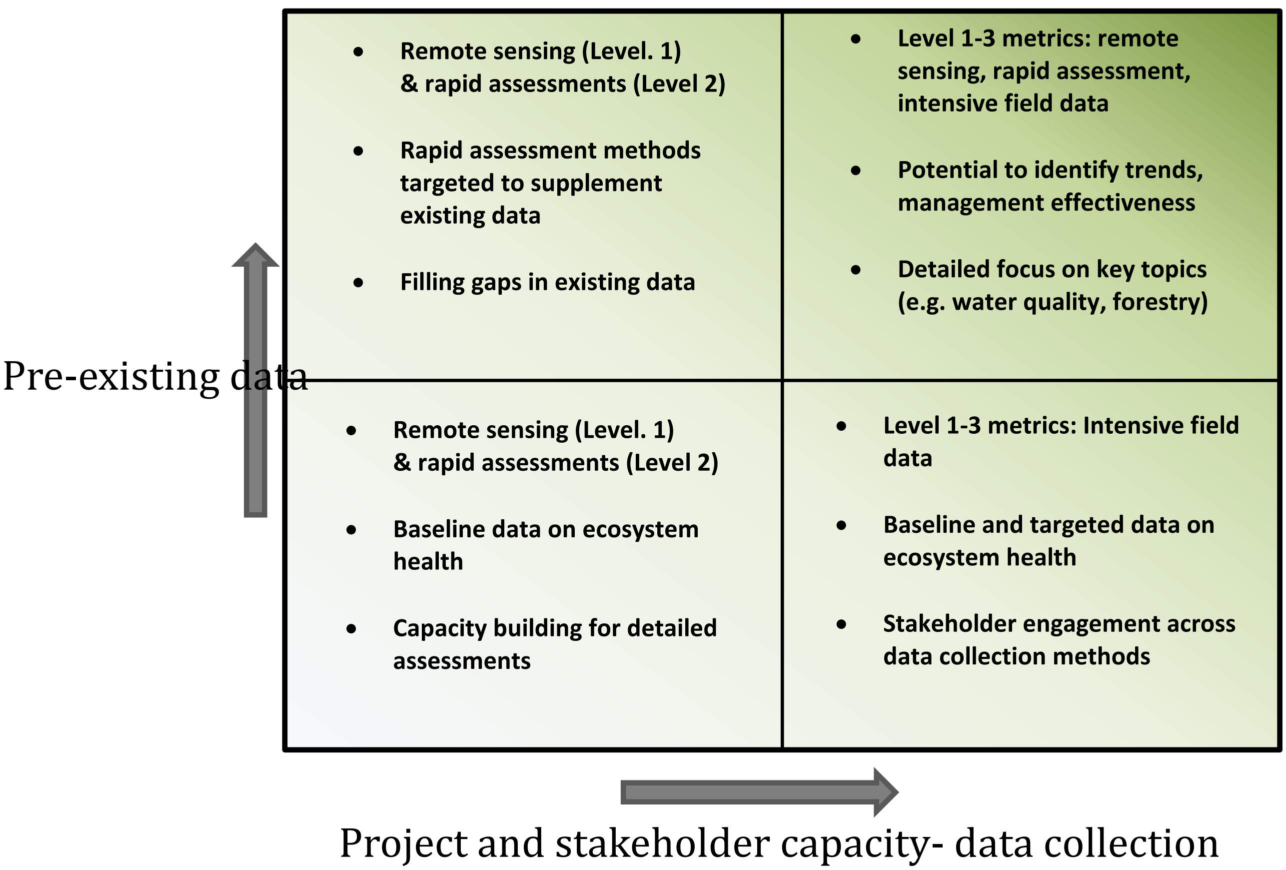


Figure 8 Examples of issues and topics for EIA in the context of local and regional capacity.

Step Two: Designing the EIA: Conceptual model with Indicators & Stressors

The next key step in designing and implementing an ecological assessment is to utilize a conceptual model of system dynamics to help guide the selection of specific ecological attributes to assess and measure the identification of reference conditions.

Designing a Conceptual Ecological Model

Conceptual ecological models are developed to clarify our knowledge of ecosystem structure and dynamics (Noon 2003, Bestelmeyer et al. 2010). They identify key system components, linkages, and processes that are the "key ecological attributes" of the target system. Once key attributes are identified, measurable indicators and specific metrics can be chosen to better understand the response of the wetland to specific drivers and stressors, and later inform restoration actions. These models typically take the form of summary narratives, cross-sectional illustrations, and/or "box and arrow" diagrams that summarize the relationships among ecological components, natural dynamics, and their responses to stressors (Figure 9). Models can be detailed to include specific attributes, such as native vs. invasive species, and ecological processes (specific hydrologic regime) or functions (e.g., flood storage capacity, fish and wildlife productivity).

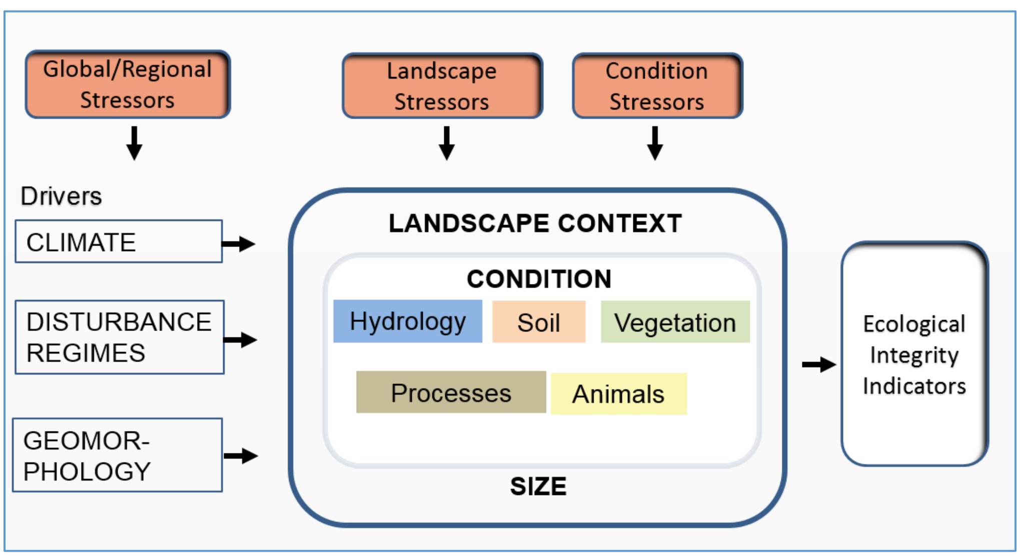


Figure 9 Generalized conceptual ecological model for assessing ecological integrity (From Comer et al. 2017).

The following terminology defines important components used in developing conceptual models (modified from Comer et al. 2017):

- **Ecosystem drivers** are major external driving forces such as climate, hydrology, and natural disturbance regimes (e.g., hurricanes, droughts, fire) that have broad and pervasive influences on natural ecosystems. Mangrove specific drivers include sedimentation rates, tidal flux, and geographic setting (e.g. deltaic, barrier island).

- **States** are the characteristic combination of biotic and abiotic components that define types or phases of ecosystems (e.g., early, mid, and late seral stage, or 'pole' to 'mature' for mangrove stands). States both control and reflect ecological processes.

- **Stressors** are human-caused physical, chemical, or biological perturbations to a system that are either foreign to that system, or natural to the system but occurring at an excessive or deficient level. Stressors cause cascading effects to other components, patterns, and processes within natural systems. Examples include native species displacement, land-use change effects, and water pollution.

Mangrove Stressor Examples

- Changes in sedimentation rates
- Sea level rise
- Sugar cane, palm cultivation
- Fire
- Logging
- Invasive species
- Herbivory
- Altered hydrology

- **Key Ecological Attributes** (KEA) are the subset of ecological factors that are critical to the ecosystem's response to both natural ecological processes and human-caused stressors (Parrish et al. 2003). Changes in key ecological attributes can result in the degradation or "collapse" of the system or occurrence. These tend to be general states such as landscape integrity, level of water quality, or successional stage, with ecosystem-specific factors identified in specific **indicators** such as sedimentation or the presence of a particular species, addressed below.

- **Indicators** are the measurable form of key ecological attributes. That is, they are the ecosystem features or processes that can be measured. Their values are indicative of the integrity of the wetland where they are measured. One or more indicators should be identified for each KEA. **Metrics** are the specific form of an indicator to be measured, specifying both a) the *units of measurement* needed to evaluate the indicator, and b) the *assessment points and ratings* (e.g., "high" to "low") by which those measures are informative of the integrity of the system or stand. Selection of specific metrics is addressed in Section 3 on EIA design and implementation. Mangrove indicators include sedimentation rates, hydrology, and size distribution of mangrove trees within stands.

Key Ecological Attribute	Indicator
Landscape integrity	Fragmentation
Biotic composition	Native and invasive species presence
Stand Development	Cover by tree stage (sapling to mature)
Water quality	Nutrition input
Hydrology	Sedimentation, flow

Table 6 Examples of Key Ecological Attributes and their indicators.

- **Focal taxa** are a special kind of indicator that – due to their sensitivity or exposure to stress, their association with other taxa, or their life history characteristics - might serve as useful indicator species of ecological integrity. Focal taxa might include dominant mangrove trees such as *Rhizophora mangle* or vertebrates of key importance such as manatees. **Table 8** presents a list of key mangrove tree species from the Americas which are likely to be focal taxa in mangrove ecological assessments.

Development of a Conceptual Model for the Alvarado Lagoon System & La Mojarra

Ecological Context

Like many large mangrove complexes, the ALS system exhibits a range of settings and conditions (See Table 7 for a summary of broad mangrove types), but is broadly a deltaic-estuarine and riverine lagoon. Tidal amplitudes are relatively small, less than 1 m. The salinity gradient from Alvarado is not strong, with much of the lagoon having low salinity (approximately 10-15 PSU or ppt). Long term data on sedimentation suggest that agricultural activities in the basin have increased sediment levels in the lagoon system, including side channels that are now more difficult to navigate (Ruiz-Fernandez et al. 2014). Mangroves are typically found bordering the lagoon and its associated rivers and backwaters, but can extend over 250 m from the lagoon and river channels. Forests are dominated by three species: *Avicennia germinans* (black mangrove), *Laguncularia racemosa* (white

Highlighted Topic: Pez Diablo The Devil Fish

A potentially important ecological threat was identified by community members during the later collaborative management workshop, but was not identified as a key threat during the more expert-driven EIA. The non-native 'Devil Fish' or Pez Diablo is a potentially important threat to fishing livelihood, as it is perceived to have recently become more common in the ALS, and can reduce the abundance of the main commercial fish (mojarra, or perch in the family Gerridae).

The Pez Diablo of the Alvarado Lagoon belong to one or more visually and ecologically similar species of invasive catfish from the *Pterygoplichthys* genus, which are invasive beyond their native ranges in South America. Because these catfish are not locally consumed, there is no fisheries market for them.

We note this issue here to highlight the importance of community engagement in the EIA process to be sure that threats and stressors identified by the local community are included. The species is addressed in the management plan developed by the community, and regional biologists are working with local communities to document the spread and effects of the Pez Diablo.

mangrove) and *Rhizophora mangle* (red mangrove). *Rhizophora* is most common along the fringes of the lagoon, but inward stands are typically mixed. Occasionally, *Languncularia* is a strong dominant, but this may be because it is favored for poles. *Conocarpus erectus* (buttonwood), although elsewhere a common mangrove component, is relatively rare in the ALS. The system falls within the Caribbean Riverine Mangrove type based on the International Vegetation Classification (INVC 2008). The fringes also contain oligohaline and freshwater wetlands. These include salt marshes dominated by *Spartina, Fimbristylis* and *Eleocharis,* as well as tall narrow-leaved marshes dominated by *Typha domingensis*, *Phragmites australis,* and *Arundo donox*. Wetlands have also been converted to flooded grasslands for grazing cattle, sometimes directly on the riverine or lagoon shore. Wetlands have also been drained for sugarcane fields. Aquatic vegetation encompasses floating aquatic vegetation, including water lilies (N*ymphaea*, *Eicchornia gracilepes*) and submerged aquatic vegetation, including seagrass (*Ruppia maritima*).

Table 7 Mangrove settings and key ecological axes. Modified from Thom (1982, 1984), Ellison 2012)

	River-dominated (Thom Type 1)	Tide-dominated (Thom Type 2)	Wave-dominated (Thom Type 3)	River- and wave-dominated (Thom Type 4)	Carbonate (Thom Types 6 &7)	Low island (Thom Carbonate Type 8)
Geomorphic setting	Deltas	Estuarine with elongated islands	Barrier islands/ spits and lagoons	Distributaries and lagoons	Abutting and over shallow carbonate platforms	Marine-dominated
Sediments	Allochthonous	Allochthonous	Autochthonous	Allochthonous	Variable	Autochthonous
Tidal range	Low	High	Any	Any	Any	Low
Mangrove locations	Seaward edge and distributaries	Tidal creeks and islands	Inside lagoons	Low-energy distributaries and lagoons	Margins of carbonate platforms; mud flats; fringing areas	Fringing or basin
Key Processes	Freshwater discharge	Tidal currents	Wave energy	Wave energy and freshwater discharge	Substrate distribution	Sea level
Example	Atrato Delta, Columbia	Guayas estuary, Ecuador	El Salvador barrier coastline;	Grijalva, Mexico	Gulf of Mexico; Laguna de Terminos, Mexico	Caribbean; Grand Cayman
Important management topics	River discharges and sedimentation	Changes in tidal action; changes in sedimentation	Change in sediment budgets	River discharges and sedimentation	Sea level Rise	Low sedimentation rates

Table 8 *Mangrove trees species of the Americas*

IUCN Rank	Scientific Name	Common Name (English)	Common names (Spanish by country)	Distribution[2]	Lifeform
Least Concern	*Avicennia germinans*	Black Mangrove	Mangle negro (MX, SV, GT,NI, PA), Mangle prieto (MX), Mangle blanco (MX), Culumate (CR), Curumo negro (HN), Mangle salado (PA), Mangle salsa (CR), Palo de sal (CR, NIC), mangle iguanero (CO, EC), mangle rosada (VE)	BR, CA, CO, EC, GU, MX, NA, PE, VE, WI	Tree to 35m
Vulnerable	*Avicennia bicolor*	Black mangrove	Palo de sal (MX, CR), Mangle negro (MX), Mangle Salado (PA), Curumo blanco (HN), Madresal (SV)	CA, CO, MX (uncommon)	Shrub or small tree to 15m
Least Concern	*Avicennia schaueriana*	White mangrove	Mangle gris (MQ), Mangle sale (LC)	BR, GU, VE, WI.	Tree to 35m
Not Ranked	*Avicennia tonduzii* Sometimes treated as a form of *A. bicolor*	Tonduz mangrove (see also *A. bicolor)*	Palo de sal (CR), mangle salado (CR), mangle salsa (CR)	CR	Shrub or small tree to 15 m
Least Concern	*Conocarpus erectus*	Silver-leaved buttonwood	Mangle botoncillo (MX, GT, PA), Mangle Gris (HN), Mangle negro (CR), palo botono (HN), Mangle zaragoza (CR, PA)	BR, CA, CO, EC, GU, MX, NA, PE, VE, WI.	Shrub to small tree to 10 (20) meters
Least Concern	*Laguncularia racemosa*	White mangrove	Mangle blanco (MX), mangle bobo (MX), Mangle chino (MX), Patabán (CU), Palo de sal (CR), Akira (SR), jeli de mangle	BR, CA, CO, EC, GU, MX, NA, PE, VE, WI.	Tree to 35 m
Least Concern	*Rhizophora mangle*	Red mangrove	Candelón(MX), Mangle Colorado (MX), Mangle dulce (MX), mangle zapatero (EC) , mangle verhelho (BR), purgua (VZ) Mangle rojo (CR)	BR, CA, CO, EC, GU, Mx, NA, VE, WI	Tree to 35 meters
Not Ranked	*Rhizophora harrisonii* Putative hybrid of R. *mangle* & *R. racemosa*	Harrison mangrove, Red mangrove	Candelón (MX) Mangle caballero (EC), Mangle zapatero (EC); Mangle Colorado (MX) ; Mangle dulce (MX) , Mangle rojo (CR, EC, VZ)	BR, CA, CO, EC, GU, MX (uncommon), VE	Tree to 35 meters
Least Concern	*Rhizophora racemosa*	NA	Mangle rojo (NC, VZ)	BR, CA, CO, GU, VE	Tree to 35 meters
Vulnerable	*Pelliciera rhizophorae*	Tea mangrove	Manglar Piñuelo	CA, CO, EC	Small tree to 11 meters

[1] by ISO country code. Augustin de Jesus, et al. 2018. Grandtner, et al. (2013)
[2] From Ulloa et al. 2017
BR (Brazil), CA (Central America), CO (Colombia), US (USA), EC (Ecuador), GU (Guianas), MX (Mexico) PE (Peru), VE (Venezuela), WI (West Indies)

Alvarado Lagoon Model

The models developed for the Alvarado Lagoon project (Figures 10 and 11) build on previous models and take the form of simple "box and arrow" diagrams that summarize the relationships among ecological components, natural dynamics, and their responses to stressors. The model identifies the main landscape stressors as sugarcane plantations and cattle ranches, as shown in the pictorial form of the model (Figure 11). The selected indicators track the mangrove response to those stressors and to the main ecological drivers. Using knowledge gained from background research on the mangroves of the ALS and engagement with local and regional stakeholders, we identified a suite of indicators that can be used to track the ecological integrity of mangroves at the ALS. Table 9. shows the list of indicators, organized by the Primary Factors and the Key Ecological Attributes (KEAs). Below, we walk through the development of Key Ecological Attributes and Ecological Integrity Indicators.

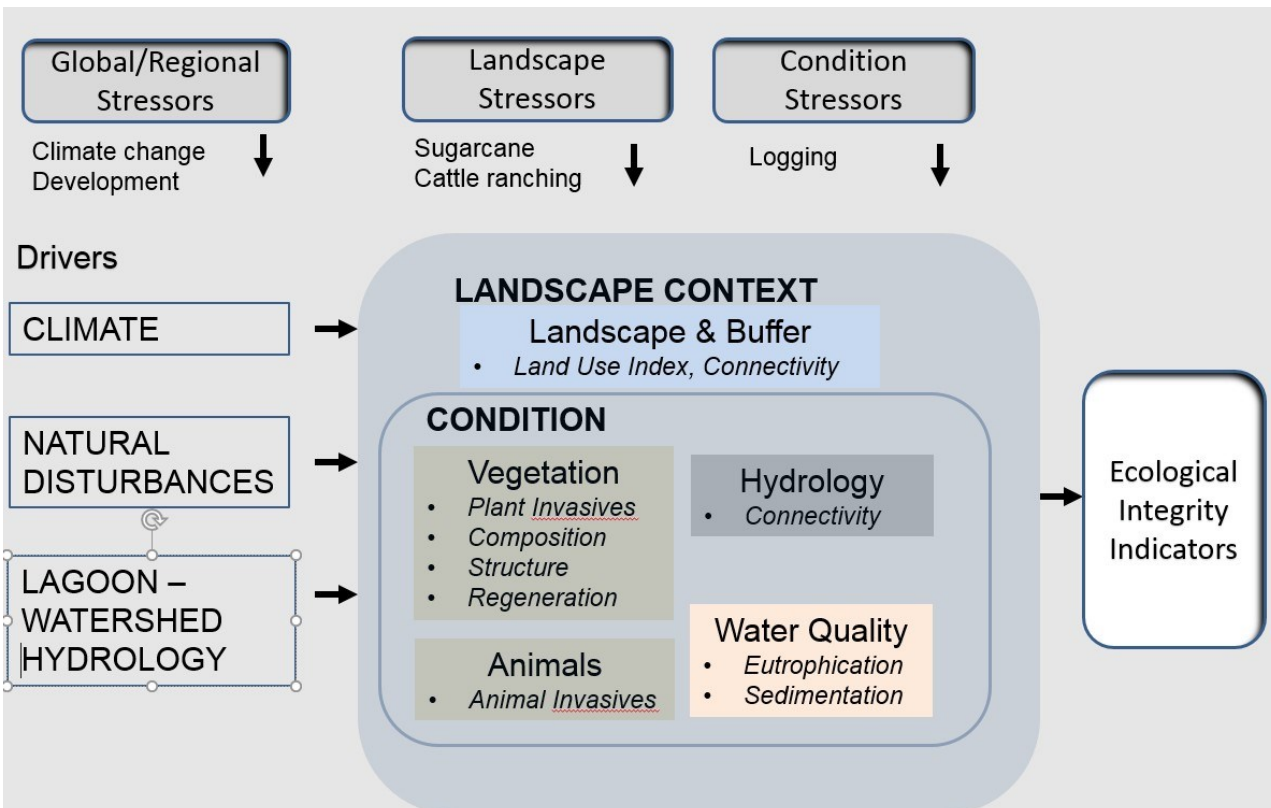
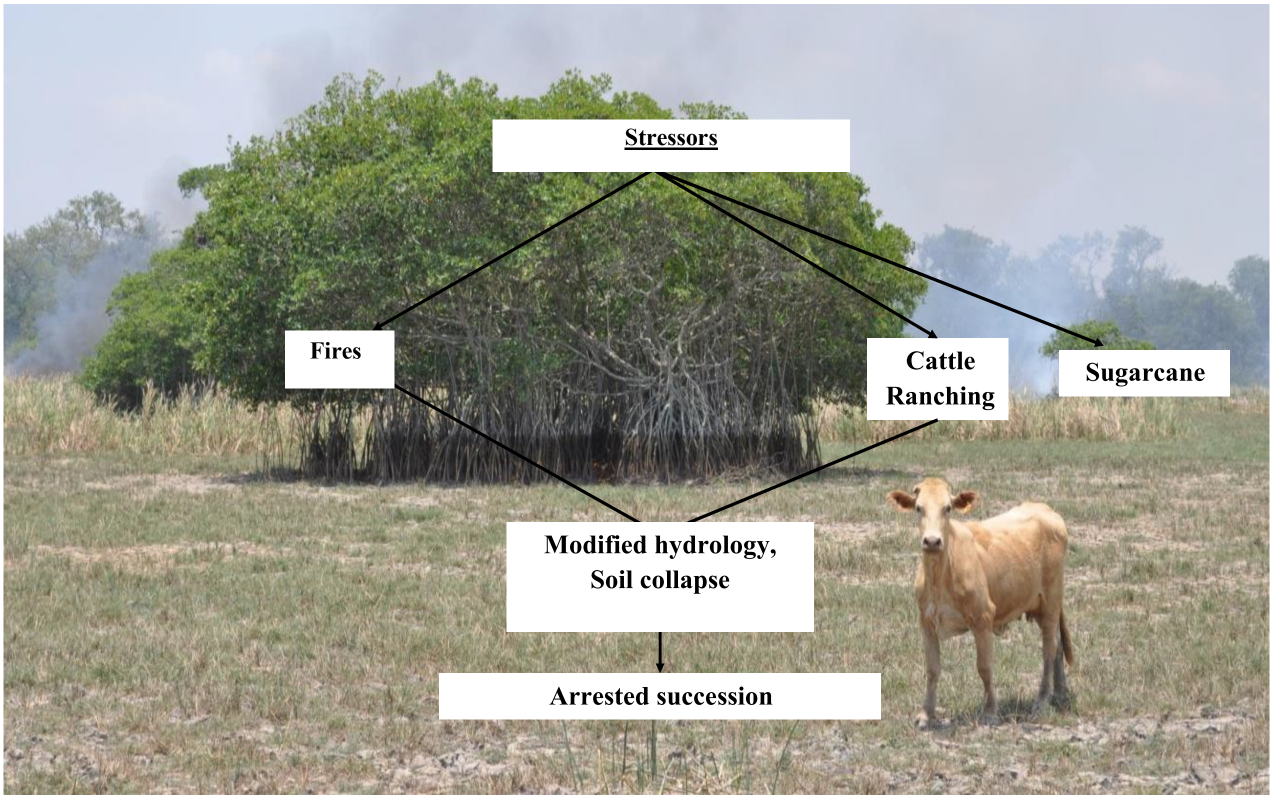


Figure 10 Conceptual model for the Alvarado Lagoon mangrove system. Major drivers and stressors affecting the mangrove system are shown, along with the major ecological attributes of the mangrove system (Vegetation, Hydrology, etc.). Italics show the chosen indicators for this study. Stressors can act at multiple levels. They are shown here in the context of the Alvarado Lagoon, with logging as a local condition stressor, and development as a regional stressor, and sugarcane and ranching as stressors at the landscape level.

Figure 11 A pictorial representation of a conceptual model for major factors in the Alvarado Lagoon. The figure shows the several main stressors (sugarcane plantation, fire, and cattle), and their effects on mangrove structure and composition.



Key Ecological Attributes

Key ecological attributes can be broken down into landscape context attributes and attributes reflecting the conditions within the system. Landscape context metrics aim to address conditions affected by land conversion and fragmentation surrounding the system or site of interest. Intactness of the buffer surrounding the system has substantial effects on the natural processes within it. Condition metrics focus on plant species composition, hydrology, and soil conditions of the target system. The composition of native plant species, such as presence of typical dominant mangrove taxa within a system, is a primary condition metric and is directly affected by the presence and abundance of non-native and/or invasive species. Hydrologic metrics address natural water sources often disrupted by diversions and obstructions, hydroperiod influencing sediment dynamics, and hydrologic connectivity affects a broad set of exchanges, including water, sediments, nutrients, organic carbon, and species dispersal. Soil condition metrics address storage capacity for water and carbon, and provide the medium for plant establishment. Table 9 List the key ecological attributes identified for the ALS project and background defining the importance of the attribute. Each ecological attribute can be measured by various specific metrics which are addressed in Step 3 on design and implementation. The key attributes identified in Table 9 were developed from a standard list of attributes that are important across wetland systems (see Faber-Langendoun 2016 for a more extensive list), and chosen specifically for mangrove systems similar to that found in the ALS. This list of key attributes can be modified based on the dynamics of the target system.

Table 9 List of Key Attributes used in the ALS assessment. Code for each indicator follows the format used by Faber- Langendoen et al. (2016b).

Primary Factor Key Ecological Attribute (KEA)
Indicator
Primary Factor: LANDSCAPE CONTEXT
KEA: Landscape & Buffer
LAN1. Contiguous Natural Land Cover
LAN2. Land Use Index
Primary Factor: CONDITION
KEA: Vegetation Composition
VEG2a. Invasive Nonnative Plant Species Cover
VEG3. Native Plant Species Composition
KEA: Vegetation Structure
VEG4. Overall Vegetation Structure
VEG5. Regeneration Potential
KEA: Animals
ANI1. Invasive Animal Species
KEA: Hydrology
HYD3. Hydrologic Connectivity (V1 - riverine)
KEA: Water Quality
WAQ1. Eutrophication
WAQ2. Sediment Load

Step Three: Designing the Assessment: Implementation

Once a conceptual model is developed and key ecological attributes are identified to assess ecosystem status, specific metrics and methodologies to assess the attributes must be identified. These include protocols for plot data collection, rapid assessment methods, and methodology for specialized sampling such as water quality or soil composition.

Site Selection

For an Ecological Integrity Assessment, sites should be selected that span the range of mangrove conditions across the evaluation area from highly degraded sites to sites with minimal disturbance. This allows for characterization of the range of conditions within an area and for future site assessments to be placed in a broad context of ecosystem condition. However, a key issue in site selection is whether data from the EIA needs to provide estimates of site conditions beyond the specific locations where data is collected. In many cases, the goal of an EIA is to place specific sites into a context of ecological condition in order to prioritize management of those sites and provide general context for stand health across a project area. In these cases, sites may be chosen deliberately and subjectively to include desired management areas and a range of reference conditions from least to most disturbed. In contrast, if a goal of an EIA is to contribute to estimates of ecological factors beyond the target sites (e.g. estimate tree density across a target area), sites need to be selected based on statistical principals in an unbiased fashion, or in a fashion where data can be extrapolated beyond selected sites to similar conditions. Truly random site selection would meet this need but is often impractical due to practical constraints on site access or requirements of high sample sizes (See Elizinga et al. 2009 for an in depth overview of sampling designs). Stratified random approaches are a hybrid approach which may be practical in applied settings. These include methods where plots are placed (systematically or randomly) within identified zones of similar vegetation, allowing extrapolation based on the area of sampled zones or vegetation types.

Highlighted Topic:
Mangrove Fires

Fire was identified by community members as one of the primary threats to mangrove forests within La Mojarra and the ALS. Mangrove fires most commonly occur in the ALS when they spread from nearby cattle pastures or sugar cane fields, which are burned annually to increase productivity and to clear debris. Areas of La Mojarra were identified as formerly mangrove that are now degraded pasture due to previous fires. In management workshops, the community identified a range of actions to reduce fires through community vigilance and communication with neighbors, with potential monetary support from a program administered by the national commission for protected areas (CONANP). Additionally, areas of La Mojarra were identified as zones for mangrove restoration through collaboration with Pronatura Veracruz and other regional organizations.

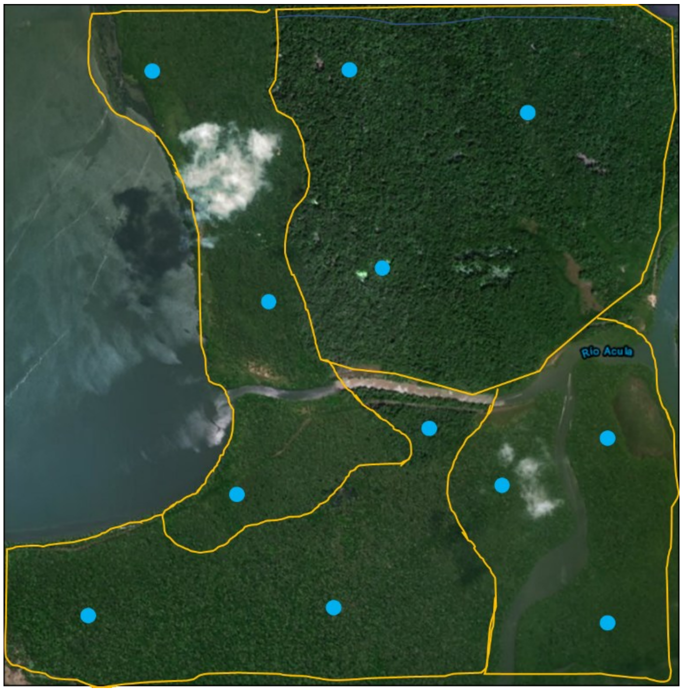


Figure 12 Example of a stratified sampling scheme, with plots placed within zones of similar vegetation delineated from satellite imagery.

Site selection for the ALS assessment is an example of both subjective site selection with the primary goal of capturing a range of ecological conditions, and utilization of previous stakeholder sampling within the region. These factors reflected land access, pre-existing monitoring site, and limited availability of certain conditions (e.g. unlogged forest, or restored sites) which are frequent factors in conservation settings. Within the ALS, sites were chosen based on their use in previous hydrology, water quality and soil monitoring assessments, and by their locations within conservation areas and restoration sites. Chosen sites for the ALS project included 9 newly selected sites and 4 sites previously established for other monitoring efforts. By placing sites in locations previously used for soil and hydrological sampling, we benefitted from access to existing information, and were more confident that sites would become part of a long-term monitoring program. Figure 13 provides a map of selected sites within the context of the ALS, serving as an overview reflecting how sites spanned a range of condition and geography with Alvarado Lagoon.

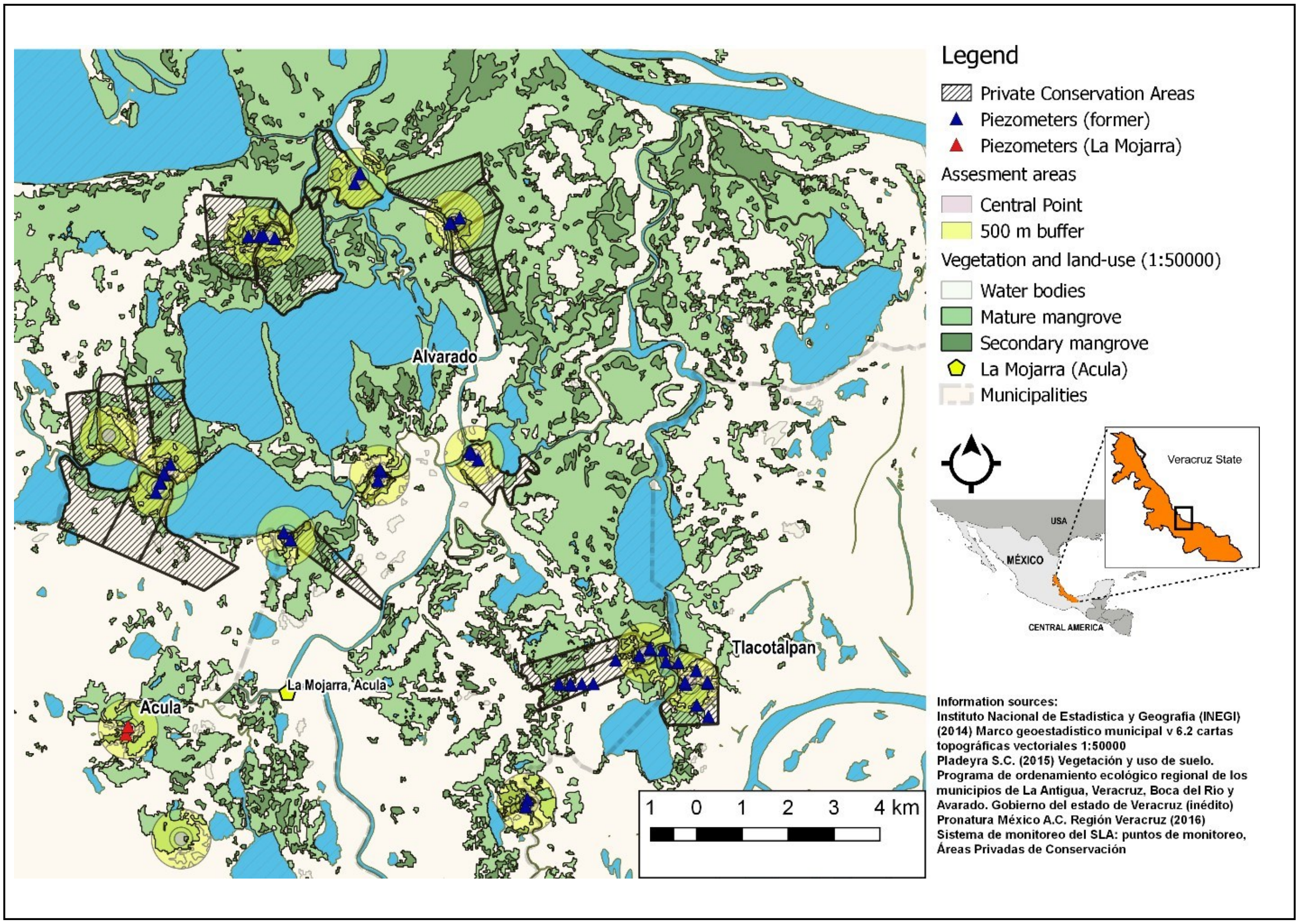


Figure 13 *Site map, showing location of mangrove forest assessment areas (within 500 m buffer). Location of piezometers in assessment area is also shown, as well as mature and secondary mangrove, and private conservation areas. Locations were chose deliberately to span a range of conditions within the lagoon, and to utilize pre-existing sites where water, soil, and tree data was being collected by project stakeholders.*

Identification of Metrics

The selection of metrics is focused on those that can detect changes in KEAs, particularly changes caused by stressors. Metrics that address a key ecological attribute and are sensitive to changes from stressors are referred to as "**Condition metrics;**" that is, metrics that directly measure changes to the KEAs (e.g., hydroperiod, native species richness, coarse woody debris). Across a series of undisturbed reference locations for the targeted wetland type, one can expect that these measures to fall within some expected range; i.e., the Natural Range of Variability (NRV). Where condition metrics fall increasingly outside of that expected NRV, there is a clear indication of departure from NRV, and an increasing indication of ecological degradation.

In contrast, "**Stressor metrics**" directly measure stressors (e.g., number of ditches or hydrologic obstructions in a wetland, presence and abundance of invasive species. Proportion of land converted in buffer zone), and are used to infer the condition or integrity of the wetland. In many instances these may be the only metrics one can feasibly address. While it is most desirable to focus on condition metrics because they are the clearest measure of departure relative to NRV, stressor-based measures may be sufficient with independent assessment of the correlations between stressors and condition measures. In these cases, there is no NRV for the stressor (other than "absence"), and so with increasing impact of the stressor, one is presuming that KEAs related to natural conditions are becoming increasingly departed from their expected NRV.

Potential metrics can be identified through a through a series of screening criteria (Andreasen et al. 2001, Tierney et al. 2009, Mitchell et al. 2014). The following questions help identify appropriate metrics (Kurtz et al. 2001; modified from Comer et al. 2017):

> *1) Is the metric ecologically relevant? Conceptually relevant metrics are related to the Key Ecological Attributes of the wetland or to stressors that affect its integrity.*
>
> *2) Can the metric be feasibly implemented? The most feasible metrics can be sampled and measured using methods that are technically sound, appropriate, efficient, and inexpensive. It is useful to select metrics based on the capacity for data collection identified during stakeholder engagement and initial planning in the context of Level 1 (remote sensing) to Level 3 (detailed field data) metrics. Table 10 provides an overview of factors associated with the level of intensity of these metrics.*

Table 10 Summary of 3-level approach to conducting ecological integrity assessments. (adapted from Brooks et al. 2004, U.S. EPA 2006).

Level 1 – Remote Assessment	**Level 2 – Rapid Assessment**	**Level 3 – Intensive Assessment**
General description: Remote or GIS-based measurement	*General description:* Rapid field-based measurement	*General description:* Intensive field-based measurement
Evaluates: Integrity of both on and off-site conditions around individual sites/occurrences using • Indicators on-site that are detectable with remote sensing data • Indicators in the surrounding landscape / watershed	*Evaluates:* Integrity of individual sites using relatively simple field indicators • Very rapid assessment (visual observations with narrative) • Rapid assessment (standard indicators) • Hybrid assessment (rapid + some intensive indicators; e.g., vegetation data from plots)	*Evaluates:* Integrity of individual sites using quantitative field indicators • Metrics based on detailed knowledge of historic NRV and statistically analyzed data • Quantitative field sampling methods
Based on: • GIS and remote sensing data • Layers typically include: spectral data, aerial photography, interpreted and cover / land use types • Stressor metrics (e.g., road location, size, density, proximity to impervious surfaces, land use types)	*Based on:* • On-site condition metrics (e.g., vegetation, hydrology, and soils) • Stressor metrics (e.g., ditching, road crossings, and pollutant inputs) • Buffer metrics observed on site	*Based on:* • On-site condition metrics (e.g., vegetation, hydrology, and soils) • Stressor metrics (e.g., ditching, road crossings, and pollutant inputs)
Potential uses: • Identify least impacted sites • Identify status and trends of acreages across the landscape • Identify land use factors influencing to condition of wetland types across the landscape	*Potential uses:* • Relatively inexpensive field observations across multiple sites • Informs monitoring for implementation of restoration, mitigation, or management projects • Landscape / small watershed planning • General conservation and management planning	*Potential uses:* • Detailed field observations, with repeatable measurements, and statistical interpretations • Inform status and trend measurements, monitoring for restoration, mitigation, and management projects

3) Is the response variability understood? Every metric has an associated measurement error, temporal variability, and spatial variability. The best metrics will have low error and variability compared to the Natural Range of Variability. In other words, good metrics have high discriminatory ability, and the signal from the metric is not lost in measurement error. Ideally the metric has been assessed across a range of sites that span the gradient of stressor levels (DeKeyser et al. 2003) and verified to show a clear response to the stressor.

4) Is the metric interpretable and useful? The best metrics provide information on ecological integrity that is meaningful to resource managers in that it can inform restoration actions.

Box 4.3. Climate Change and Carbon Assessments in Mangrove systems

Specific guides for the assessment of climate change vulnerability (e.g. Ellison 2012, Duncan et al. 2018) and carbon assessments (Howard et al. 2018, Broadhead et al 2016) exist for mangroves. Here we present a brief summary of issues related to climate change and carbon assessments and refer readers to the key references listed here for further information. In terms of climate change assessments in mangrove systems, the ability of systems to withstand or respond to changes in sea level rise are especially important. Carbon assessments are most commonly implemented when there is a nexus for payment for ecosystem services programs related to climate change mitigation.

Climate Change Specific Attributes and Metrics for Mangroves (Adapted from Ellison 2012)

Arrow denotes whether an increase is generally a positive (green) or negative factor (red), or whether the direction of change is variable (e.g. precipitation). These metrics are designed around three commonly used aspects of climate change vulnerability:

Exposure: Rate, magnitude, and nature of climate-induced stress (e.g. sea level rise)
Sensitivity: Characteristics of a system affecting tolerance to changes
Adaptive Capacity: Characteristics affecting potential for ecosystem to cope with climate change

Exposure	Sensitivity	Adaptive Capacity
↑ (green) **Tidal range**	↑ (green) **Mangrove Basal Area**	↑ (green) **Adjacent areas suitable for migration**
↑ (green) **Sedimentation Rate**	↑ (green) **Mangrove recruitment**	↑ (green) **Community management capacity**
↑ (red) **Sea Level Rise**	↑ (green) **Legislation / Protection**	↑ (green) **Stakeholder involvement**
↑ (red) **Temperature Changes**	↑ (green) **Sedimentation rate relative to sea level rise**	
↑ (red) **Invasive species/ pathogens**	↑ (green) **Changes in extent**	
⇔ **Precipitation Changes**	↑ (green) **Range of elevation**	
	↑ (red) **Mortality**	
	↑ (red) **Changes in extent**	
	↑ (red) **Seaward edge retreat**	

***Carbon Stock Assessments*:** The IPCC uses a tiered framework for carbon stock assessments from least (Tier 1) to most detailed (Tier 3)[1]. We present a brief overview of this framework here as a grounding point for carbon assessments. Most field assessments of carbon stocks would fall under Tier 3. However, projects may commonly rely on Tier 1 or Tier 2 for preliminary estimates for scoping, funding and assessment.

Tier 1	Tier 2	Tier 3
Generic Global Estimates	**Country/Region Specific**	**Site Specific**
• Standard values for carbon e.g. 511 Mg C ha^{-1} total carbon • Values differ by latitude and habitat classification • Standard above/below splits • Combined with estimates of forest extents • Standard values for extraction, conversion	• Species specific C sequestration equations • Mangrove stand composition • Standard country values for extraction, conversion • Component estimates for soil, above and below ground estimates based on regional values	• Detailed field measurements -DBH & height measurements -Prism techniques -Soil cores • Species specific C sequestration equations • Site specific remote sensing • Site specific modeling • Soil, Vegetation, Flux • Litter & debris contrubtions

1 Hiraishi et al. 2013; IPCC 2006; 2019 updated anticipated from IPCC

CLIMATE BOX, ADDITIONAL REFERENCES

Gathering Data

Once appropriate metrics have been identified and existing information on assessment points has been utilized, consistent sampling protocols need to be applied to both the project site and the reference sites. Field methods depend, in part, on the goals of the project and a detailed review of specific methods for vegetation, hydrology, and soil surveying is beyond the scope of this document. We provide examples of specific methodology from the ALS project that can be applied in similar mangrove systems, and point readers to additional resources where available.

Table 11 Specific metrics utilized in the ALS Ecological Integrity Assessment

Primary Factor Key Ecological Attribute (KEA)	**Specific Metric(s)**
Indicator	
Primary Factor: LANDSCAPE CONTEXT	
KEA: Landscape & Buffer	
LAN1. Contiguous Natural Land Cover	% Natural land cover with 500 m radius of plot
LAN2. Land Use Index	Weighted value of land use category surrounding focal plot (0 = minimal use, 10 = intense use.
Primary Factor: CONDITION	
KEA: Vegetation Composition	
VEG2a. Invasive Nonnative Plant Species Cover	Invasive species absent vs. abundant (>30%)
VEG3. Native Plant Species Composition	Native diagnostic species present & native species indicative of disturbance absent vs. diagnostic species absent & native species indicative of disturbance present
KEA: Vegetation Structure	
VEG4. Overall Vegetation Structure	Full complement of vegetative zones present. [recruitment to mature] vs. absent [burned, clearcut]
VEG5. Regeneration Potential	> 4 seedlings or saplings per 0.01 ha vs. < 2 seedlings or saplings per 0.01 ha
KEA: Animals	
ANI1. Invasive Animal Species	Invasive animal species absent vs. present and severe effects on vegetation structure or native animal populations
KEA: Hydrology	
HYD3. Hydrologic Connectivity (V1 -	No geomorphic modifications made to

riverine)	contemporary floodplain. Channels not Entrenched vs. entrenched channels, extensive modification
KEA: Water Quality	
WAQ1. Eutrophication	Total Phosphorous < 0.1 and Total Nitrogen < 1.0 mg L -1 vs. TP > 0.9 and TN > 7
WAQ2. Sediment Load	Total Suspended Solids > 2100 vs. TSS < 100

Landscape context

Within the ALS, landscape context was assessed using land use from national and regional GIS sources (INEGI, Pronatura Veracruz), and readily available satellite imagery, along with locally available aerial photography. However, a range of satellite based imagery and other remote sensing products are available to support estimates of mangrove cover, fragmentation, and change in extent over time (Table 12). Remote sensed data are increasingly used to provide estimates of productivity (e.g. NDVI), biomass (Synthetic Aperture Radar-SAR, or other approaches), or to use combinations of multispectral imagery to identify stands of different mangrove tree species. Utilization of raw satellite imagery can be a powerful tool, but can also present technical challenges in terms of processing and interpreting images due to issues such as cloud cover. Duncan et al. (2018) present a recent overview of remote sensing approaches that can be utilized to characterize aspects of mangrove ecology including vulnerability to climate change. Resources from Global Forest Watch, which built on collaborations between Google and the University of Maryland's Global Land Analysis and Discovery lab to compile a seamless Landsat based resource for global forest change (Hansen et al. 2013)

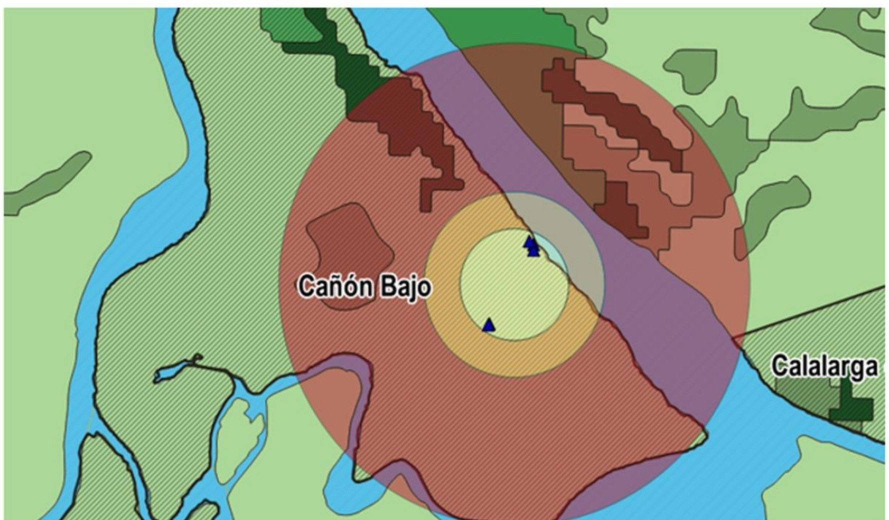
Table 12 *Imagery and remote sensing resources or tools for mangrove assessments.*

Source	Note	Resolution	Availability
Global Forest Watch	Integrates data from multiple sources; provides layers and tools for estimation of forest cover and loss rates.	Variable- data from multiple sources.	Freely available tool https://globalforestwatch.org
Landsat	1973- present Multispectral imagery	30m	Free online (USGS) https://landsat.usgs.gov
WorldView-2 /QuickBird	2001-present Multispectral imagery	2m	Primarily commercial https://www.digitalglobe.com
Spot	1986- present Multispectral imagery	2.5-20m	Commercial (free after 5 years) Multiple sources
Sentinel	2014-present; Multispectral imagery	10m	Free- European Space Agency https://sentinel.esa.int/
CBERS	2000- present China/Brazil collaboration. Multispectral imagery	20m	South America coverage freely available Brazil's National Institute for Space Research https://inpe.br
GeoEye / IKONOS	2001-present Multispectral imagery	1-5 m	Mixed. Some data freely available through GoogleEarth.
MODIS	2000-present Multispectral imagery	250m	Free online NASA https://earthdata.nasa.gov
ASTER	2000 present Multispectral imagery	15- 100m	Free- USGS https://asterweb.jpl.nasa.gov/
ALOS/PALSAR	2006- present SAR- Biomass estimation	3 – 10m	Commercial and public versions http://global.jaxa.jp
ENVISAT-MERIS	2002-present Suspended solids	2km	Free (MERIS) and restricted (SAR) https://spacedata.copernicus.
Mosaic drone imagery	Increasingly utilized as an alternative to satellite based imagery.[1,2] Range of custom sensors	sub-meter (to 5 cm)	Implemented on a per-project basis. Current costs high relative to satellite imagery.

[1] Ruwaimana et al. 2018, [2] Otero et al. 2018

Buffer and Landscape Metrics: ALS

Existing land cover maps from Pronatura Veracruz and INEGI (Mexico's National Institute of Statistics and Geography) were used to assess landscape and buffer metrics. Our sites were defined by a focal circle with a 150 m radius, encompassing two piezometers. The focal circle was surrounded by a 100 m radius buffer for assessing adjacent landscape context, and an additional 400 m radius was used for assessing broader landscape variables, for a total landscape context radius of 500 m surrounding the assessment area (Figure 14). Land cover percentages based on the pre-existing landscape use map were calculated in each circle (i.e., Assessment Area = 150 m radius, 100 m distance Buffer, 500 m landscape, excluding buffer). Within the 150-m radius, we also used the Land Use Index as a proxy for vegetation composition, so that sites that contained secondary mangrove, burned areas, or marsh were scored lower for naturalness of vegetation composition than sites with all mature mangrove. We collected and developed a detailed geographical information system describing the landscape of the ALS, including land cover and land use. Habitat fragmentation has proceeded quickly in the ALS and the original habitat types have been transformed by settlement, cattle ranching and secondary growth of sabal palm forest. Major vegetation types and land-use categories used to quantify sites are provided in Appendix 1, Table A1.1.



Legend	
Primary Mangrove	
Secondary Mangrove	
Marsh	
Pasture - Wet	
River	
Protected Area	

LAND USE INDEX		0-100 m		100 - 500 m	
Land Cover	C.	%	Score /100	%	Score /100
Primary Mangrove	*10*	100	10	76	7.60
Secondary Mangrove	*7*	0	0	11	0.77
Marsh	*4*	0	0	8	0.32
Pasture-Wet	*4*	0	0	6	0.24
Total = 9.57 = A		100	10 (0.6)	100	8.93 (0.4)

Metric Rating	*Land Use Index: ALL WETLANDS*
EXCELLENT (A)	Average Land Use Score = 9.5–10
GOOD (B)	Average Land Use Score = 8.0–9.4
FAIR (C)	Average Land Use Score = 4.0–7.9
POOR (D)	Average Land Use Score = <4.0

Pronatura México A.C. Región Veracruz (2016)
Sistema de monitoreo del SLA: puntos de monitoreo, Áreas Privadas de Conservación

Figure 14 Illustration of the application of land cover types with the Land Use Index from the ALS project. The green inner circle represents an assessment area or site that includes both exterior (next to river) and interior piezometers (triangles). Mangrove plots were placed midway between the two piezometers. Surrounding the site is a 100 m buffer, and a larger 400 m landscape. Land cover percentages are calculated for both buffer and landscape. In each, we weighted the land covers by a coefficient (c) of naturalness (10 = natural, 0 = non-natural) to create a separate Land Use Index score. An overall Land Use Index was calculated by adding the buffer (weighted 0.6) and landscape (weighted 0.4).

Vegetation Sampling Design: ALS

Plot data. There are numerous plot designs for collecting detailed vegetation data which are beyond the scope of this review (see Shiver and Borders 1996 for additional approaches). Here, we present a standard forest management plot sampling design for assessing forest management potential in Mexican mangroves developed by Valdez (2002), and utilized in the ALS project. The intensive assessment was conducted in three 30x10 m plots. Plots were arranged in a helix around a midway point between previously-deployed piezometers (Figure 13). Each plot was divided into three kinds of subplots: three 10x10 m modules, two 4x4m quadrats and five 1x1m quadrats. The 10 x 10 m module is also a standard used for forest plots around the world.

Figure 15 Pronatura and NatureServe biologists collecting forest plot data. Note high density of small diameter trees (< 10 cm). *Relative to many other forest types, small diameter trees in mangrove forests can contribute a substantial portion of stand biomass and are important to include in estimates of basal area.*

Forest Plot Design

Plots were located approximately midway (125 m) between the exterior (along river) piezometer and the interior piezometer, which are 250 m apart. We used the 125 m distance as the central hub for a spoke sampling design, in which transects were established in N (0 degrees), SE (120 degrees) and SW (240 degrees) directions. Each plot was initiated 10 m from the central hub, and laid to the left of the tape. Three plots were sampled in each site. Because plots were close to each other, they were treated together to generate site values. Results include basic mangrove structure, composition and function parameters, including mangrove Importance Values and Complexity Index.

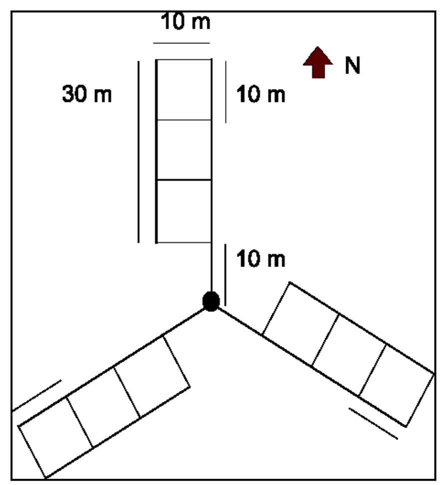


Figure 16 Forest Plot sampling design.

The various layers of vegetation were sampled as follows:

Trees: all stems > 2.5. cm diameter at breast height (dbh).

Regeneration:

- propagules and flowers: five 1 x 1 m quadrats – total count.
- small regeneration: five 1 x 1 m quadrats. Very small < 30 cm, Small > 30 cm - 1.3 m

- tall regeneration: two 4 x 4 m quadrats: 1.3 m - 2.5 cm dbh.

Importance Value Index (IVI): Indicates the structural importance of a species within a stand of mixed species. It is calculated by summing the relative percentages of basal area, density and frequency, weighed equally for each species, relative to the same dimensions for the entire stand.

Complexity Index (CI): The complexity index was computed for a 0.1 ha plot as follows: Complexity Index = No. of species X Total Stand Density X Basal Area X Stand Mean Height X 10–3. Height of the tallest tree in each plot was estimated.

Structural Stage Class: Mangroves have a relatively simple forest structure, with small canopy gap dynamics as the predominant disturbance regime (ALS is not subject to tropical hurricanes or catastrophic disturbance). For that reason, we developed a structural stage class for mangroves based on standard temperate forest development models that assign structural stage categories – from seedling/sapling, pole, mid, and mature (Lorimer and Halpin 2014). This results in a mangrove structure similar to that presented by (Ellison 2012). We used the percentage of basal area distributed across four stem sizes: seedling/sapling (stems 30 cm – 2.5. cm dbh), small (2.5-10 cm dbh), pole (10–25 cm), medium (26–50 cm), and large (>50 cm). These size classes also have meaning for forestry management, as the primary size favored for fence poles is between 10 and 20 cm.

We applied the following criteria to define the structural stages:

- *Seedling/Sapling*: $\geq$ 67% of stem relative basal area (RBA) in seedling/sapling plus small trees, with more RBA in seedling/sapling than pole. Total basal area < 10 m^2 ha^{-1}.
- *Pole*: $\geq$ 67% of stem RBA in small plus pole, with more RBA in small than pole OR $\geq$ 67% of stem RBA in pole plus medium + large, with more RBA in small than pole. Total basal area $\geq$ 10 < 20 m^2 ha^{-1}.
- *Mid:* $\geq$ 67% of stem RBA in small plus pole, with more RBA in pole than small, OR $\geq$ 67% of stem RBA in pole plus medium-large, with more RBA in pole than medium + large. Or no combination > 67%. Total basal area $\geq$ 20 m^2 ha^{-1}.
- *Mature*: $\geq$ 67% of stem RBA in pole plus medium + large, with more RBA in medium + large than pole. Total basal area $\geq$ 20 m^2 ha^{-1}.

Hydrology and Soils ALS Monitoring

Hydrology

Flood level and interstitial water factors (nitrates, ammonium, phosphates, dissolved oxygen, turbidity, temperature and salinity) had been assessed in the ALS since 2015 by the Pronatura Veracruz monitoring team. The assessment was based on monthly measurements taken from 21 permanent piezometers (2m long, 1m below ground; *assessment sites*) displayed along the ALS according to a stratified model, following the directions of Moreno-Casasola and Warne (2009). Flood level was recorded in cm by direct measurement while interstitial water factors are measured directly in the field with a multiparametric probe (temperature, salinity, dissolved oxygen) or in the lab by photometry (nitrates, ammonium, phosphates, turbidity).

Soil survey

Standard soil measurements were taken once for each of the 21 assessment sites during Summer 2016 for building the basal line of soil conditions in Alvarado Lagoon System. Soil variables assessed included: Bulk density and apparent density; pH; Electrical conductivity; Soil organic matter; Total organic carbon; Available phosphorous; % nitrogen; Trace elements (Cu,Cr, Ni, Pb); %Sand/Clay/Loam; Cation exchange capacity; and Carbon:Nitrogen ratio. Soil survey methods were chosen to match ongoing regional monitoring efforts so that EIA data collection would contribute to broader efforts to categorize the state of the Alvarado Lagoon System.

STEP FOUR: ANALYZING AND SCORING THE ASSESSMENT

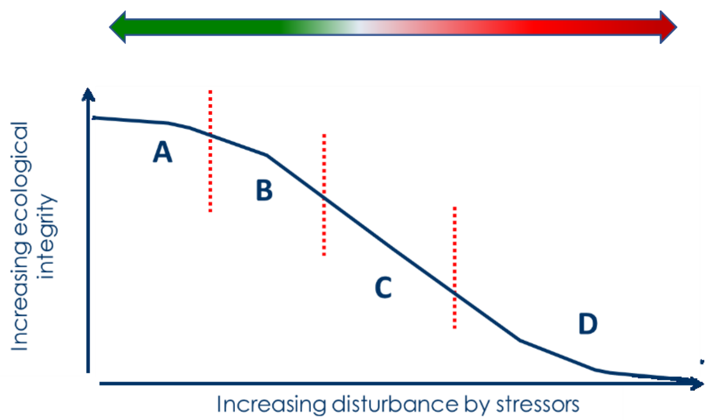


Figure 17 *Visualization of the relationship between disturbance and the different categories of ecological integrity.*

Once metrics are identified, they need to be placed in a framework that allows for sites to be scored in a multi-metric fashion that combines different types of metrics. We present a practical approach here that identifies conditions or values for each metric on a simple four category scale from least disturbed (reflecting conditions thought to represent reference or excellent conditions) to highly disturbed (Figure 17) In the ALS project all metrics were scored based on a simple 4 category scale of A = 4 pts, B = 3pts, C = 2pts and D= 1pt. Although data were ultimately summarized on this simple scale, quantitative results can be used to calibrate this scale. Calibration of values is explored below in an example showing quantitative and qualitative data that can be used to place overall vegetation structure within the A-D categorical range.

Metrics and Scoring: Vegetation Structure

As an example of ways to evaluate a condition using both qualitative and quantitative measures, we provide text descriptions and numeric values corresponding to the range of mangrove conditions found in the ALS. Table 13. presents written descriptions of overall stand condition ranging from A (e.g. minimal disturbance and with pole to mature trees present) to D (highly disturbed, burned, clear cut), along with corresponding values from quantitative plot assessments of total basal area (TBA), percentage of basal area in medium to large trees, and results from the complexity index taking into account tree height, dbh, density, and species diversity. Quantitative results can be used to calibrate and validate descriptive categories. Although the specific categories and values used for the ALS assessment may apply to similar mangrove habitats in nearby areas, results for an EIA always be calibrated on a site and project basis to account for variation in local conditions and species composition. Local values can be placed in the context of regional mangrove condition using reported values from the literature.

Table 13 *Example scoring categories for vegetation structure within ALS mangrove stands, with written description of structure (applicable for rapid assessments) and corresponding quantitative metrics from plot data. Quantitative measurements can be used to support qualitative categorical scoring divisions.*

Score	Description	% Basal Area in Medium (>26 cm) & Large (>50cm) Trees	Total Basal Area (m^2 ha^{-1}) mean and range	Complexity Index-mean & range
A (4 pts)	Vegetation structure is at or near minimally disturbed natural conditions. Little to no structural indicators of degradation evident. Full complement of vegetative zones present. [MATURE]	70% (56-85)	38 (24-60)	18 (12 to 30)
B (3 pts)	Vegetation structure shows minor alterations from natural conditions. Structural indicators of degradation are minor. Full complement of vegetative zones slightly diminished by anthropogenic disturbance. [MID]	40% (36-50)	26 (20-31)	16 (13 to 50)
C (2 pts)	Vegetation structure is moderately altered from natural conditions. Structural indicators of degradation are moderate. Full complement of vegetative zones moderately diminished by anthropogenic disturbance. [POLE]	15% (0-23)	16 (12-19)	8 (3 to 19)
D (1pt)	Vegetation structure is greatly altered from natural conditions. Structural indicators of degradation are strong. Missing full complement of vegetative zones. [BURNED, CLEARCUT]	Rapid assessment; indicators of disturbance	Rapid assessment; indicators of disturbance	Rapid assessment; indicators of disturbance

In addition to quantitative measurements of stand condition, overall stand condition can also be assessed using rapid evaluation methods. These may involve training and calibration of stands into broad categories based on written description as in Table 13, or through the use of photos or illustrations depicting the range of variation in conditions, as shown in Figure 18.

Figure 18 Range of Structural Stages assessed in the Alvarado Lagoons System. The structural stages are summarized in a Structural Stage Index (relevant to metric VEG4). Top photo shows Mature stage (Excellent or A rating) at Las Pataratas 2017. Lower right shows Mid stage (Good or B rating) at Cañon Bajo, and Lower left shows Pole stage (Fair or C rating) at San Antonio. D rating not shown, corresponds to highly degraded or converted mangrove forest.

Calibration and verification

Correspondence between quantitative and qualitative assessments of the same variables can be assessed through examination of results using both methods. Within the ALS we explored the relationship between the quantitative Land Use Index based on the categorization of land into distinct uses, with an assessment of vegetation condition based on structural stage inferred from detailed plot data. We then included data from rapid assessment methods assigning plots to categories based on visual evaluation of their overall condition. Results from a rank order regression suggest that both variables (Land Use & Vegetation Structure) generally correspond to each other and reflect overall site condition (Figure 19). Furthermore, rapid assessment methods corresponded to results based on these quantitative measures, at least in terms of overall site ranks. These approaches to calibration can help to validate rapid ecological assessment approaches and support their utilization to supplement or be used in lieu of quantitative assessments where resources are limited.

Interpreting scores and utilizing in management goals

The full scoring criteria for the ALS is presented in Appendix Table A.1, with qualitative descriptions of each attribute, as well as quantitative values used to assign conditions where

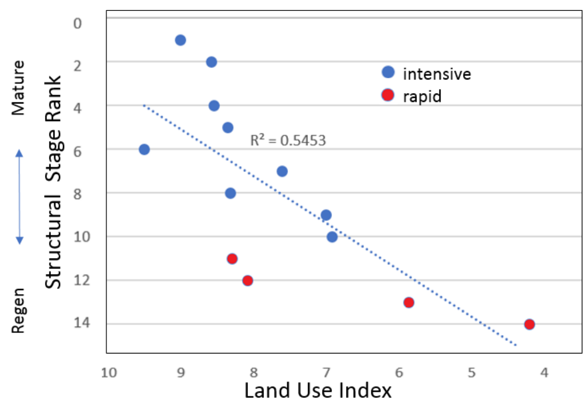


Figure 19 The effect of surrounding Land Use on Mangrove Structure. Intensive sites have quantitative forest plot data, rapid sites have a brief characterization of vegetation. Rapid sites typically were open marsh or early regeneration sites, where mangroves had been previously cleared off.

appropriate, as for soil and hydrology metrics. We present an abbreviated table of metrics here (Table 14) which describes qualitative and quantitative characteristics corresponding to scores for each metric. At this stage, it may be appropriate to revisit initial scoring criteria to calibrate according to the documented range of variation by examining sites that are scored for each metric. Within the ALS EIA, examination of scores for regeneration indicated that recalibration for this metric may be warranted, as all sites scored in the highest category for regeneration (> 4 seedlings per ha). However, as this criteria was consistent with values from other mangrove assessments we opted to retain these values.

At this stage results should be assessed for their contribution to the original goals of the EIA, such as characterizing the range of variation for the target ecosystem and for particular sites. In this case, the sites of particular interest were the two sampling locations from the community of La Mojarra: 'Las Islas' and 'Las Minas'. Within the context of the full range of sites from the ALS, the La Mojarra sites score at the lower end of the spectrum for overall vegetation structure, as they were characterized as "pole" stands dominated by trees in the smallest diameter category (Table 14) and were characterized by lower DBH relative to the best reference sites (12 and 19 m^2 ha^{-1}, vs. 30 to 60 m^2 ha^{-1}; Appendix 1 Table A1.3). This suggests that one management goal for La Mojarra would be to implement strategies to promote better stand composition with greater biomass and structure complexity. These might be accomplished by setting aside reserve areas from logging, by protecting mangrove areas from disturbances such as fire, or by performing selective logging to promote retention of larger trees within stands.

Metric	A (4 pts.)	B (3 pts.)	C (2 pts.)	D (1 pt.)
LAN1. Contiguous Natural Land Cover	**Intact:** Embedded in 90-100% natural habitat.	**Variegated:** Embedded in 60-90% natural habitat	**Fragmented**: Embedded in 20-60% natural habitat	**Relict:** Embedded in < 20% natural habitat
LAN2. Land Use Index	Average Land Use Score = 9.-10 (Minimal Land Use)	Average Land Use Score = 8.0–9.4 (Moderate Land Use)	Average Land Use Score = 4.0–7.9 (Severe Land Use)	Average Land Use Score =<4.0 (Intense Land Use)
VEG2. Invasive Nonnative Plant Species Cover	Invasive nonnative plant species absent	Invasive non-native plant species present but sporadic in any stratum (1-3% cover)	Invasive non-native plant species somewhat common in any stratum (10-30% cover)	Invasive non-native plant species abundant in any stratum (> 30% cover)
VEG3. Native Plant Species Composition	Typical range of native diagnostic species present. Native species indicative of anthropogenic disturbance (i.e., weedy or ruderal species) absent to minor. *[proxy: on-site Land Use Index 9.5 – 10]*	Some native diagnostic species absent or substantially reduced in abundance. Native species indicative of anthropogenic disturbance (weedy or ruderal) with low cover. *[proxy: on site Land Use Index 8.0-9.4]*	Many native diagnostic species absent or substantially reduced in abundance. Native species indicative of anthropogenic disturbance (increasers, weedy or ruderal species) are present with moderate cover. *[proxy: on site Land Use Index 4.0-7.9]*	➢ Most or all native diagnostic species absent, a few may be in very low abundance. Native species indicative of anthropogenic disturbance with high cover. *[proxy: on site Land Use Index <4]*
VEG4. Overall Vegetation Structure	At or near minimally disturbed natural conditions. Little to no structural indicators of degradation evident. Full complement of vegetative zones present. [MATURE]	Minor alterations from natural conditions. Structural indicators of degradation are minor. Full complement of vegetative zones slightly diminished by anthropogenic disturbance. [MID]	Moderately altered from natural conditions. Structural indicators of degradation are moderate. Full complement of vegetative zones moderately diminished by anthropogenic disturbance. [POLE]	Greatly altered from natural conditions. Structural indicators of degradation are strong. Missing full complement of vegetative zones. [BURNED, CLEARCUT]
VEG5. Regeneration Potential	> 4 seedlings or saplings per 0.01 ha.	2-4 seedlings or saplings per 0.01 ha	<2 seedlings or saplings per 0.01 ha or propagules present	< 2 seedlings per 0.01 ha and propagules are absent.
ANI1. Invasive Animal Species	No evidence of invasive animal species	Invasive species presence, but minimal to no effect on vegetation structure (especially regeneration), or native animals	Invasive species presence, and moderate effects on vegetation structure (especially regeneration) or native animal populations.	Evidence of invasive species presence and severe effects on vegetation structure or native animal populations.
HYD3. Hydrologic Connectivity (V1 - riverine)	Completely connected to Floodplain (backwater sloughs and channels). No geomorphic modifications made to contemporary floodplain. Channel is not unnaturally entrenched.	Minimally disconnected from floodplain. Up to 25% of stream banks affected from dikes, rip rap and/or elevated culverts. Channel is somewhat entrenched (overbank flow occurs during most floods).	Moderately disconnected from floodplain due to multiple geomorphic modifications. Between 25 and 75% of stream banks are affected (e.g., dikes, tide gates, rip rap, concrete, and elevated culverts). Channel is moderately entrenched ((overbank flow only occurs during moderate to severe floods).	Channel is severely entrenched and entirely or extensively disconnected from the floodplain; >75% of stream banks are affected due to dikes, tide gates, rip rap, concrete, and elevated culverts. Channel is substantially entrenched overbank flow never occurs or onlyduring severe floods).
WAQ1. Eutrophication	TP < 0.1 and TN < 1.0 mg L^{-1}	TP 0.1-0.2 and TN 1.0- 2.0	TP 0.2 – 0.9 -and TN 2.0- 7.0	TP > 0.9 and TN > 7
WAQ2. Sediment Load	TSS > 2100	TSS 500 - 2100	TSS 100 - 500	TSS < 100

Table 14 Mangrove Indicators, with Key Ecological Attributes and full description of Indicators and Thresholds.

Table 15 Example of Ecological Integrity scorecard for mangrove sites in the Alvarado Lagoon System. The metrics for Vegetation are complete, and both the values and the ratings are shown. Metrics for other variables, such as hydrology, are not shown as they were pending additional sampling data. Metric ratings are given points as follow: A = 4, B = 3, C = 2, D = 1. For additional details on metrics see Appendix 2.

Metric		Site Name									
		La Flota	**Pataratas 2017**	**Pataratas 2016**	**Necaxtle sin P**	**El Pájaro**	**Cañón Bajo**	**Necaxtle con P**	**San Antonio**	**La Tortuga (La Mojarra)**	**Las Minas (La Mojarra)**
LAN2. Land Use Index	Rating	**B**	**B**	**n.d**	**B**	**B**	**A**	**C**	**B**	**B**	**C**
	Value	9.2	8.7	*	8.7	8.4	9.5	7.9	8	8.3	7.2
VEG2. Invasive Nonnative Plant Species Cover	Rating	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**
	Value	0	0	0	0	0	0	0	0	0	0
VEG3. Native Plant Species Composition	Rating	**A**	**A**	*****	**A**	**B**	**A**	**C**	**B**	**A**	**C**
	Value	10	9.6	n.d.	10	9.1	10	5.4	8.3	9.6	6
VEG4. Overall Vegetation Structure	Rating	**A**	**A**	**A**	**A**	**B**	**B**	**B**	**C**	**C**	**C**
	Value	MATURE	MATURE	MATURE	MATURE	MID	MID	MID	POLE	POLE	POLE
VEG5. Regeneration Potential	Rating	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**
	Value (seedlings /ha)	5	10	5	6	9	11	4	8	5	7

COMPONENT THREE: SOCIO-ECONOMIC ASSESSMENT

Importance of Socio-Economic Assessments

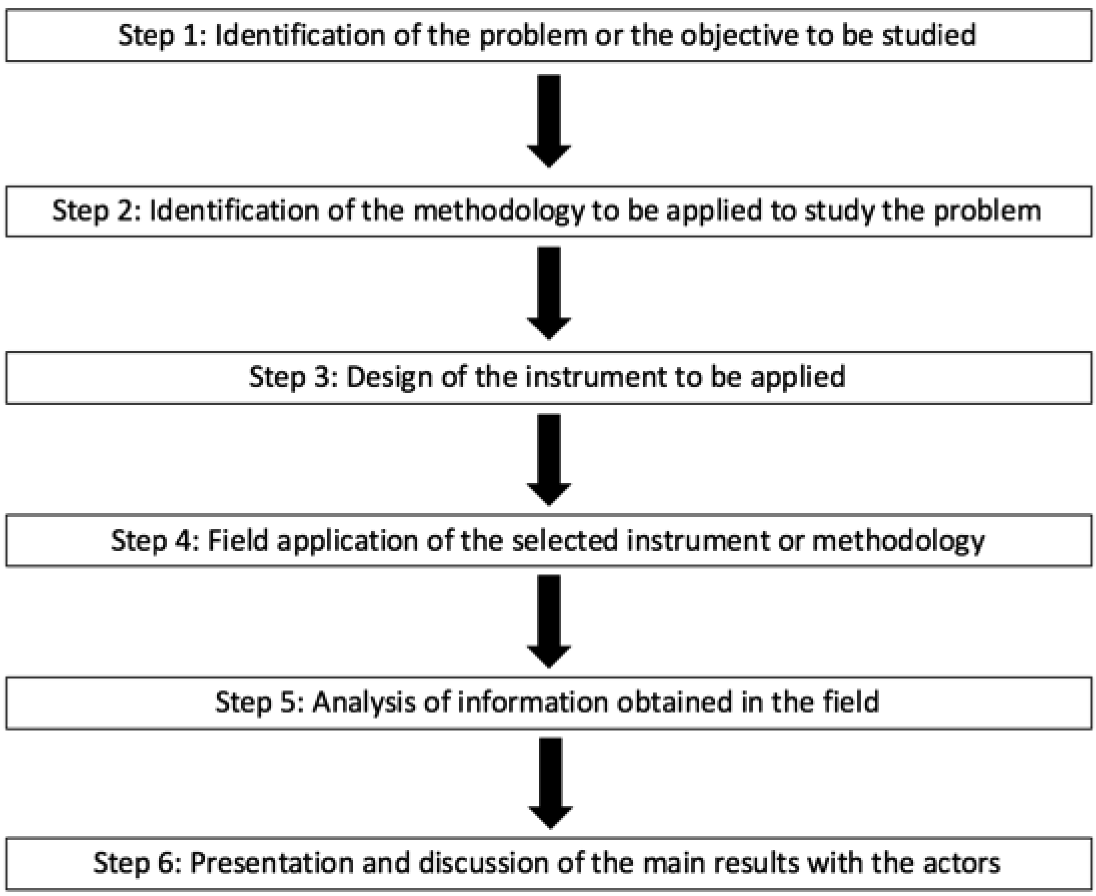
The conservation and sustainable use of environmental goods and services depend on an accurate understanding of the relationship between biophysical components and the interests of society. Therefore, to develop public policy that benefits society, it is necessary to understand the socio-economic issues around the use of these goods and services, in addition to understanding physical and/or ecological issues.

While the needs and wants of society are unlimited, resources are not, even when we try to use them efficiently. In order to make better resource use decisions, it is helpful to measure the value(s) that society assigns to their use and enjoyment, as well as other incentives and impediments to sustainable use. Economists often try to understand values by measuring the benefits and costs society derives from projects or public policies. The evaluation of such projects or policies can be made either from a private or social perspective. In the first case, evaluation considers only the market prices and effects (benefits and costs) that affect the individual who develops the activity or project. In the second case, evaluation is expanded to include effects on third parties. It is also important to distinguish whether the resource in question is a public, private, toll, or a common pool resource.

For the case of environmental goods and services, those which are of greatest interest often demand consideration of social as well as private values. Furthermore, many are common pool resources (CPR), defined as those: 1) that once consumed by an economic agent are no longer available for another agent to do so, and 2) where it is difficult to restrict anyone's consumption or use. These two features of CPR (formally high-rivalry and non-exclusion) drive the classic problems of CPR management. All economic agents have access to the system and therefore derive private wellbeing from both extraction and the level of conservation of the ecosystem services. However, each economic agent typically considers extraction, which is an individual decision and generates private benefit, to be of higher priority than conservation, which requires a collective decision and generates societal benefit. This situation typically leads to overexploitation. However, it is also important to note advances in economic theory and understanding of CPR management, e.g., by Ostrom (1990, 1998, 2009), which highlight aspects of social capital such as cooperation, altruism, and reciprocity. In some contexts, these communal practices enable a higher degree of conservation and sustainable use of natural resources. With all of this in mind, an efficient policy design for CPR, such as for communally-owned mangroves, should include a socio-economic assessment that considers not only financial and economic aspects, but also social capital and a diverse set of perspectives on classic market failures.

Based on these considerations, we propose the following steps for conducting a socio-economic assessment of the use and conservation of communally owned mangroves (Figure 20). Illustrations of the approach are taken from the fishing community of La Mojarra, which is located within the Lagoon System of Alvarado in Veracruz, Mexico. This lagoon system encompasses approximately 19,000 hectares of mangrove forest, one of the most extensive in North America, and is of great importance in ecological and productive terms for the local people who depend on this rich ecosystem for their livelihoods and sustenance (Muñoz 2011; Castañeda-Chávez et al. 2017 & 2018). The mangrove forest in this area is also threatened by both internal and external factors (Moreno-Casasola 2016), which influence the quantity and quality of ecosystem goods and services provided.

Figure 20 Steps to carry out a socio-economic assessment *for the use and conservation of natural resources*



Source: report authors

Step One: Identification of the Problem and the Objective to be Studied

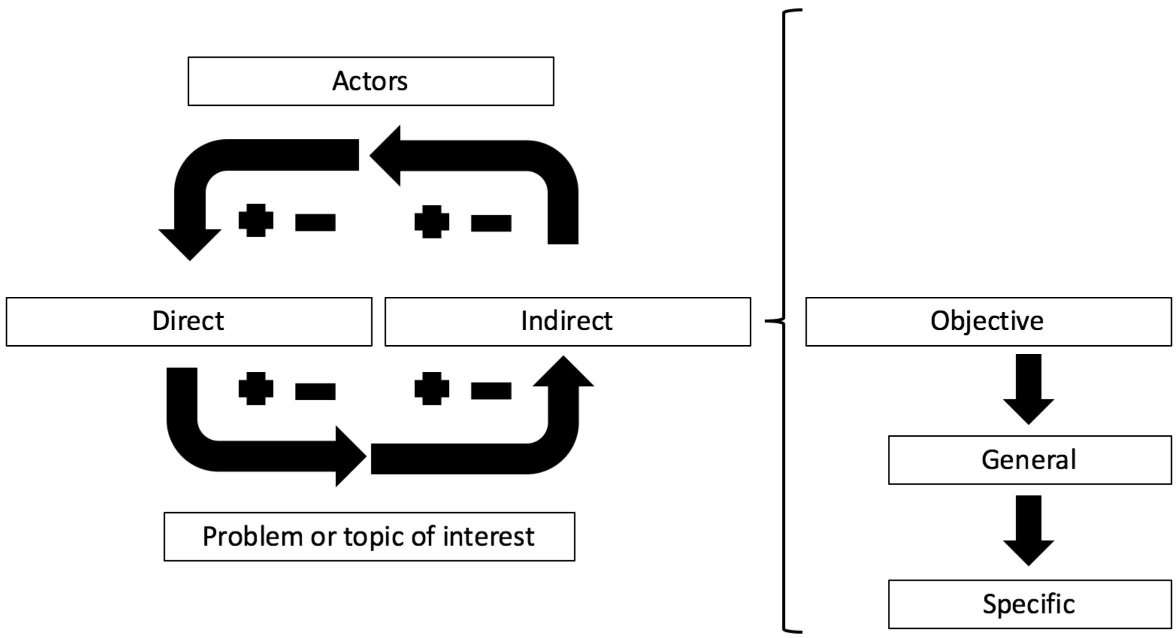
The first step in developing a socio-economic assessment for the management of communally owned mangroves is to determine the problem to be addressed and overall objective of the study. A clear understanding of all the players involved and the relationships between them is critical at this stage. To gather information, it is advisable to begin by reviewing other studies of the area, carry out a first field visit to understand the problem, and conduct interviews with key participants (Figure 21). Field engagement should be based on an existing relationship of trust with the community.

For the case study of mangroves in the Alvarado Lagoon System, CPR fisheries were identified as both an important problem to study directly, and also an issue with likely learning implications for management of other community owned mangrove resources. The main fishing resources in La Mojarra are the sunfish, tilapia, and shrimp, on which most local people depend for family consumption as well as income via export to markets. These fisheries are also at risk from mangrove degradation. An analysis of fishing resources as they relate to the mangrove health and community decision-making was therefore selected as important for future decisions by community members, developers, and politicians.

***Box 5.1**: Description of La Mojarra*

The village of La Mojarra is located in the Municipality of Acula, in the State of Veracruz, in southeastern Mexico. According to the 2010 Housing and Population Census, La Mojarra is inhabited by approximately 130 people, of which 53.5% are men and the rest women. Of these 130 people, 11.2% of the population over 15 years olds is illiterate, and almost 80% have an incomplete basic education. There are approximately 39 houses, of which 80.2% do not have piped water from the public network; and 2.5% do not have electricity or drainage. La Mojarra has a high degree of marginalization and high incidence of poverty. Residents' main economic activities are fishing (sunfish, blue crab, shrimp, and snook, among others), the extraction of mangrove wood and non-timber forest products, and to a lesser extent, the production of livestock for milk and beef.

Figure 21 *Identification of the problem and the objective to be studied*



In the case of La Mojarra, with all the preliminary information reviewed, field visits and stakeholder interviews conducted (Figure 22), the objectives of the socio-economic assessment were determined to be as follows:

General Objective

Develop technical tools deriving from experimental economics to identify measures, and in the medium and long-term, to influence the protection and sustainable use of mangroves in the Alvarado Lagoon System, Veracruz, Mexico. The results should serve both to better understand the behavior of users of the collective ecosystem goods and services provided by the mangroves, as well as to support communities in increasing their own understanding of the resource management dilemmas they face.

Specific Objectives

a) Analyze the behavior of fishermen regarding extraction of sunfish (mojarra) in a scenario where the regeneration rate of the resource is negatively affected by an external activity (in our case study we use water pollution). This point considers how people solve the challenges of managing a collective resource through the interaction of economic issues, social capital, and commitment to sustainable management of fishing stocks.

b) Analyze users' behavior when faced with the possibility of contributing individually to an action with collective benefits, as represented by a common fund for mangrove protection. This point seeks to analyze the extent to which people in the community are willing to commit individual resources to achieve social benefits.

c) Analyze the preference of La Mojarra community members for changing land use from maintaining mangrove for fish resources to raising livestock or extracting wood products in a sustainable manner.

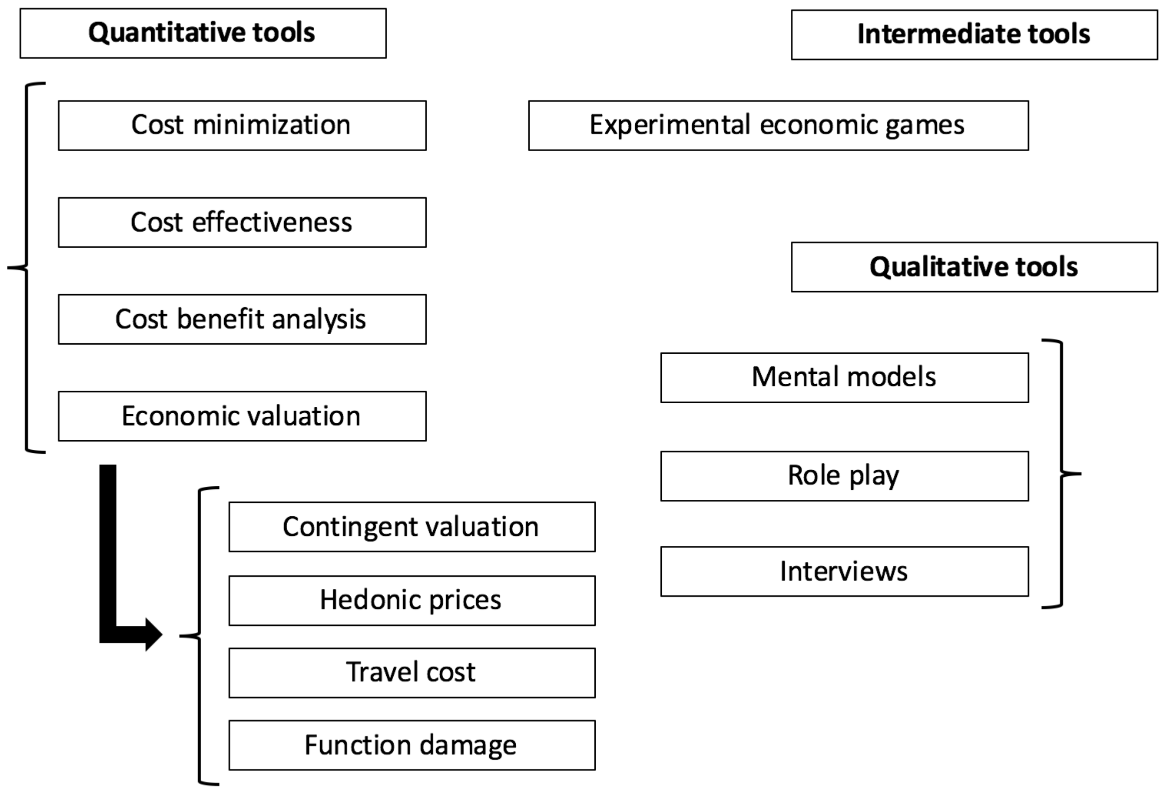
Figure 22 *Field visit to La Mojarra*

Source: Report Authors

Step Two: Identification of the Methodology to be Applied to Study the Problem

There are a variety of methodological tools for quantitative and qualitative analysis of socio economic issues (Figure 23). Quantitative tools include: cost minimization, cost-effectiveness analysis, cost-benefit analysis, and economic valuation (e.g., through contingent valuation, hedonic prices, travel cost, damage function, and others). The qualitative tools include mental models, role-play, and interviews. Experimental economic games fall in between the two.

Figure 23 Socio-economic assessment methodologies



Source: Report Authors

Quantitative Tools

Cost minimization*:* This type of analysis compares the costs of two or more projects or policy interventions with similar goals, and finds the lowest-cost option (Goodacre & McCabe 2002). For example, this method could involve a comparison of three mangrove conservation projects, each with different tasks and budgets, and determine which would deliver the desired result at the lowest cost.

Cost effectiveness: This technique compares different alternatives and determines which will achieve the objective most effectively, typically understood as the alternative that achieves the desired effect in the shortest time possible, and with the least amount of resources (Drummond et al. 1997). Other differences between alternatives may also be considered. For example, the three projects for the conservation of mangroves proposed above might each achieve the goal in a different time period, and involve different levels of effort by community members. Cost effectiveness analysis would also consider these issues.

Cost-benefit analysis**:** This method looks at return on investment by comparing the financial income of a project or policy against the costs of that project over a certain period of time. Key indicators are typically net present value of financial flows and internal rate of return, among others (Goodacre & McCabe 2002). The cost benefit analysis framework can be applied at both the private and social levels. For example, for the three conservation projects, this method would identify, in monetary terms, the investment in and income resulting from each project over time. Results could also include consideration of distribution of returns by stakeholder group.

Economic valuation: The economic valuation of environmental goods and services aims to quantify the monetary gain or loss of welfare or utility that a person or group of people experience because of improvement or damage to the goods or services in question (Revollo, 2016). Several common approaches are reviewed here. A detailed review is outside of the scope of this report, but see, e.g., *Ecosystem Valuation* (*2006*).

> ***Contingent valuation****:* This method relies on creating a hypothetical market by means of a survey, which is used to elicit the economic value that a person or group of people places on a particular environmental good or service. The approach is used to estimate the demand function of a good or service that is not transacted directly in a market and does not have ready substitutes (Ecosystem Valuation 2006).
>
> ***Hedonic prices:*** This method is used to calculate the economic value of environmental goods and services that directly affect market prices (Revollo 2016), typically in real estate markets. Preferences for environmental attributes such as air quality or proximity to nature, for instance, can be revealed in housing prices, alongside more obvious preferences for features like number of rooms, neighborhood schools, and proximity to transit.
>
> ***Travel Cost****:* Travel cost studies consider expenses made to visit nature as an indicator of value placed on visitation (Ecosystem Valuation 2006). Relevant expenses can include direct costs of travel, tours, food, and lodging, as well as the opportunity cost of time. These expenses are used to create a demand curve for visitation, which can be used to estimate changes in welfare if site attributes or pricing policies change.

***Damage function**:* In this method, natural resources are considered as an input into production. For example, the effect of industrial contamination of a river might include damage to farm production through reduced or polluted irrigation water. Damage or production functions seek to relate physical change to change in production of ecosystem services either in physical terms (e.g., crop production), or economic value (e.g., value of crop production).

Qualitative Tools

Mental models: A mental model gives information about the perceptions of an individual or group (Robles de la Torre & Sekuler 2004). These include beliefs about the network of causes and effects that explain how a system works, potential consequences, and other variables. Mental models collect information about *how* an individual thinks about making decisions regarding the use and conservation of natural resources. This information can be used to design solutions that work within a particular way of thinking.

Role play: Role plays are practical exercises in which multiple players assume a particular role in a situation simulating reality (Dosso 2009). These type of games can help to understand participatory action and shed light on the context in analytical and synthesis exercises. For example, before implementation of a policy for the conservation of mangroves, stakeholders could role play that policy with fishermen pretending to be government officials, government officials pretending to be members of civil associations, and the members of the civil associations pretending to be fishermen, all with the aim of analyzing and understanding the conduct and behavior of themselves and others.

Interviews: According to Monje 2011, an in-depth interview is a qualitative tool through which information is gathered by direct verbal exchanges, usually including pre-designed open-ended questions. Conversations between an interviewer and a respondent or group of respondents seek to inform pre-determined problems or objects of study. Interviews can either be pre-designed and semi-structured, with a certain degree of flexibility in the questions, or unstructured in format, where the interviewer has absolute freedom to ask any question and where the only previously determined element is the subject or objective to be addressed.

Hybrid Tools (Qualitative-Quantitative)

***Experimental Economic Games (EEG)*:** These games recreate real life situations in a controlled environment wherein the behavior of the players is analyzed based on their decisions under the given incentive structure (Carpenter et al., 2005, Cardenas et al., 2011). The example used throughout this guide is indicative of the behavior of fishers in response to both environmental degradation, and opportunities for greater collaboration to promote the public good. EEG are especially well suited to understanding decision-making when basic economic models of rationality are inadequate.

STEP THREE: DESIGN OF THE INSTRUMENT TO BE APPLIED ACCORDING TO THE CHARACTERISTICS OF THE STUDY SITE AND PROBLEM

Methodologies should be selected depending on objectives, needs, and constraints. It may be useful to combine multiple approaches. However, we recommend that EEG be applied as a consistent element of any methodology, as they provide a means by which to perform a socio-economic assessment that combines qualitative and quantitative analyses. In this case, we assess the monetary importance of extraction of fish, wood, and other resources, as well as the importance of formal and informal institutions, social norms, and agreements that have been developed in mangrove owning communities' daily life.[1] They also provide an important space for internal reflection. Finally, during Step 6 of this methodology, EEG provide a ready platform for communities to work towards solutions to problems requiring coordination and individual sacrifice to promote sustainability and the common good.

The experimental economic game developed for La Mojarra is described in the remainder of this section. In particular, we developed an EEG around the extraction of sunfish, which is a common pool resource representative of the central challenge community members face in working towards sustainable mangrove management.

Specifically, the EEG examined: a) a fisher's baseline extraction of sunfish, b) change in extraction in a scenario where, due to externally generated contamination, the rate of fish stock regeneration is adversely affected (as is the case in the study area), and c) a fisher's willingness to take personal risk and incur private loss to contribute to the public good, simulated by a communal fund for mangrove protection that would generate greater social benefits through improved ecosystem productivity.

[1] More detail about the EEG can be found at: "Experimental Economic Games with Users of Mangrove in the Lagoon System of Alvarado, Veracruz, Mexico - Protocol" Revollo, D., Bruner, A., Lucio, C., Hernández, C., Ramirez, A. ,& Faber-Langendoen, D.. (2018). The report presents three different EEG that can be developed to analyze decision making in communally owned mangroves. The first game, described in this manual, considers the change in extraction due to pollution generated by a third party, as well as behavior around a common action fund for conservation. The second game is about extraction decisions with different fishing gear and different levels of monitoring and penalties. The third game about the decisions on change of land use from mangroves to cattle ranching.

The earnings of the players were obtained by the following decisions during multiple rounds of game play:

a) Fish extracted: This simulates sale in the market, that is, a fisherperson's private profit. Players decided how many hypothetical fish, within a range of one to five, they would like to extract each round.

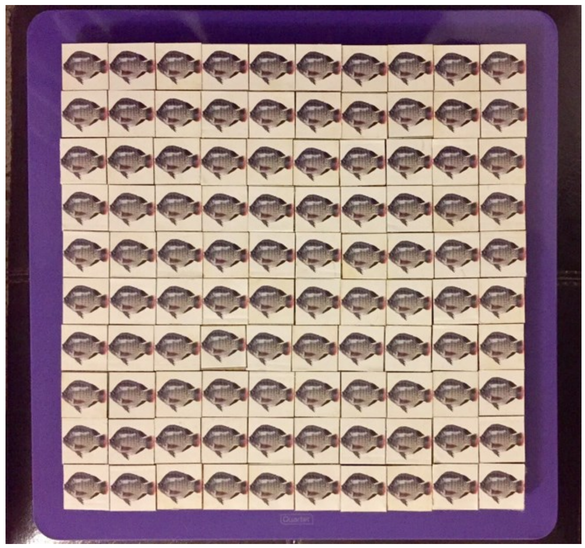
b) Fish not extracted**:** These earnings, which reflect the collective interests, simulate the benefits from a more productive balance in the ecosystem, resulting in benefits to the collective users. Payoffs are calibrated such that if each player was purely focused on private income maximization, they would always extract their private maximum.

c) Contribution to a communal fund for mangrove management: A communal fund simulates the hypothetical return from contributing time or money to better mangrove management. All players receive an equal portion of the community fund to which they may voluntarily contribute a share of their private funds. Payoffs are calibrated such that in the absence of trust or concern for others' wellbeing, each player faces the classic public good incentive not to contribute, hoping that the rest of the players will do so. As in the case of real-life fish extraction, the players face a dilemma between individual and collective interest.

Twenty (20) sessions of experimental economic games were carried out with people from the community of La Mojarra. Each session lasted approximately 2.5 hours, and five people participated (i.e., 100 people participated in total). Within each session of 2.5 hours, 1.5 hours were dedicated to the explanation and application of the game, and the rest was devoted to the application of a survey designed to obtain socio-economic information and information on participants' perceptions about mangrove management. The survey also included a specific section to investigate the participants' preferences for converting unused mangroves to sustainable use of mangrove wood and/or livestock.

The game consisted of a board with 100 chips, wherein each chip represents a one-kilogram sunfish (Figure 25). Each session had five people playing the role of fishermen facing the decision of how many sunfish to extract. The twenty game sessions that we ran in the community were equitably divided into three scenarios (SCE) SCE1: control – standard fish regeneration = 6 sessions; SCE2: water pollution – moderate reduction in fish regeneration = 7 sessions; and SCE3: water pollution – extreme reduction in fish regeneration = 7 sessions. All sessions included three stages (ST1, ST2, and ST3), each with six rounds, for a total of 18 rounds of actual play. There were three additional rounds of practice at the beginning to ensure understanding of the game by all participants (Table 16).

Figure 24 Experimental economic game board



Source: Report Authors, 2018.

Table 16 Stages and treatments in the experimental economic game

	STAGE		
TREATMENT 20 sessions x 5 people = 100 participants	ST1º (1 - 6 Rounds)	ST2º (7 - 12 Rounds)	ST3º (13 - 18 Rounds)
Scenario 1 (Sce1) 1/3 of the groups 6 sessions x 5 people = 30 participants	**Base Line (BL)** RR 1 x 5	**Base Line (BL)** RR 1 x 5	**Contribute (BL + C)** RR 1 x 5
Scenario 2 (Sce2) 1/3 of the groups 7 sessions x 5 people = 35 participants	**Base Line (BL)** RR 1 x 5	**Moderate Effect (BL + ME)** RR 1 x 10	**Contribution (BL + ME + C)** RR 1 x 10
Scenario 3 (Sce3) 1/3 of the groups 7 sessions x 5 people = 35 participants	**Base Line (BL)** RR 1 x 5	**Extreme Effect (BL + EE)** RR 1 x 15	**Contribution (BL + EE + C)** RR 1 x 15

Base Line (BL): Open access to a common resource was simulated (as is the case now with extraction of sunfish); this stage generates the control data necessary to compare the decisions made in the second and third stage of the game. Recovery rate (RR) is set at 1x5.

Moderate effect (ME): Players are told that the mangrove water begins to suffer pollution problems as a result of a company releasing contaminated water. This causes a change in the regeneration rate of the sunfish. RR declines to 1x10.

Extreme Effect (EE): Players are told that the mangrove water begins to suffer pollution problems as a result of a company releasing contaminated water. This causes a change in the regeneration rate of the sunfish. RR declines to 1x15.
Contribution (C): Players are told they have the option of contributing to a common fund for the protection of mangroves.

During the first stage (ST1) of the three scenarios (baseline = BL), open access to a common resource was simulated, as is the case now with extraction of the sunfish. This stage generates the control data necessary to compare the decisions made in the second and third stage of the game, where different situations are introduced. After every round, the common pool resource is regenerated at a rate of 1 per 5 (RR 1 x 5). That is, another sunfish is added to the board for every five sunfishes left on the board at the end of the previous round.

In the second stage (ST2), rounds 7 to 12, the first scenario (SCE1) maintains the same rules as the first six rounds to continue to generate a control against which behavior changes can be evaluated. In the second and third rounds, however, players are told that the mangrove water begins to suffer pollution problems as a result of a company releasing contaminated water. This causes a change in the regeneration rate of the sunfish. In the case of the second scenario (SCE2), the resource regeneration rate drops from 1 per 5 to 1 per 10, while in the third scenario (SCE3), the regeneration rate drops to 1 per 15. In other words, in both scenarios, we can observe the behavior of the players when they experience a negative change in the resource regeneration rate.

In the third stage of the game (ST3), round 13 to 18, the players had the option to contribute to a public good, in this case the formation of a common fund (Table 16). All other rules remained as in stages one and two. The purpose of the common fund is the protection of the mangrove ecosystem and therefore an improvement of the ecosystem goods and services that it offers. In each round, players can individually decide to contribute anywhere from zero to a hundred percent of private profits obtained in that round. Depending on the total contribution from the five participants of the session, the fund generates a greater or lesser return, with revenues distributed equally. This stage of the game was designed to improve understanding of the degree to which community members would be willing to incur individual costs to contribute to the collective well-being, taking into account that those who do not contribute still share in any benefits.

To ensure that participants and those running the game had a clear and common understanding, a formal protocol document was developed and made available to all stakeholders.

Players' profit in the experimental economic game is given in Table 17. These profits were calculated to reflect actual data on sunfish extraction that takes place in the community of La Mojarra. Payments reflect the reality that as the player extracts more from the resource, he or she obtains greater individual gains. However, as the group extracts more, each individual gets less because the total stock and reproductive capacity declines.

Table 17 Individual payment to participants based on individual and group extraction decisions

	Number of sunfish captured by the individual participant						
		1	**2**	**3**	**4**	**5**	**Average capture by the group**
Number of sunfish captured by the rest of the group	**4**	$16	$17	$18	$19	$20	1
	5	$15	$16	$17	$18	$19	1
	6	$14	$15	$16	$17	$18	1
	7	$13	$15	$16	$17	$17	2
	8	$13	$14	$15	$16	$17	2
	9	$12	$13	$15	$15	$16	2
	10	$11	$13	$14	$15	$15	2
	11	$11	$12	$13	$14	$15	3
	12	$10	$11	$13	$13	$14	3
	13	$9	$11	$12	$13	$13	3
	14	$9	$10	$11	$12	$13	3
	15	$8	$10	$11	$12	$12	4
	16	$7	$9	$10	$11	$11	4
	17	$7	$8	$9	$10	$11	4
	18	$6	$8	$9	$10	$10	4
	19	$6	$7	$8	$9	$10	5
	20	$5	$6	$7	$8	$9	5

Source: Report Authors.

Table 18. Individual payment from the common fund based on total contribution of the group

Common Fund **Total contribution of the group**	**Growth of** **Common Fund**	**Individual return of** **Common Fund**
a) Less than $2.00	$0.00	$0.00
b) $2.1 to $4.0	$5.00	$1.00
c) $4.1 to $6.0	$10.00	$2.00
d) $6.1 to $8.0	$15.00	$3.00

Common Fund Total contribution of the group	Growth of Common Fund	Individual return of Common Fund
e) More than $8.0	$20.00	$4.00

Source: Report Authors.

Finally, following the economic games, we surveyed participants to identify socio-economic variables relevant to preferences and behaviors for the use and conservation of sunfish. The survey also included a specific section to investigate participants' preferences for converting unused mangroves to sustainable use of mangrove wood and/or livestock. Players were presented with land use change scenarios as follows:

"Suppose you have three (3) hectares where you can develop either MANGROVE activity in which your activity is fishing, MANGROVE WOOD where your activity is wood extraction in rotation, and LIVESTOCK where your activity is milk production and live cattle. The three activities generate different economic profit. You will be presented with three different scenarios which specify the activities you can develop in the three hectares you have. The first scenario will always be three hectares of mangrove (baseline). The other two options are hypothetical scenarios where there is a variety of combination between mangrove, mangrove wood, and livestock; but it's always three hectares."

Each player was presented with three different scenarios wherein mangroves, mangrove wood, and livestock are combined, but each player is always given the same baseline scenario: three hectares of mangrove. Respondents were asked to assign a value of 1 to 10 to each scenario, without repeating, where 1 represents the least preferred and 10 the most. Table 19 presents an example. The baseline (three hectares of mangrove) is presented as scenario "0", along with two hypothetical scenarios: Scenario 1, consisting of two hectares of mangrove and one of livestock; and Scenario 2, which consists of two hectares of mangrove and one of mangrove wood. The possible combinations of scenarios were given to participants at random. An example is given in Table 19.

The economic profit for each land use type was estimated with the community in a field visit prior to the application of the game. It is interesting to note that the profits from standing mangroves that support fishing and mangroves used for wood extraction are competitive with the profits from livestock, with the former slightly less profitable and the latter slightly more. However, as expressed by the people in the community, having livestock as an economic activity generates more social status than being a fisherman or extracting mangrove wood.

The analysis of this section of the survey allows us to identify participants' preferences for changes of land use, considering likely profit and other sources of preference. These might include interest in mangrove conservation, or conversely, preference for status conferred by cattle ownership. Specifically, we calculate average scores participants assign to each potential change (a value of 1 to 10). Rationally, participants should choose the scenarios that bring them greater economic gains; however, they may also take into account preferences for non-monetary values, as would be indicated by a preference for scenarios with lower earnings, but which include greater conservation of mangroves.

Table 19 Example of scenarios presented to a random player. Mangrove refers to mangroves that support fishing. Mangrove wood refers to direct use for timber extraction. Livestock refers to land cleared for cattle to produce milk and meat.

SCENARIO								
0 (Base Line)			**1 (Hypothetical scenario 1)**			**2 (Hypothetical scenario 2)**		
Mangrove	Mangrove	Mangrove	Mangrove	Mangrove	Livestock	Mangrove	Mangrove	Mangrove wood
$18,750	$18,750	$18,750	$18,750	$18,750	$18,150	$18,750	$18,750	$20,500
		$56,250			$55,650			$58,000
Extraction of mojarra			Extraction of mojarra / milk and cattle			Extraction of mojarra / Wood extraction		

Source: Report Authors.

Example 1: "Technical Inputs to strengthen mangrove concessions in Ecuador through Socio Bosque: combining techniques of economic valuation and experimental games".
Moreno-Sánchez, R., Maldonado, J., Campoverde, D., Solís, C., Gutiérrez, C. & Bruner, A. (2015).

In 2014, the Government of Ecuador decided to extend its national program of conservation incentives, "Programa Socio Bosque (PSB)," into mangroves through the creation of the sub-program "Socio Manglar." This sub-program provides economic incentives to farmers and indigenous communities that voluntarily commit to the conservation of mangrove areas. In Ecuador, mangroves are State owned, with sustainable use concessions granted to communities and ancestral groups. Many of decisions regarding mangrove use are therefore collective, and classic incentives for over-exploitation prevail in many places. In this context, the authors used experimental economic games (combined with another approach - choice experiments), to analyze means by which Socio Manglar could most efficiently concessionaires in transitioning to sustainable management.

Step Four: Field Application of the Selected Instrument or Methodology

Field studies using experimental economic games depend on both the participants' perception of the games as legitimate reflections of their values, and their ability to relate the insights generated over the course of the games to the rest of their community. To implement EEG, the community must participate in groups. Key community people can help organize and support attendance and participation. We recommend a sign-up sheet wherein those interested in participating can pick the dates and times most convenient for them. Facilitators must take into account logistical concerns such as the availability of seating, writing materials, and table space for participants to carry out the games unhindered.

In the case of the EEG in La Mojarra, to ensure sufficient community participation, an initial workshop was held to engage key individuals, describe the process, and encourage others to participate. Before the games themselves, key community members and local implementers received training in the purpose of the research, the dynamics of the EEG, and how to organize sessions. Logistics of implementation were also discussed (Figure 25 and 26).

Figure 25 *Field application of experimental economic games (EEG)*

Source: Report Authors, 2018.

Figure 26 Field application of the surveys to fishermen of the community of La Mojarra

Source: Report Authors, 2018.

Example 2: "Social Preferences among the People of Sanquianga in Colombia".
Cardenas, JC. (2011).

Afro-descendant communities in the Sanquianga region of Colombia's Pacific coast often live in conditions of extreme poverty. Their main source of food and income economic is fishing in mangrove areas. On the other hand, social capital and pro-social interests are high. Experimental economic games were used to understand and quantify levels of altruism and willingness to cooperate in management of a common pool resource, and mangroves. Economic games also showed that greater personal material wealth is associated with greater levels of generosity.

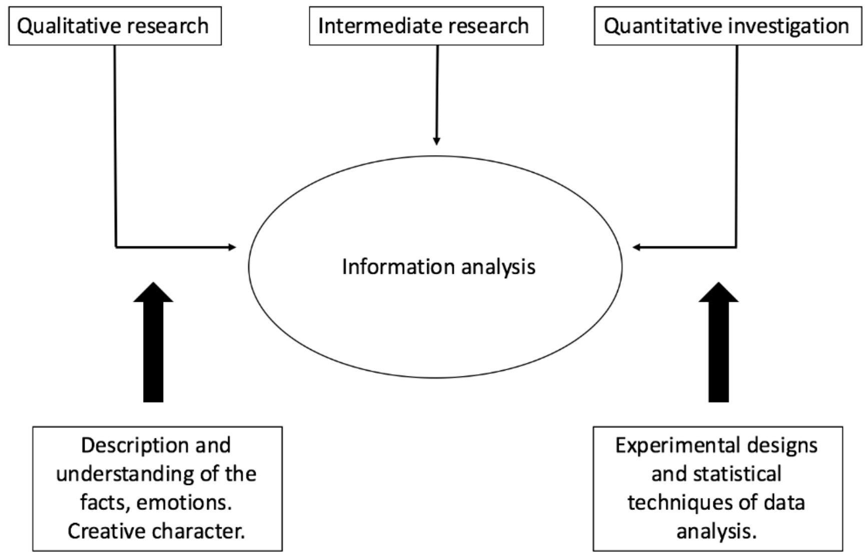
STEP FIVE: ANALYSIS OF THE INFORMATION OBTAINED IN THE FIELD

Depending on the information obtained through the methodology selected for socio-economic assessment, analysts can carry out a qualitative, quantitative or mixed analysis (Figure 27). Qualitative analysis is focused primarily on elucidating the relationship between observed structural issues and the context from which communities approach those issues. In La Mojarra, field visits and interviews with key stakeholders allowed us to obtain nuanced information important in its own right, and informed our interpretation of quantitative findings. Furthermore, we were able to better understand the best ways to communicate and identify the main issues to include in (and omit from) the EEG and follow up surveys.

As noted, EEG can be used to generate both qualitative and quantitative information. Qualitative findings can help understand the role and types of social capital, for example cooperation or reciprocity. Quantitative analysis determines the strength of association and relationship between variables, which supports inferences to the population from which the sample is taken, as well as inferences about why things happen or not in a certain way. In La Mojarra, analysis of the information collected through the experimental economic games and eventually through surveys allowed us to generate a set of descriptive statistics and econometric models that attempt to both identify a causal relationship between scenarios and behavior change, and provide a scenario analysis that describes preferences for land-use changes.

We suggest that analysis should begin by generating an Excel file that contains participants' choices in each different round, as well as information on the different treatments. Subsequently, statistical analyses should be performed to generate descriptive information. For example, averages and graphs that show the evolution of decisions can support interpretation of econometric findings. Finally, econometric models should be developed to explore the significance of pro-social preferences as well as the relationship between choices and socio-economic variables such as age, gender, level of social organization, and income. Econometric analysis may be performed either in Excel, or using programs such as Stata, Limped, SPSS, R, or Eviews.

Figure 27 Analysis of information, methods and contribution of each



Source: Report Authors, 2018.

In the case of EEG in La Mojarra, econometric analysis was carried out using two types of general multivariate analytical models. First, we used a balanced panel data model. To avoid problems of contemporaneous correlation, heteroskedasticity, and autocorrelation, we used Panel Corrected Standard Errors (PCSE) estimators (Bailey & Katz, 2011; Wooldridge, 2016). The second type of model accounted for the fact that participants' choice of extraction level is censored, given that participants can only "fish" between 1 and 5 units. In particular, we used a Tobit specification with panel data, which allowed us to set an upper and lower limit for the dependent variable.

The construction of both econometric models is a function of two types of features: (i) socio-economic characteristics, and (ii) behavior under baseline and with respect to changes in the rules of the game. Accordingly, we combined behavioral choices in the EEG, with information from the subsequent survey. In both models, the dependent variable is the extraction of a CPR (sunfish) in each round of the game, while the independent variables are considered within two categories: (i) treatment step (TRS) and (ii) socio-economic information (SEC-V).

To account for the significant differences between the steps of different scenarios, we used a difference-in-differences approach. Basically, we compare two groups (the treatment and control) over multiple scenarios and calculate the difference in the change observed in each group as a means to eliminate all disturbances not related to rule changes in the game. Specifically, the variables used to estimate the impact of the phase of treatment are: a) Moderate Effect on fishery health (ME), b) Non-Moderate Effect on fishery health (NME), c) Extreme Effect on fishery health (EE), d) Non-Extreme Effect on fishery health (NEE), e) contribution to the common fund (C), f) No contribution to the fund (NC), g) Moderate Effect + contribution (MEC), h) Moderate Effect + no contribution (MENC), i) Extreme Effect + contribution (EEC), j) Extreme Effect + No contribution (EENC). To construct these variables, we generated dichotomous variables that reflect only the impact of this phase of the treatment with its corresponding control phase (Table 20).

Table 20 Construction of dichotomous variables by differences in differences

	ROUNDS: 1 – 18			**COMPARISON**		
	R1: 1 - 6	**R2: 7 - 12**	**R3: 13 - 18**	**Analysis**	**Change**	**Base Line**
Sce1	Base Line	Base Line	Contribution (BL+C)	**Δ Contribution**	13	12
	11	12	13	**Δ Contribution + Moderate effect**	23	22
Sce2	Base Line	Moderate effect (BL+ME)	Contribution (BL+ME+C)	**Δ Contribution + Extreme effect**	33	32
	21	22	23	**Δ Moderate effect**	22	21
Sce3	Base Line	Extreme effect (BL+EE)	Contribution (BL+EE+C)	**Δ Extreme effect**	32	31
	31	32	33			

Source: Report Authors, 2018.

Introducing these dichotomous variables allows the analysis to capture changes between the baseline stage and treatment stages, controlling for other sources of variation that may stem from simply playing the game over time. Players might, for instance, simply begin to feel friendlier towards other players and be more willing to cooperate based on the experience of playing together. This sort of effect is controlled for by the difference in differences approach.

The econometric specifications are:

Model 1:

$Extraction_{i,t} = \alpha_0 + \alpha_1*ME + \alpha_2*NME + \alpha_3*EE + \alpha_4*NEE + \alpha_5*Agreements + \alpha_6*Age + \alpha_7*Gender + \alpha_8*Children + \alpha_9*Education + \alpha_{10}*Income + \epsilon_{it}$

Model 2:

$Extraction_{i,t} = \alpha_0 + \alpha_1*C + \alpha_2*NC + \alpha_3*MEC + \alpha_4*MENC + \alpha_5*EEC + \alpha_6*EENC + \alpha_7*Children + \alpha_8*Income + \alpha_9*Agreements + \alpha_{10}*Age + \alpha_{11}*Gender + \epsilon_{it}$

Where:

Extraction *i,t* : the amount of sunfish extraction, from 1 to 5 units, that each player i chooses in round t

Children: Player's number of children

Income: Player's estimate of their economic income

Age: Player's age

Gender: 1 if male and 0 if female

Agreement: 1 if there are agreements regarding the use of mangroves in the player's community, 0 otherwise

Education: Player's level of education.

The objective of the first specification is exclusively to study the impact of moderate and extreme effect treatments (declining regeneration rate of sunfish) on participants' extraction decisions. The objective of the second specification is to investigate how participants make use of the communal fund for mangrove protection, and how this decision interacts with their resource extraction decisions.

STEP SIX: PRESENTATION AND DISCUSSION OF THE MAIN RESULTS WITH THE PARTICIPANTS INVOLVED

The last step is the presentation and discussion of the main results with the community where the research is conducted. In addition to offering simple and understandable information, this step should seek to generate discussion on implications for moving towards sustainable mangrove management.

In the case of La Mojarra, a workshop was organized for the entire community for this purpose (Figure 28) and as part of the broader approach to supporting community decision making.

Figure 28 Presentation and discussion of the main results with the community in La Mojarra, Veracruz

Source: Report Authors

One useful way to present main results for this purpose is via graphs of participants' average choices, in this case with respect to the extraction levels of sunfish (Figure 29), as well as monetary contributions to the common fund (Figure 30).

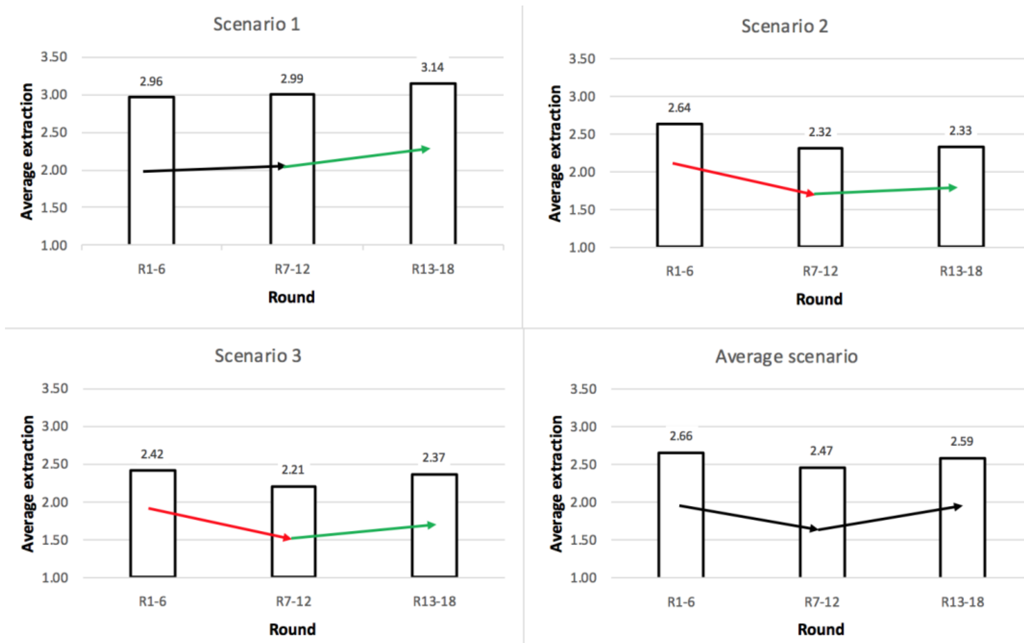
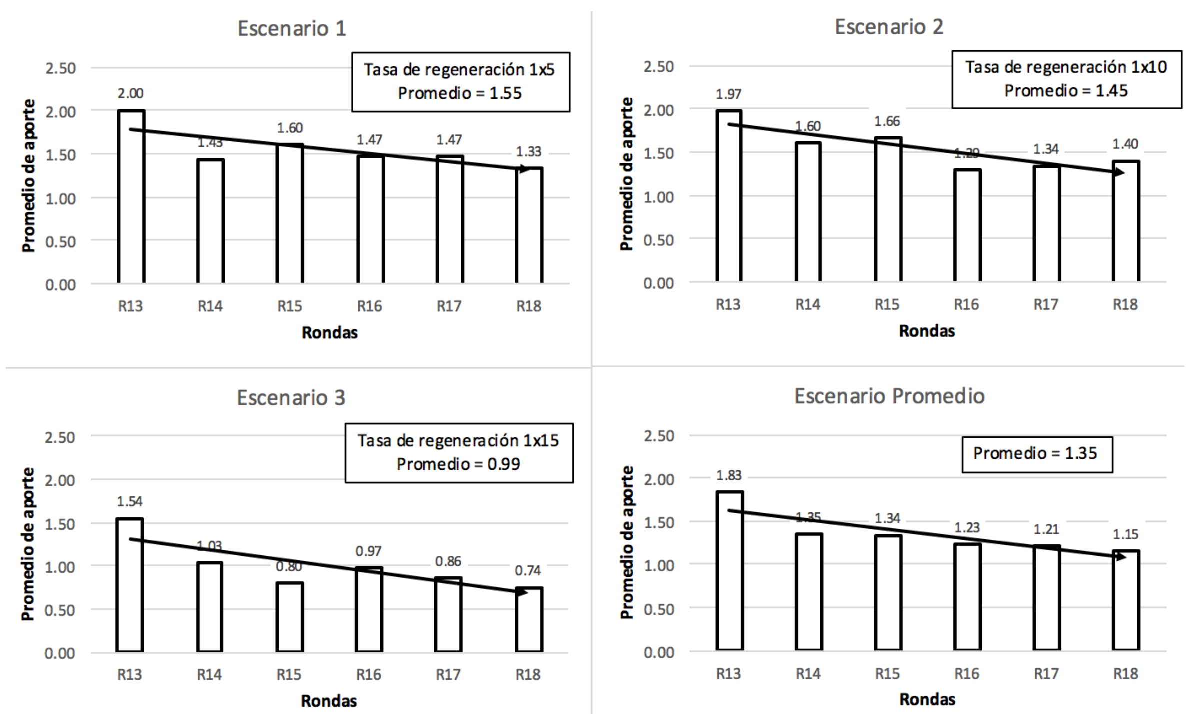


Figure 29 La Mojarra players' average extraction of sunfish by scenario

Source: Report Authors, 2018.

Figure 29 Average contribution to the fund made by players depending on the scenario



Source: Report Authors, 2018.

With results presented and the generation of a discussion, community members and the organizations supporting them can better understand current decisions, as well as challenges and opportunities for moving towards more sustainable management. Perhaps even more importantly, community participation in the process of socio-economic research supports the community in generating its own policy for improving social wellbeing from mangrove management.

Example 3: "Economic behavior of fishers under climate-related uncertainty: Results from field experiments in Mexico and Colombia".
Arroyo, JS., Revollo, D., Aguilar, A., Georgantzis, N. (2016).

The authors study the behavior of fishermen in Isla Natividad, Mexico and in the Gulf of Tribugá, Colombia by means of experimental economic games. In particular, they assess fish extraction under different scenarios of uncertainty as a result of the possible effects of climate change. The adoption of marine protected areas are identified as a measure to cope with such uncertainty

COMPONENT FOUR: STAKEHOLDER MANAGEMENT PLANNING

INTRODUCTION

Here, we present methods for engagement with local stakeholders to collaboratively develop management plans that enhance stakeholder capacity to adaptively manage mangrove ecosystems for natural capital and biodiversity resilience. Our approach falls broadly under methods of vision, scenario, and pathway planning (Wollenberg et al. 2000, Evans et al. 2008). These methods focus on identification of desired visions for the future and pathways to achieve those visions. Outcomes of these processes are pathway scenarios for achieving objectives, which can be incorporated as goals, objectives, and community agreements within management plans. For alternative frameworks focusing on evaluating multiple planning scenarios, and quantitative methods for selecting among alternative actions, we refer readers to reviews of multi-criteria decision analysis (MCDA; e.g. Ananda. and Herath, 2009; Huang et al. 2011) and quantitative approaches for alternative scenarios such as Analytic Hierarchy Process (AHP; e.g. Görener et al. 2012). We outline a generalized approach built on the La Mojarra case study, which utilized vision scenario planning and pathway scenarios to collaboratively develop management objectives. Collaborative planning builds off earlier engagement with stakeholders in ecological and socio-economic assessments. We share examples of the exercises used with the community of La Mojarra to identify visions for the future of the community, and exercises to develop goals and objectives to achieve those visions. Throughout this section we present lessons learned and key topics that arose in the workshop that are relevant to community-based mangrove management planning such as charcoal production, invasive species, and social dynamics.

Figure 30 *Management planning workshop in La Mojarra.*

Key steps

Below we outline key steps in the collaborative workshop held with the community of La Mojarra to develop a vision for the future, pathways to achieving that vision, and incorporation of these into a management plan. These include:

1) Planning the workshop:

- **Identify local and regional stakeholders**
- **Define goals, agenda and structure**

2) Implementing the workshop:

a) **Incorporating results from socio-economic and ecological assessments with the community.**
b) **Stakeholder visioning and planning with focal communities(s)**
c) **Involvement of additional stakeholders- local, regional and national NGOs, institutions, governments**

Step 3: Integration of results in a management plan

- **Identifying goals, strategies, and objectives**
- **Adaptive management and follow-up**

Figure 31 Key steps of designing and implementing a management planning workshop

STEP ONE: PLANNING THE WORKSHOP(S)

The composition of stakeholders engaged in the project may evolve as a result of working with stakeholders following initial engagement and development of economic and ecological assessments. It is important that community leaders or decision makers are available to participate, as well as those who may have taken active roles in the economic or ecological assessments. However, as one of the goals of this phase is the development of a shared vision for the future, it is important to ensure broad participation throughout the community and to facilitate an environment wherein individuals are encouraged and free to present their ideas and opinions. Facilitating participation across gender and age categories is an important consideration. A history of working with the community, as may be the case with a local or regional NGO familiar with local cultural dynamics, may help to ensure that workshops are timed, and invitations presented, in a fashion that facilitates participation beyond a set of 'standard' representatives of the community in order to be more inclusive. In addition, the timing and manner in which participation by broader stakeholders from outside the community participate in planning is an important question to address.

Depending on the history of collaboration and the level of trust between workshop facilitators and the members of the community, workshop components may need to be spaced out in time to allow the community to debate potential scenarios, agree to management actions, or decide on the role(s) and participation of regional stakeholders from outside of the community. In the case of La Mojarra, the decade long history of mangrove conservation and community engagement by staff from Pronatura Veracruz with communities in the area facilitated a condensed workshop and efficient process. Community representatives appeared eager to progress with visioning and proposed pathways and actions as part of the workshop. Because the Secretary for Natural Resources for the Municipal Government of Acula was a community member of La Mojarra, this facilitated a level of interest and trust in engaging the municipal government within the workshop which may not be a common characteristic of other communities. As a result, the planning and management workshop was condensed to three days, consisting of two days of internal planning by La Mojarra facilitated by the NGO team, followed by a third day in which representatives from the Municipal Government were invited to hear concerns and participate in planning, along with representatives from neighboring Ejido communities. Table 21 presents an outline of the agenda used in La Mojarra. The project NGO team had initially planned for additional days, and spacing between components of the workshop to allow the community time to debate visions and actions. However, due to logistical constraints by community representatives and a positive working relationship with the local NGO, the workshop was held over a shorter time. We would anticipate that other workshops initially plan to allow additional time between stages.

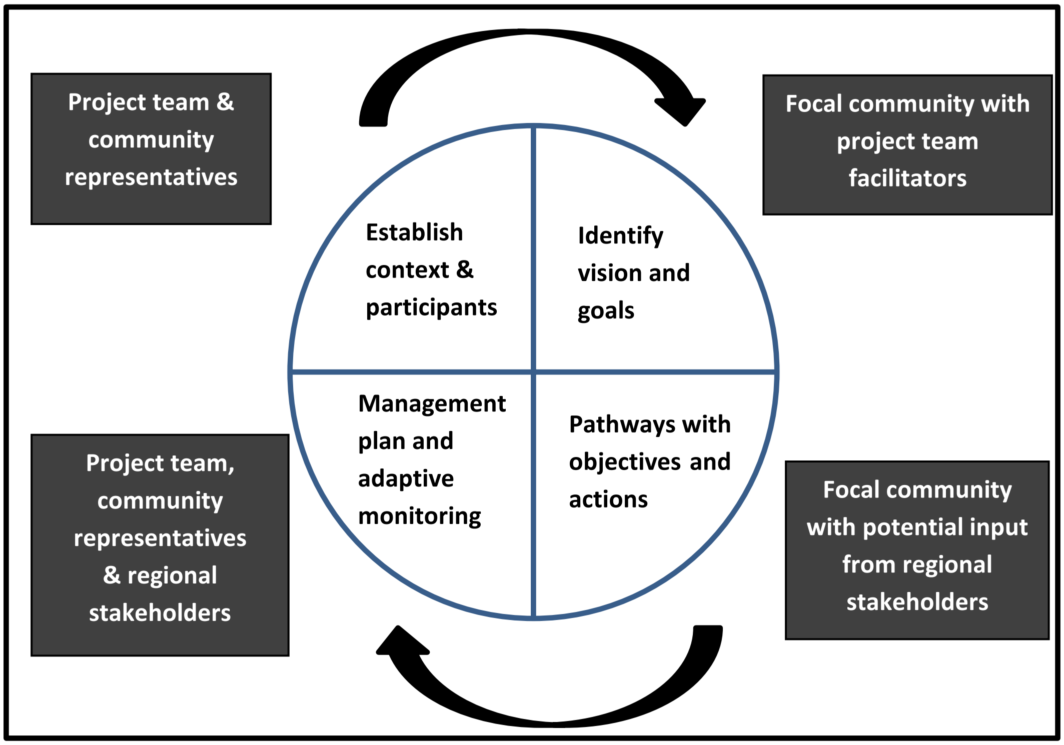


Figure 32 Overview of planning process and roles from the La Mojarra workshop, with participants at various stages.

Day	Activities	Participants
1	• Registration and Introductions • Presentation & discussion of the results of the participatory economic games • Participatory community map exercise capturing key resources and activities (See Box 6.1)	Community Members Facilitators Subject Experts
2	• Shared vision for the future (See Box 6.2) -Guided vision exercise -Capturing results across community -Voting & discussion of shared vision • Pathways to achieving vision (See Box 6.3) -Identifying short and long term goals -Strengths and obstacles for goals -Activities and monitoring	Community Members Facilitators Subject Experts
3	• Presentation of conclusions and agreements of the community • Exchange with the municipal authorities and representative of neighboring communities • Agreement on follow-up plans and actions	Community Members Facilitators Subject Experts Regional Stakeholders -neighboring communities -municipal government
Follow-up	• Presentation of management plan documents and proposed activities • Confirmation and agreement on plan with community	Community Members Local NGO (Pronatura Veracruz)

Table 21 Example agenda for participatory management planning. Example shown here is the agenda outline from the La Mojarra ALS project. For a detailed agenda see Appendix A2.1

STEP TWO: IMPLEMENTING THE WORKSHOP(S)

Results of socio-economic and ecological assessments

Figure 33 *Discussion of results of participatory economic games with community representatives.*

The collaborative approach we present to management planning involves participatory economic and ecological assessments to support decisions made at later planning steps. Therefore, a key step is to ensure that results from these activities are presented back to the community so that they can inform the workshop process. Ideally, time should be allowed in the workshop to discuss how results from the assessment may be similar to or different from expectations or thoughts on these topics that members of the community hold, and where results are in agreement with community perceptions. Depending on the time and capacity of the community to engage in participatory workshops, presentation and discussion of earlier results may take place prior to a planning workshop, or as part of the visioning and scenario planning activities during the workshop. In La Mojarra, the presentation of previous results from the participatory economic games was incorporated into the early phases of the workshop activities (Table 21) in order to help inform community decision making, while simultaneously respecting community members' need to resume regular activities. Key results from the economic analysis included recognition of the desire of members of the community to engage in cattle raising as well as fishing and wood extraction (motivated by desires to diversify their economic activities and by higher social status conferred by cattle ownership, respectively) and the perceived willingness of members of the community to collectively manage resources (e.g. to extract fewer fish given a low regeneration rate under a polluted condition scenario). In contrast, results from the ecological assessment were not reviewed in a specific exercise, but rather were incorporated by facilitators in discussions throughout the workshop (e.g. mangrove wood extraction, identification of potential resotration areas) and to place proposed objectives and activities in a region context in the development of the management plan.

Stakeholder visioning and planning with focal communities(s)

Figure 34 Community members discuss visions and goals for the future.

We present activities and tools here to conduct a collaborative workshop on visioning and planning with members of the focal community. Depending on the context and relationship of the focal community with other regional or national stakeholders, participation beyond the focal community may be appropriate at this stage. However, this should be balanced with the possibility that participation by those 'outside' of the focal community may influence open discussion of the goals and visions within the community. In the La Mojarra workshop, visioning and identification of goals were limited to residents of La Mojarra, led by facilitators from Pronatura Veracruz. Outside representatives from other local communities and from the regional government were invited to participate and contribute to identification of pathways to achieve goals, as these pathways involved collaboration and support from other regional stakeholders. This was key to developing strategies to address some of the most pressing problems identified by the community, which were regional in nature. Examples include water pollution where sources of pollution are primarily outside of the community of La Mojarra, maintenance of the canal system which requires work and investment from communities across the ALS, and fire prevention which requires communication with neighboring communities.

The workshop with La Mojarra used three adaptable exercises commonly used in community-based resource planning. These are described in detail in Boxes 6.1-6-3, and are presented below in outline form, as a basic set of planning exercises for collaborative mangrove management planning.

1) **Exercise 1: Building a participatory community map capturing:**
    a. Key resources
    b. Economic activities
    c. Management issues

2) **Exercise 2: Vision Scenario Planning Exercise**
    a. Guided facilitation of community members visions of the future
    b. Documenting individuals' visions for discussion with community
    c. Discussion and voting among community members
    d. Facilitate shared vision for the future

3) **Exercise 3: Pathways to achieving the shared vision**
    a. Ask participants to compare the vision scenario with current resources
    b. Facilitate identifying main constraints and opportunities to achieving the vision
    c. Actions in the short term to achieve long term objectives

Box 6.1 Map Based Exercise: Documenting resources, key areas, land uses

Goal(s): Facilitate planning discussions. Capture key resources and issues in map form to facilitate community decision making. Documentation of resources and decisions for a management plan.

Exercise: Ask participants to identify areas used for key economic activities, locations of natural resources, and to document how the community utilizes different areas. These might include areas important for different fishing activities (perch, crab, shrimp and in the case of La Mojarra), apiculture, wood extraction, cattle grazing, and hunting. Areas with that represent problems (e.g. theft of wood, areas vulnerable to fire from agricultural burning). Places valued for recreation and potential tourism should be noted as well. Colored pens or markers can be used to denote different types resources or activities, or opinions from different individuals or groups.

It may be useful or necessary to divide the community into multiple groups, and ask each group to document and describe the resources of the community. If work is done in multiple groups, it is important to allow time for groups to come back together and share their maps with the larger community and identify discrepancies and resolve these where possible (e.g. which areas are considered the most important for a particular resource).

Questions used to by facilitators in guiding this exercise in La Mojarra included: Where are the most conserved / damaged / threatened mangrove zones? What goods and services are important to you in each of the selected areas? Which areas are used for livestock/cane cultivation/beekeeping? Where are the mangrove areas? What areas are import to people for recreation or for their beauty? Which places might be good for ecotourism activities? What areas have been subject to restoration? Do they do any vegetation and wildlife monitoring activity, if so where? What are the problems that you consider most important?

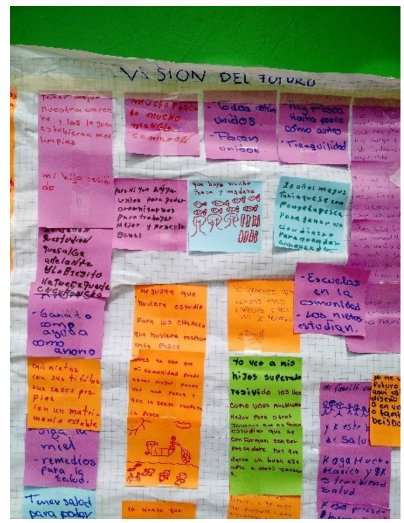
Materials: Large format maps (e.g. 1m x 1m or larger)
Colored markers, sticky notes
Tables, stands or wall space for placing maps

Box 6.2 Visioning and Prioritization Exercise

Goals: Identify key issues and goals within the community, with a sense of overall priority/importance. Utilize these in identification of a shared vision for the future, and to guide strategies and actions to achieve that vision.

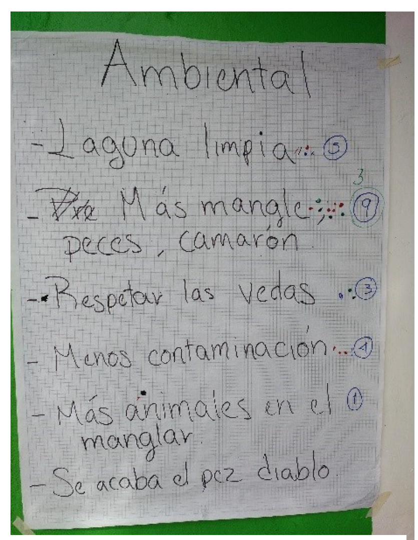
1) **Visioning exercise:** A facilitator guides the community through an exercise of imagining a positive vision for the future (e.g. 10 – 20 years in the ALS scenario). The facilitator may ask guided questions regarding the environment, social context, economic situation. Care should be taken to be neutral in soliciting ideas, while prompting participants to think across a broad range of issues. For example: What does the community look like? What jobs do people have? What is the lagoon like? What do the Mangrove forests look like? The schools? What are the children doing? What are men and women doing?

2) **Documenting individuals' visions:** Participants write, draw, or otherwise describe the things that they envisioned. Where age, literacy or language are barriers to written descriptions, drawing or verbally describing the results of the visioning scenario so that others capture the results may help ensure broader representation by stakeholders. In the ALS project individual ideas were captured on sticky notes. These included a range of desires from creation of a local school to better levels of fish, improved health, and paving of the main road leading to the community.



Capturing individual visions for the future.

3) **Grouping of results:** Facilitators or group participants organize the collected ideas into sets of similar themes in order to produce manageable list of ideas for the community to discuss. To the extent possible, similar ideas and visions can be organized together (e.g. better education; building a local school). It is important when organizing ideas to confirm with the community members that important visions/ideas are not lost when results are combined. Themes may emerge that lend a natural organization to the results, or pre-determined categories such as those used in the ALS project: 'environmental', 'social', 'economic' can be used to guide the exercise



Voting on different environmental priorities.

4) **Shared Vision:** Participants are asked to review the results and vote on and discuss their relative importance. In the ALS, community members were asked to mark their top priority from visions/ideas/proposals in each of three categories: environmental, social and economic. This resulted in a shared vision for the future built around a prioritized list of topics in each category.

5) **Materials used:** Markers, Sticky-notes, large format papers

<u>Box 6.3 Identifying Pathways to Achieving a Shared Vision</u>

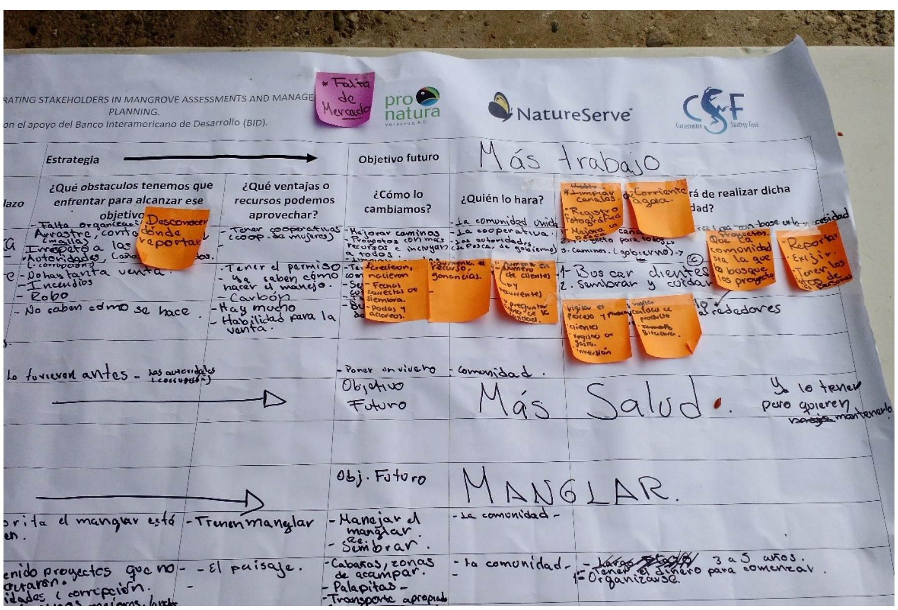
Goals: Facilitate identification of activities to achieve long term goals. Identify strategies, obstacles and means of identifying whether the objective is being achieved. Capture proposals in an organized framework for a management plan.

Exercise: Using the shared vision and prioritized goals for the future, facilitators assist community members in identifying strategies and actions to achieve each long term goal. For this process, a format with the following questions was used to facilitate the process: What obstacles do we have to face in order to achieve the objective? What advantages or resources can we take advantage of? How do we change it? Who will do it? When will the activity be completed?

Along with strategies and actions to achieve long term goals, community members were asked to identify indicators that would signal that the goal was being achieved. Example questions used to facilitate this step included: How can we evaluate the success of our objectives? What will be the monitoring method? Who will be responsible for the monitoring? What will be the monitoring time?

In the ALS workshop facilitators guided participants to fill out the following matrix, which placed results in a familiar management-plan framework:

	Strategy →		Future Objective:	
Short term goal/action	***What advantages and resources can support the goal?***	***How will we change things to achieve the goal?***	***Who will do it?***	***How to know if the goal is being achieved?***



Materials: Large format tables for objectives and strategies (e.g. 1m x 1m or larger)
Colored markers
Sticky notes
Tables, stands or wall space for placing tales

Example Results from the Visioning Exercises

To illustrate development of a shared vision through a collaborative workshop, we present a summary of results from the La Mojarra workshop and walk through how the community and facilitators arrived at the key components of the vision for the future. Table 22 presents a summary of the individual ideas and visions for the future expressed by the community members. From a range of ideas expressed in written and pictorial form by community members (see Box 6.2), facilitators worked with community members to consolidate similar visions into environmental, social, and economic themes. This facilitated voting (on the top issue in each category for each person) and focused discussion on which visions expressed during the exercise were most important across the community.

Examples of future vision ideas from individuals

Table 22. Desires and visions for the future generated by the community from the visioning exercise. Organized and summarized by environmental, social, and economic categories. Number of votes indicating the top issue for an individual in parentheses.

Environmental	Social	Economic
More mangroves, fish, shrimp (9)	Have good health (12)	More work for the members of the community (15)
Clean lagoon (5)	More education- schools and professionals (6)	United in fishing (5)
Less Pollution (4)	Better Future for the Children (5)	To save money through/with cattle grazing (4)
Respect agreements on the restriction of fishing and other activities (3)	Work with family (2)	Have more wood (2)
More Animals in the Mangroves (1)	Live in community, organized together (1)	More money with/from nature
Get rid of the Devil Fish (an invasive catfish)	Honesty (1)	
	Better roads (1)	
	Have tranquility/peace	
	Children are independent	

The shared vision for the future highlighted three goals and issues: **1) Having more work for the community members, 2) Having good health, and 3) More extensive mangroves supporting more fish and shrimp** (along with wildlife and usable wood). From the key visions and topics identified by the community, participants then worked to develop actions to achieve their vision. Facilitators worked with participants to address the following questions and topics:

1. **Identify activities and objectives to help achieve the most important aspects of the shared vision.**
2. **What advantages and resources can support the goal?**
3. **How will the community change things to achieve the goal?**
4. **Who will do it? / Who is responsible?**
5. **How will the community know if the goal is being achieved?**

Although the community identified three factors as the most important for the vision for the future (more work, good health, and more mangrove cover), there was unequal development of goals and objectives across these categories. For example, having good health was one of the most commonly expressed visions, but in discussions the community also expressed relative satisfaction with the state of health compared to the goal of increased work. For this reason, and perhaps also due to challenges developing strategies to improve health, most goals and objectives focused on attaining more work. Similarly, few goals and objectives were identified explicitly under the environmental goal of increased mangroves. However, many of the goals and objectives identified under the increased work objective were closely tied with the condition of natural resources as reflected through economic activities such as fishing, apiculture and wood extraction. A good example of this was an activity identified to reduce loss of mangroves from fires in order to maintain economic livelihood. The community proposed to form vigilance groups to watch for and be aware of burning activities (primarily sugarcane and cattle fields) within and beyond the community, and to work with neighboring communities on fire prevention. The community identified this activity under the economic category, but it applies equally to the ecological goal of maintaining and increasing mangrove cover. Similarly, although specific goals were not identified under the social category of good health, the proposed economic activities focused on sustainable use of natural resources would be likely to have direct and indirect effects on the health of community members.

Highlighted topic: Mangrove Charcoal

Worldwide, mangroves are a favored source of charcoal due in part to the high wood density of many mangrove tree species. Although primarily a fishing community, members of the community of La Mojarra were working to diversify their economy by producing sustainable charcoal and other uses of mangrove natural resources.

This issue highlights the complexity, strengths, and challenges of management planning within the community of La Mojarra. A key strength of planning in the community of La Mojarra is residents' familiarity with the political processes to obtain a permit and approved plan (UMA) for sustainable extraction of plant and wildlife species. A portion of the community (but not the entire) has invested in production of charcoal. This included receipt of an UMA permit with conditions for sustainable harvest, and constructions of kilns based on consultation with an ejido with specialized experience in charcoal.

The issue also highlights challenges facing the community. In attempts to develop other economies, members of the community must learn specialized techniques from other fields (e.g. charcoal or honey production), as well as develop approaches to marketing new products and cultivating clients.

The overarching goal of the community was to increase economic work with the sustainable use of mangrove resources as an important moral and strategic consideration. The goals and strategies developed by the community members and identified in the management plan were:

Goal 1: More work for community members

i) Management of fisheries resources
ii) Legal sale of mangrove wood and coal
iii) Production and sale of honey
iv) Production and sale of cattail (*Typha* spp.) and water lily (*Nymphae* spp.) handicrafts (women's collective)
v) Develop sustainable ecological tourism services

vi) Management and legal use of wildlife species

Goal 2: Having Good Health (specific strategies not considered, see discussion)

Goal 3: Conservation of Mangroves (addressed primarily through economic activity)

Associated Activities:

- Designated restoration areas, restoration with local NGOs
- Canal cleaning to improve water quality
- Removal of cattail

The activities, strategies and challenges associated with obtaining these goals were refined through an iterative process that involved initial planning by the community members, and facilitation by members of the NGO project team. As challenges associated with goals often included a component involving neighboring communities and resources from regional (and national) governmental programs, the initial pathways identified by the community were refined in a meeting with representatives from neighboring ejido communities and representatives of the municipal government. These objectives and pathways were further refined by capturing them in the format of a formal management plan prepared by the regional NGO Pronatura Veracruz and presented back to the community for agreement. Below we address the involvement of additional stakeholders and how the results of the workshop were captured in a management plan for the community.

Involvement of Additional Stakeholders

Following the activities designed to identify the community's shared vision for the future of the community and a set of goals and activities to achieve that vision, representatives from outside the community of La Mojarra were invited to participate. This was important because goals and activities identified by the community to achieve their shared vision necessitated collaboration with, and support from, those outside of the community. For example, goals for maintenance of canals and prevention of fire involved communication with neighbors, and a desire by the community for a paved road potentially involved support from the regional

Figure 35 *Discussion of goals and pathways with representatives from neighboring communities and the regional government.*

government. However, outside representatives were invited to participate only following internal development by the community of their desired goals for the future.

Key topics / Lessons learned during incorporation of additional stakeholders:

- Exchange of knowledge: In discussion with representatives from neighboring ejidos, it appeared that individuals from La Mojarra held expertise in the UMA permit process for sustainable harvest of managed species that was of interest to neighbors. In contrast, neighboring communities had experience of interest to La Mojarra in terms of employment assistance programs through agencies such as CONANP and SEMARNAT for protection of natural areas from fire and wood/wildlife theft.
- Addressing regional issues requiring cooperation among neighbors: cleaning of canal system to ensure good water flow and prevent stagnation of mangrove pools.
- Assessing interest and knowledge in the region for new efforts such as a proposal for a women's collective to produce handicrafts built from cattails and water lilies.
- Awareness by regional authorities of key issues from an organized community: need for paved road to enhance economic activities

Highlighted topic: Proposed Handicraft Collective

Participation by women in community-based management planning is often identified as important for successful outcomes. Representation by women in the at La Mojarra workshops was high and included a proposal to start a collective that would produce and sell handicrafts made from aquatic plants such as cattail (*Typha* spp). and water lily (*Nymphaea* spp.). These act as invasive species in the Alvarado Lagoon System, so utilizing them was seen as making use of waste materials and potentially helping with a problem while providing additional income to the community.

We highlight this proposal both to address gender based participation in planning, as well as an example of an issue that that brings up common challenges. Similar to charcoal production and apiculture, production of handicrafts requires aquiring a high level of skill before it represents a viable economic activity. It also requires the development of new markets for the community, and would benefit from common goals such as paving of the road to the community to better transport goods and customers.

Step Three: Incorporating Workshop Results into a Management Plan

The vision, goals, and objectives of a community as identified through the participatory workshops were captured in a management plan which included supporting information from the ecological and economic assessments, along with information on the ecological context of the Alvarado Lagoon System from regional monitoring efforts by Pronatura Veracruz and other regional stakeholders. Key components of a management plan include:

- Goal(s) statement
- Management activities
- Responsibilities
- Monitoring indicators
- Evaluation criteria and
- Process for adaptive management
- Supporting ecological, social and economic information

Prior to development of the workshop, a general outline of a management plan addressing these components was developed in a format commonly used across the region by Pronatura Veracruz for planning. Combined with exercises that were designed to result in goals, objectives, actions and strategies to achieve the shared vision, this was used to identify specific goals, strategies and objectives within the management plan.

Highlighted Topic:
Apiculture

Producing honey from mangroves has been promoted globally as an alternative income source for communities in mangrove zones. Honey from many mangrove species, including the black mangrove (*Avicennia germinans*) in the ALS, is prized for its flavor and quality. La Mojarra is in the process of scaling up a small apiculture business as a means of diversifying community income sources. Pronatura Veracruz and local university experts are assisting in strategies to promote mangrove honey regionally with certification, testing and marketing strategies promoting the quality and sustainable origins of local mangrove honey.

Black Mangrove honey from La Mojarra

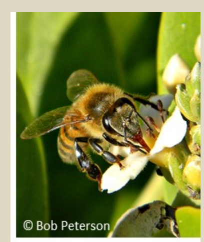


Table 23 *Example elements of a management plan, modified from the ALS management plant outline.*

1. INTRODUCTION	• **Background** • **Justification**
2. OBJECTIVES	• **General objective** • **Specific objectives**
3. DESCRIPTION & CONTEXT OF THE PROJECT AREA	• **Location** • **Physical-geographical characteristics** • **Biological Characteristics**
4. HISTORICAL AND CULTURAL CONTEXT	• **History of resource use** • **Relevant cultural factors**
5. DEMOGRAPHIC, ECONOMIC AND SOCIAL CONTEXT	• **Economically active population by sector** • **Schools** • **Housing conditions** • **Characterization of the economic system** • **Land tenure** • **Use of national land and waters**
6. DIAGNOSIS AND PROBLEMS	• **Ecosystem conditions and threats**
7. HANDLING AND ZONING	• **Participatory tools methods**
8. RESULT OF THE PARTICIPATORY WORKSHOPS AND ECONOMIC GAMES	• **Decision making for the management of mangrove resources** • **Management description and zoning** • **Approach of goals and objectives for the community of La Mojarra**
9. MONITORING AND EVALUATION	• **Monitoring metrics / indicators** • **Responsibilities**
10. ADAPTIVE MANAGEMENT	• **Responses to indicators** • **Decision frameworks** • **Follow-up actions**
Supporting Material	• **Wildlife and plant species lists** • **Related documents (permits, monitoring plans)**

Translating goals and objectives from the workshop into the management plan

Although the exercises presented here are designed to capture visions and proposals from the community in a format that is similar to how goals and objectives are commonly presented in management plans, goals may need to be further elaborated in a collaborative process with the community to produce a set of agreed actions. In refining goals and the strategies proposed to obtain them, it can be useful to assess the capacity of the community in the context of strengths and weaknesses for planning. A standard approach that provides a useful framework for this is analysis of strengths, weaknesses, opportunities, and threats, or SWOT, a planning approach used in businesses as well as in stake-holder engaged resource planning (e.g. Wheelen and Hunger, 1995, Mendoza and Prabhu 2005; Reihanian et al. 2012). This framework can be formally applied, or used qualitatively as we present here to help develop strategies. Table 24 presents a SWOT exercise used to help address strengths, challenges and opportunities in setting management goals. The strengths and opportunities were used in follow-up with the community to identify actions and strategies to achieve goals. These included, for example, identification of a number of community support programs from government agencies the community might be eligible for. These identified possible funding for community vigilance groups to prevent fires and reduce theft of wood, to conduct canal cleaning, and to conduct monitoring. These opportunities are supported by temporary employment programs from the national commission for natural areas (CONANP), national water commission (CONAUGA) and secretary for natural resources (SEMARNAT)

Table 24 Summary of Strengths, Weaknesses, Opportunities & Threats. Modified from original Spanish version (Pronatura Veracruz 2018).

Strengths (Internal)	Opportunities (External)
• Experience in business administration-supporting sales and markets for wood, honey, handicrafts • Familiarity with permit process for approval (UMA) for sustainable extraction of flora and fauna; strategic contacts that facilitate the permit process. • Knowledge of ecological restoration techniques, forest and hydrological restoration for the maintenance of each management zones and fishing resources. • Community has the necessary equipment to monitor vegetation and fauna. • Community is organized and cooperates in the cleaning of canals, road cleaning, ecological restoration activities, etc.	• Close relationships with other communities. Strengthens viability of surveillance, restoration and resource use agreements. • Pronatura Veracruz NGO for training in the development of a market strategy and monitoring of birds and water quality. • University Veracruzana for training in production of products with aquatic lily and water lily. • CONANP and a support for community surveillance and temporary employment program for cleaning channels, ecological tourism, conservation and use of wildlife. • Capacity for obtaining UMA permits
Weaknesses (Internal)	**Threats (External)**
• Lack of paved road that would facilitate the sale of various products and rural / sustainable tourism • Lack of financing to invest in the construction of infrastructure and equipment for tourism and beekeeping activities. • Lack of training to implement sustainable tourism actions, as well as to strengthen beekeeping or silviculture. • Lack of training in management and marketing for mangrove products obtained in a sustainable manner.	• Extraction of natural resources such as mangrove wood and wildlife by those outside the community. • Oil and gas extraction • Livestock and illegal wildlife extraction • Obstruction of pipes, preventing water flow. • Contamination of water bodies from fertilizer factory; lack of infrastructure for water treatment • Lack of respect for fisheries resource agreements such as closure, use of illegal size mesh and trawling/dredging.

Below we highlight the development of objectives in the management plan arising from proposed activities in the workshop on the sustainable selling of mangrove wood and charcoal and how these were captured as objectives in the management plan.

Translating goals- example: **Sustainable and Legal sale of wood and mangrove coal**

Background: The community holds a government permit (an UMA) for the sustainable use and sale of timber and legal mangrove coal. The main product derived from wood is posts for livestock fencing, along with charcoal produced in two recently constructed kilns designed especially for this purpose. The problem the community faces is to develop and maintain consistent sales of products derived from mangrove wood.

Obstacles Identified:

- Buyers are skeptical as wood and charcoal from La Mojarra are not well known.
- Fires from cattle and cane fields spread into and damage or destroy mangrove forest
- Wood is stolen by outsiders
- Lack of knowledge in the community for reporting illicit practices to authorities

Advantages Identified:

- Community members have an official UMA permit for the extraction of wood
- Although they are still acquiring expertise, community has infrastructure (the 2 kilns) and training in the production of mangrove charcoal.
- Permit for selling wood for construction from SEMARNAT (Secretariat of Environment and Natural Resources)
- Potential clients who require the verification of the legal origin of the products before purchase.

Strategies to overcome Obstacles:

- ***Short-term action***: Document the legal provenance of wood and mangrove coal, with labels that include the permit number of the UMA. Branding with a label from La Mojarra.
- ***Medium-term action*****:** Registering with the municipal government to strengthen the legal origin of the products.
- **Vigilance Actions**:
    - Construct firebreaks around the identified mangrove conservation and restoration zones.
    - Place signage with official institutional logos to help prevent theft and disturbance
    - Conduct awareness-raising talks with neighbors and formalize agreements for the planning of annual burning of agricultural and cattle fields in a responsible manner.
    - Seek funding for projects that support community surveillance, such as official funding for surveillance and vigilance program of CONANP (National Commission of Protected Areas).
    - Clean canals to promote water quality within mangrove stands

The elements captured in the above discussion of obstacles, advantages and strategies were then formalized into a table of proposed activities and responsibilities which are presented here in abbreviated form (Table 25). For additional examples we refer readers to Appendix 2 and to the management plan document itself

Table 25 Obstacles and opportunities facing La Mojarra in establishing the community as a mangrove wood supplier.

Obstacles	Opportunities	Actions	Time Scale and Duration	Responsibility	Evaluation of Effectiveness
Unfamiliarity and distrust of wood and coal from La Mojarra among buyers prevents sales	1. Possess government permit for sustainable wood harvest (UMA). 2. They have the infrastructure (2 kilns) and knowledge for production of mangrove charcoal. 3. Possess permit that allows the legal sale of wood for construction (SEMARNAT). 4. Potential clients that require verification of the legal origin of the products to complete the sale.	1. Label wood and charcoal with the permit number of the UMA. 2. Register with the finance secretary to strengthen the confidence and legality of the product.	1. Short term & Permanent 2. Medium term & Permanent.	Head of the community	Levels of sales Frequency of repeat customers
Fire and wood theft by outsiders		1. Make firebreaks around mangrove conservation and restoration zones. 2. Place signs with official institutional logos. 3. Carry out awareness-raising talks and formalize agreements for fire control with neighbors 4. Obtaining funding for community surveillance program of CONANP. 5. Channel cleaning with employment support funds (PET) from CONANP	1. Short term & Permanent 2. Short term & Permanent 3. Short term & Permanent 4. Short term & Permanent 5. Medium term & Permanent	Representatives of La Mojarra in coordination with neighboring communities;	Reduction of uncontrolled fires, especially in the months of May and June. Decrease in wood theft Increased frequency of controlled fires
Lack of knowledge in the community about reporting people or illegal practices with local government and neighboring communities		1. Organize within the community of La Mojarra and with other communities to strengthening of community surveillance 2. Funding for project for community surveillance with the PROVICOM program of CONANP.	1. Short term & Permanent 2.Medium term & Permanent.	Organizations of La Mojarra and other communities. Individual fishers. Technicians to support subsidies, and projects.	Knowledge of reporting process. Actions by regional government or neighboring communities in response to reports.

Community Maps and Resource Use

Map based planning is an important component of the stakeholder engagement process we present, as it captures resources, threats, and actions in a visual manner. Utilizing the maps generated during the workshop (Box 1.1), the community characterized important zones for resource use, local and regional threats and problems, as well as identification of areas of mangrove restoration. Resource use and threats identified in map form are shown in Figure 38 as an example of the types of topics identified in by stakeholders. The community also identified four zones for potential restoration within the ejido. Key results from the map-based exercise included:

Resources

- Key fishing areas
- Apiculture areas
- Wildlife
  -Iguana (multiple species)
  -Spotted Paca (*Cuniculus paca*)
- Ecotourism locations with manatees

Threats & Problems

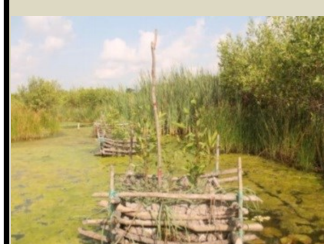
- Unfenced cattle
- Harmful fishing practices (trawling /dredging incorrect mesh for nets)
- Invasive aquatic plants
- Pez Diablo (invasive catfish *Pterygoplichthys* spp.)
- Polluted water discharges

Actions

- Locations of canals to clean to improve water flow
- Community vigilance sites
- Mangrove restoration areas
- Construction of firebreaks

Highlighted Topic: Mangrove restoration

Mangrove restoration presents many technical challenges due to the shifting and variable tidal environments mangroves are situated in, as well as the narrow environmental range characteristic of mangrove tree species. Within the Gulf of Mexico, Pronatura Veracruz has pioneered and refined a range of restoration techniques that have proven effective in reestablishing mangroves. The most prominent of these is the use of ***chinampas***, a variation on ancient Mesoamerican farming techniques using raised planting beds or construction of small islands. With mangroves, the use of chinampas allows the establishment of patches of soil and young trees which act as centers of recruitment and expansion. These methods were award the 2018 Ramsar prize for wetland innovation. Within the region, these methods represent proven mangrove restoration techniques (over 500 ha restored as of 2018) that are not readily available in other regions. The methodology has been tested successfully in other areas, such as Guatemala, and is currently taught in annual courses on mangrove restoration by Pronatura Veracruz.



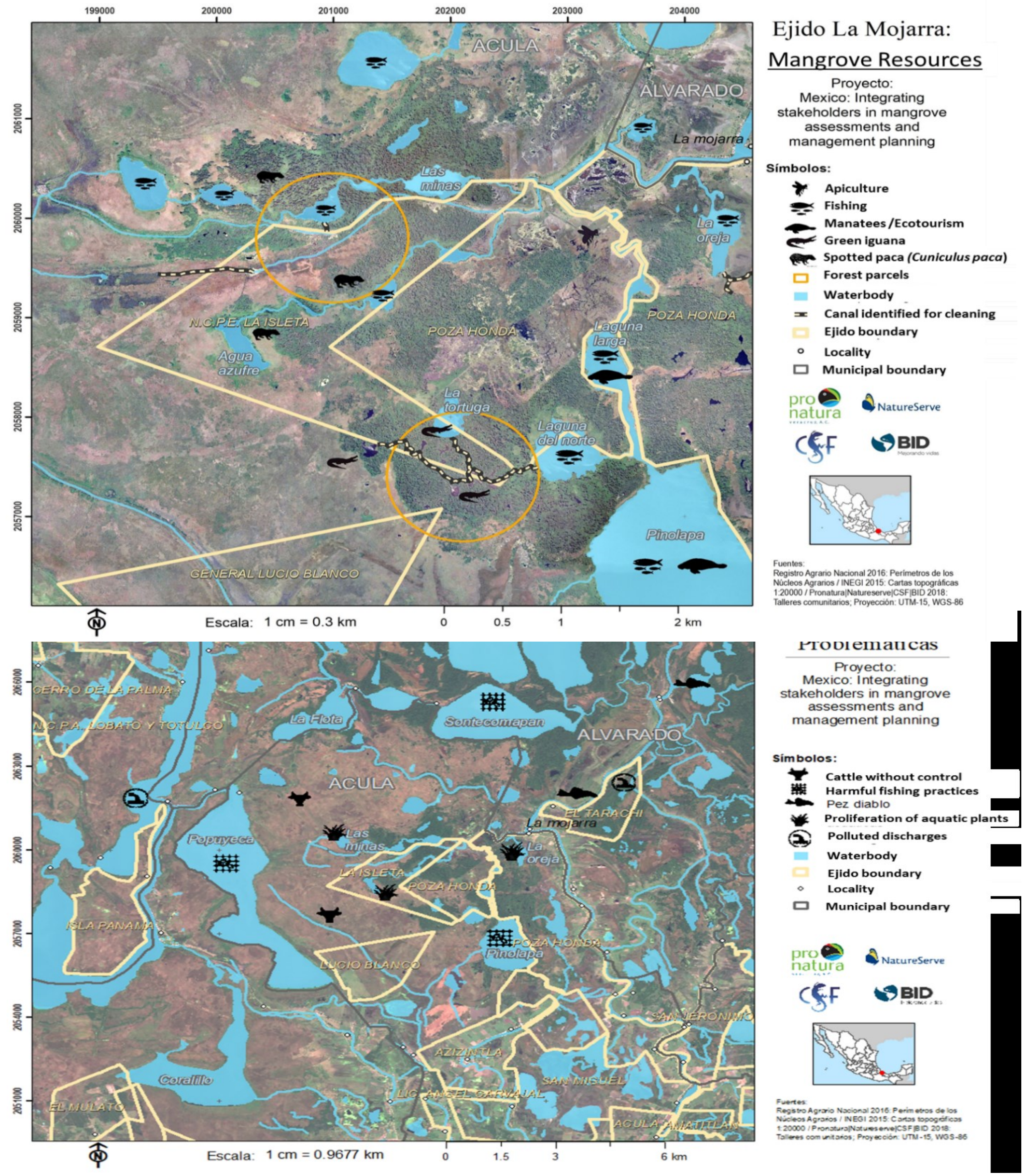


Figure 36 Example community maps denoting zones of current or potential resource use (top panel) ranging from fishing resources to areas of potential tourism. Areas of problems/threats such as unfenced cattle and harmful fishing practices are shown in the lower panel. Note the boundaries of distinct ejido parcels, reflecting the complex nature of land rights and stakeholder within the area. Ejido parcels for La Mojarra include Poza Honda and La Isleta. The community identified threats and problems at a regional scale.

Implementation and Follow-up

The components of collaborative planning we present here are designed to identify actions and strategies to benefit communities and the mangrove ecosystems in which people live and work. Although one concrete product of this process is a management plan with strategies and actions agreed upon by the community, the ultimate goals of the process are improved livelihoods and ecosystem health. While each of the goals identified in a management plan may have identified metrics and responsibilities, this formal management plan structure may better fit the decision-making frameworks of resource management agencies, funding agencies, and technical experts better than it does the decision-making processes of local communities. Thus, a critical component of setting up projects for success is planning for follow-up with communities to facilitate implementation of the proposed actions, assess whether those actions are helping to achieve the desired outcomes, and whether the proposed outcomes are still a priority for the community. True implementation of collaborative planning objectives involves a collective effort by the full range of stakeholders invested in the system. For example, actions and responsibilities identified by the community of La Mojarra included outside stakeholder in the following activities:

- Mangrove restoration projects supported by local NGOs (Pronatura Veracruz)
- Municipal government funds for road paving to enhance economic activities
- Technical support from experts at the University of Veracruz related to apiculture and initiation of a women's handicraft collective
- Regional governmental support for training in ecotourism
- Funds from national Mexican resource agencies (CONANP, SEMARNAT, CONAGUA) to help support habitat protection through vigilance groups
- Regional and national funds to address water quality issues and

Collaborative follow-through on community planning can be the most challenging phase of management planning. However, the relationships and capacity building formed during the planning process can directly contribute to the success of follow-up. In the case of La Mojarra, the ongoing work by Pronatura Veracruz and other NGOs in the ALS system provides a nexus for follow-up and connections to national and international funding opportunities.

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APPENDICES

Initial Stakeholder Engagement and Assessment

Appendix A1.1 List of stakeholders engaged in the early phases of the project.

Institution	Type	Level	Representative	Authority/Role
Acula Gobierno Municipal	Government	Municipality	Filiberto Sanchez Aguirre	Mayor at time of project initiation
Acula Gobierno Municipal	Government	Municipality	Felipe Pineda Barradas	Current Mayor
Alvarado Gobierno Municipal	Government	Municipality	Octavio Jaime Ruiz Barroso	Mayor at time of project initiation
Alvarado Gobierno Municipal	Government	Municipality	Bogar Ruiz Rosas	Current Mayor
Comisión Nacional de Acuacultura y Pesca (CONAPESCA)	Government	State	Jorge Alberto Valdiviezo Rodríguez	State Representative
Comisión Nacional de Acuacultura y Pesca (CONAPESCA)	Government	State	Lic. Horacio Cruz Lugo	Regional Director
Comisión Nacional de Acuacultura y Pesca (CONAPESCA)	Government	Municipality	Lic. Gabriela Baltazar Peña	Local department chief
Comisión Nacional del Agua (CONAGUA)	Government	Federal	Roberto Ramírez de la Parra	Bureau in charge of water management and disposition, including watersheds and wetlands management
Comisión Nacional del Agua (CONAGUA)	Government	State	César Triana Ramírez	State Representative
Comisión Nacional del Agua (CONAGUA)	Government	Federal	Mario Gilberto Aguilar Sánchez	Bureau in charge of fisheries management and regulation
CONABIO - Comisión Nacional para el Conocimiento y Uso de la Biodiversidad	Government	Federal	José Sarukhán Kermez	The mission of promoting, coordinating, supporting and carrying out activities aimed at the knowledge of biological diversity, as well as its conservation and sustainable use for the benefit of society

CONABIO - Comisión Nacional para el Conocimiento y Uso de la Biodiversidad	Government	Federal	María Isabel Cruz López	Sub-coordinator of Remote Sensing and Monitoring (emphazis con mangroves)
CONAFOR - Comisión Nacional Forestal	Government	Federal	Jorge Rescala Pérez	The National Forestry Commission, created by presidential decree on April 4, 2001, is a Decentralized Public Organism whose objective is to develop, favor and promote productive activities, conservation and restoration in forestry, as well as participate in the formulation of plans, Programs, and in the implementation of sustainable forest development policy.
CONAFOR - Comisión Nacional Forestal	Government	State	Valeria Madrigal Sánchez	Representative at state level
CONANP - Comisión Nacional de Áreas Naturales Protegidas	Government	Federal	Alejandro del Mazo Maza	For more than 15 years, the National Commission of Natural Protected Areas (CONANP) has worked to conserve Mexico's natural heritage and ecological processes in protected natural areas (ANP), combining conservation goals with those of the well-being of residents and users from the same. In this time, CONANP has promoted and strengthened multiple initiatives for the conservation and sustainable management of our biodiversity. It is from this learning that CONANP has been given the task of structuring a long-term strategy, which will be the institutional planning framework that will guide our actions in the short and medium term, in order to strengthen and consolidate the institution and its
CONANP - Comisión Nacional de Áreas Naturales Protegidas	Government	State	José Carlos Pizaña Soto	Regional Director
Instituto Nacional de Eclogía y Cambio Climático (INECC)	Government	Federal	Maria Amparo Martínez Arroyo	INECC is in charge of generate, integrate and divulge information for public policy and capacity building regarding global change, with special focus on climate change, air pollution and environmental economy

Instituto Nacional de Eclogía y Cambio Climático (INECC)	Government	Federal	Margarita Caso Chávez	General Coordinator of Climate Change Adaptation Strategies
Instituto Nacional de Pesca (INAPESCA)	Government	Federal	Pablo Roberto Arenas Fuentes	Research institute releted to federal government. Its research agenda tries to solve problems regarding to development and administration of Mexican fisheries
InterAmerican Development Bank - Mexico	Financial	Regional	Veronica Zavala Lombardi	The Bank's country strategy with Mexico for 2013-2018 focuses on stimulating productive, social, and territorial development to boost the economy's growth potential. To this end, the IDB supports the country in the following areas: public management; the financial system; labor markets; business competitiveness; social protection; health; urban development; rural development; and climate change.
La Mojarra	Ejido	Local	Arturo Valencia	Consume and manage natural resources
Petróleos Mexicanos (PEMEX)-Agencia de Seguridad, Energía y Ambiente	Government	State	Carlos de Régules Luis Funes	Federal representative
Secretaría de Marina (SEMAR)	Government	Federal	Vidal Francisco Soberón Sanz	This Federal Bureau is organized by Mexican Army and vigilates Mexican coastal and inland waters while performing oceanographic research and social linkage

Appendix 1. Ecological Integrity Assessment Materials

Table A1.1. Summary of major vegetation types in the Alvarado Lagoon System**.** See text for details on mangrove types.

Vegetation Type (Spanish common name in parentheses)	Description	Map Legend Name
Mangrove (Manglar)	*Avicennia germinans, Laguncularia racemosa, Rhizophora mangle*	
Mid to Mature Mangrove (Manglar conservado)	Intact canopy, with full range of tree stem sizes, including stems > 50 cm dbh.	Manglar conservado
Pole Mangrove (Manglar secundario**)**	Open to very open canopy, dominated by tree stems less than 25 cm dbh.	Manglar secundario
Mangrove Regeneration / Restoration (manglar regeneración/restoración)	Areas either undergoing natural mangrove regeneration (Zone A) or suitable for Natural Regeneration (Zone B)	Not mapped (but see other map with Zones A and Zones B)
Recently Burned Mangrove (Manglare quemados)	Mangrove burned in the last 5 years, and canopy largely to completed killed.	Tular-popal, tulillar y espartales, incluye manglares quemados
Tall Narrow-leaved Marsh (Tular)	*Typha*, *Scirpus* y *Cyperus*, *Phragmites communis* y *Arundo donax* (both referred to as carrizales).	
Broad-leaved Marsh (Popal)	*Thalia geniculata*, *Calathea ovandensis*, *Heliconia* spp	
Eleocharis Marsh (Tulillar)	*Eleocharis*	
Spartina Marsh (Espartales)	*Spartina*	
Pasture (Pastizal)	Pastizal: Pasture: former forested or open wetlands converted to pasture	
	Pasture with trees up to XX canopy cover	Pastizal con árboles
	Flooded pasture.	Pastizal ocasionalmente inundado y humedales pertubados
	Non-flooded pasture	Pastizal no inundable
Floating Aquatic Vegetation	*Eicchornia …., Nymphaea*	Cuerpos de agua (includes all water bodies, with or without vegetation)
Submerged Aquatic Vegetation (seagrass)	*Ruppia maritima*	
Sugarcane	Agricultural fields with sugarcane plantations	X
Palm Wetland [mostly wetland, but also agricultural fields?]	Wetlands with open canopy of *Sabal mexicana. Sabal mexicanal* stands can also occur in uplands, in agricultural fields	X
Forested Swamp	Freshwater forested wetland with *Pachira aquatica, Anona glabra, Salíx* spp.	X

Table A1.2 Summary of sites used in the ALS study**.** Sites with Project Source as “Mangrove IDB” were sampled for mangrove data as part of the ALS project. Sites with Project Source “Forestal Pronatura” were sampled in earlier studies by Pronatura Veracruz staff.

Site	CODE	Information Source	Assessment Type	Piezometers	Soil	No. of plots
Cañon Bajo	PRCB	Mangrove IDB	Intensive	x	x	3
Calalarga	PRCL	Mangrove IDB	Rapid	x	x	1
Isleta de Pataratas 2017	PRIP17	Mangrove IDB	Intensive	x	x	3
Isleta de Pataratas 2016	PRIP16	Forestal Pronatura	Intensive	-	x	3
El Nacaxte	PRNA	Mangrove IDB	Rapid	x	x	1
Plaza de Armas	PRPA	Mangrove IDB	Rapid	x	x	1
San Antonio	PRSA	Mangrove IDB	Intensive	x	x	3
Isla De Jade	PRIJ	Mangrove IDB	Rapid	x	x	1
La Mojarra Las Minas	RELM	Mangrove IDB	Intensive	x	-	3
La Mojarra La Tortuga	PRLT	Mangrove IDB	Intensive	-	-	3
La Flota	PRFL	Forestal Pronatura	Intensive	x	x	3
Nacaxtle con Pizometro	PRNAC	Forestal Pronatura	Intensive	x	x	3
Nacaxtle sin Pizometro	PRNAS	Forestal Pronatura	Intensive	-	x	3
El Pájaro	PRPA	Forestal Pronatura	Intensive	x	x	3
Canates	RECA	-	None	x	x	-
Puente Fierro	REPF	-	None	x	x	-

Table A1.3. Summary of Mangrove Structure: Relative Basal Area from ALS Ecological Integrity Assessment. Absolute and relative basal area (BA) of broad stem size classes: small (2.5-10 cm dbh), pole (10–25 cm), medium (26–50 cm), and large (>50 cm). STST = Structural Stage

Site	Absolute Basal Area ($m^2 ha^{-1}$)					Relative Basal Area (%)					
	Total	Small	Pole	Medium	Large	Small	Pole	Medium + Large	STST Rank	Structural Stage Class	% RBA in M+L
La Flota	60.23	0.3	8.9	28.1	22.8	0.6	14.8	84.6	1	mature	>50
Isleta Pataratas 2017	29.64	1.0	6.1	22.5	0.0	3.5	20.6	75.9	2	mature	
Isleta Pataratas 2016	24.40	3.4	5.9	15.1	0.0	13.7	24.2	62.1	3	mature	
Necaxtle - Sin P	40.57	3.5	14.0	15.8	7.2	8.6	34.6	56.8	4	mature	
El Pájaro	26.62	9.4	3.9	7.9	5.4	35.4	14.7	49.9	5	Mid	25-50%
Cañon Bajo	20.04	2.4	10.7	7.0	0.0	12.0	53.2	34.8	6	Mid	
Necaxtle - Con P	31.53	0.3	19.8	11.5	0.0	1.0	62.7	36.3	7	Mid	
La Mojarra (La Tortuga)	19.75	5.5	9.8	4.5	0.0	27.8	49.4	22.7	8	Pole	<25%
San Antonio	18.39	3.7	10.7	4.0	0.0	20.2	58.1	21.7	9	Pole	
La Mojarra (Las Minas)	12.52	9.4	3.1	0.0	0.0	75.1	24.9	0.0	10	pole	

Table A1.4. Summary of Mangrove Structure: Complexity Index. Stands are presented in order of their Structural Stage Rank from the ALS Ecological Integrity Assessment.

		Trees > 2.5. cm dbh / 0.1 ha				Trees > 10 cm dbh / 0.1 ha			
Site	**Structural Stage Class**	**s**	**d**	**B**	**Complexity Index [1]**	**s**	**d**	**b**	**Complexity Index [1]**
La Flota	mature	3	90.0	6.023	**29.3**	3	76.7	5.988	**24.8**
Isleta Pataratas 2017	mature	3	97.8	2.964	**16.5**	3	51.1	2.861	**8.3**
Isleta Pataratas 2016	mature	2	138.9	2.440	**12.2**	2	48.9	2.105	**3.7**
Necaxtle - Sin P	mature	3	187.8	4.057	**36.6**	3	76.7	3.708	**13.6**
El Pájaro	mid	3	373.3	2.662	**50.7**	2	41.1	1.718	**2.4**
Cañon Bajo	mid	3	141.1	2.004	**11.0**	3	54.4	1.763	**3.7**
Necaxtle - Con P	mid	3	106.7	3.153	**15.1**	3	97.8	3.123	**13.7**
La Mojarra (LaTortuga)	pole	1	235.6	1.975	**3.7**	1	84.4	1.424	**1.0**
San Antonio	pole	3	189.0	1.839	**19.9**	3	72.2	1.468	**6.0**
La Mojarra (Las Minas)	pole	3	315.6	1.252	**19.0**	3	26.7	0.312	**0.4**

[1] Complexity Index = s x d x b x h x 10^{-3}

S = Species Richness (0.09 ha^{-1}, d = Density (stems 0.1 ha^{-1}), b = Basal Area (m^2 0.1 ha^{-1}), h = Height (m)

Table A1.5. Summary of Mangrove Structure: Species Importance Value**.** Stands are ordered by Structural Stage Rank (see Table 3).

SITE	STST Rank	Mangrove Species	F	BA	D	RF	RBA	RD	I.V.
La Flota	1	*Avicennia germinans*	100.0	29.3	222.2	34.6	48.7	24.7	36
		Laguncularia racemosa	100.0	24.5	466.7	34.6	40.7	51.9	**42**
		Rhizophora mangle	88.9	6.4	211.1	30.8	10.6	23.5	22
Isleta Pataratas 2017	2	***Avicennia germinans***	100.0	24.1	388.9	39.1	81.2	39.8	**53**
		Laguncularia racemosa	77.8	1.8	422.2	30.4	6.2	43.2	27
		Rhizophora mangle	77.8	3.7	166.7	30.4	12.6	17.0	20
Isleta Pataratas 2016	3	***Avicennia germinans***	88.9	18.8	355.6	57.1	77.2	25.6	**53**
		Laguncularia racemosa	66.7	5.6	1033.3	42.9	22.8	74.4	47
Necaxtle - Sin P	4	*Avicennia germinans*	77.8	21.7	288.9	38.9	53.4	15.4	36
		Laguncularia racemosa	77.8	15.7	1444.4	38.9	38.6	76.9	**51**
		Rhizophora mangle	44.4	3.3	144.4	22.2	8.0	7.7	13
El Pájaro	5	*Avicennia germinans*	77.8	15.0	555.6	29.2	56.5	14.9	34
		Laguncularia racemosa	100.0	11.1	2877.8	37.5	41.7	78.9	**56**
		Rhizophora mangle	55.6	0.5	233.3	20.8	1.8	6.2	10
Cañon Bajo	6	***Avicennia germinans***	100.0	11.4	555.6	36.0	57.1	39.4	**44**
		Laguncularia racemosa	77.8	5.3	522.2	28.0	26.6	37.0	31
		Rhizophora mangle	100.0	3.3	333.3	36.0	16.3	23.6	25
Necaxtle - Con P	7	***Avicennia germinans***	88.9	15.7	500.0	33.3	49.8	46.9	**43**
		Laguncularia racemosa	88.9	8.8	277.8	33.3	27.9	26.0	29
		Rhizophora mangle	88.9	7.1	288.9	33.3	22.4	27.1	28
La Mojarra (La Tortuga)	8	***Laguncularia racemosa***	100.0	19.8	2355.6	100.0	100.0	100.0	**100**
San Antonio	9	*Avicennia germinans*	33.3	0.9	44.4	21.4	4.9	2.3	10
		Laguncularia racemosa	100.0	16.4	1833.3	64.3	89.1	96.5	**83**
		Rhizophora mangle	22.2	1.1	22.2	14.3	6.0	1.2	7
La Mojarra (Las Minas)	10	*Avicennia germinans*	33.3	0.7	111.1	23.1	5.8	3.5	11
		Laguncularia racemosa	100.0	11.7	3022.2	69.2	93.2	95.8	**86**
		Rhizophora mangle	11.1	0.1	22.2	7.7	1.0	0.7	3

BA = Basal area (m^2 ha^{-1}), Absolute Density (stems ha^{-1}), F = Frequency, RBA = Relative Basal Area, RD = Relative Density, RF = Relative Frequency, I.V. = Importance Value.

Table A1.6. Water chemistry and Soil Properties of Mangrove Sites**.** Data are a partial presentation of available data. For the Vegetation column, Tula-popal etc.= Tular-popal, tulillar y espartales, incluye manglares quemados. Pastizal etc. = Pastizal ocasionalmente inundado y humedales pertubados. PSU – practical salinity units. Data are taken from unpublished Pronatura Veracruz data.

Lugar	Piezómetro	Vegetación	*n*	Inundación _avg (cm)	Amplitud inundación (cm)	# meses inundados	PSU avg	NO_{3-} (mg·L^{-1}) avg	NO_{3-} max	Amoniaco NH_3 (mg·L^{-1}) avg	NH_3 max	Ortofosfatos PO_4^{3-} (mg·L^{-1}) avg	PO_4^{3-} max	Suelo-pH	Distancia a costa (km)
Canates	RECAI1	Manglar secundario	23	15.45	80	6	12.69	0.06	0.51	1.12	2.59	0.24	2.5	5.5	19.1
Puente Fierro	REPFI2	Pastizal con árboles	23	-7.62	114	5	12.68	0.07	0.51	0.82	2.73	0.24	2.7	7.1	14.85
El Pájaro	REPAI4	Manglar secundario	23	-6.11	118	5	12.28	0.01	0.05	0.07	0.29	0.2	2.5	6.3	16
La Flota	PRFLE1	Manglar conservado	23	2.13	78	6	12.88	0.01	0.1	0.18	0.94	1.19	2.51	8.1	17
Necaxtle con P	PRNEE1	Tular-popal, etc	23	0.67	106	7	13.08	0.02	0.09	0.15	0.61	0.45	2.42	7.1	16.8
San Antonio	PRSAE1	Manglar conservado	23	-2.98	64.5	5	12.37	0.02	0.43	0.88	2.51	0.52	2.64	7	16.2
Isleta de Pataratas	PRIPE1	Manglar conservado	23	-33.96	79	2	13.22	0.06	0.3	0.77	2.51	0.32	2.51	7.6	11.2
Isla de Jade	PRIJE1	Pastizal etc	23	-6.81	82.5	4	12.78	0.05	0.5	0.66	2.51	0.31	2.51	7.4	13.9
El Nacaxte	PRNAE1		23	-12.65	69	3	12.41	0.02	0.35	0.83	2.51	0.22	2.01	7.6	11.6
Cañón Bajo	PRCBE1	Manglar conservado	23	3.29	60	6	11.83	0	0.06	0.15	0.93	0.96	2.51	6.6	9
Plaza de Armas	PRPAE1	Pastizal etc.	23	-11.66	87.5	4	13.42	0.04	0.51	0.59	2.19	0.17	1.08	8.1	12.6
Calalarga	PRCLE1	Tular-popal rtv	23	-38.92	97	3	10.27	0.02	0.16	0.19	1.5	0.23	1.15	9	8.5
			AVG	-8.27	86.29		12.49	0.03	0.3	0.53	1.82	0.42	2.25	7.28	
Moj. Las Minas	RELMPZI1	Manglar secundario	1				12.15	0.01		0.11		0.02			22

Table A1.7. Example of Ecological Integrity Scorecard for Mangrove Sites in the Alvarado Lagoon System. The metrics for Vegetation are complete, and both the values and the ratings are shown. Metric ratings are given points as follow: A = 4, B = 3, C = 2, D = 1. The scores are averaged across metrics to give an overall vegetation score, based on the scale: A+ = 3.8 – 4.0, A- = 3.5-3.79, B+ = 3.0-3.49, B- = 2.5-2.99, C+ = 2.0 -2.49, C- = 1.5-1.99, D = 1 – 1.49.

KEA Metric		SITE									
		La Flota	Pataratas 2017	Pataratas 2016	Necaxtle sin P	El Pájaro	Cañón Bajo	Necaxtle con P	La Tortuga La Mojarra	San Antonio	Las Minas La Mojara
KEA: LANDSCAPE & BUFFER	Rating										
LAN1. Connectivity	Value										
	Rating	n.d.	n.dd	n.d.	n.d.	n.d	n.d	n.d	n.d	n.d	n.d
LAN2. Land Use Index	Value	9.2	8.7	n.d	8.7	8.4	9.5	7.9	8.3	8.0	7.2
	Rating	B	B	*	B	B	A	C	B	B	C
KEA: VEGETATION	**Rating**	**A+**	**A+**	**A+**	**A+**	**A-**	**A+**	**B+**	**A-**	**B+**	**B+**
VEG2. Invasive Nonnative Plant Species Cover	Value	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Rating	A	A	A	A	A	A	A	A	A	A
VEG3. Native Plant Species Comp,. [proxy LAN2 - onsite]	Value	10.0	9.6	n.d.	10.0	9.1	10.0	5.4	9.6	8.3	6.0
	Rating	A	A	*	A	B	A	C	A	B	C
VEG4. Overall Vegetation Structure	Value	MATURE	MATURE	MATURE	MATURE	MID	MID	MID	POLE	POLE	POLE
	Rating	A	A	A	A	B	B	B	C	C	C
VEG5. Regeneration Potential[1]	Value	5	10	5	6	9	11	4	5	8	7
	Rating	A	A	A	A	A	A	A	A	A	A

Appendix A2.1. Detailed Agenda Used in Planning Workshop (translated and modified from original Spanish).

Time	Topic	Objectives	Activities	Materials
10:10-10:30	Preparation of space and registration of particapnts	Prepare space and materials Start registration of participants	Prepare the workshop space with chairs and tables, as well as the projector and materials. Start registration of attendees in lists.	Tables, chairs, projector table, extensions, power strip, white canvas.
10:30 - 11:30	Presentation of results	Present the results of the experimental economic game to the people of the La Mojarra community	Enter work day goals. The CSF team will present the results through audiovisuals.	Computer and projector
11:30 – 12:30	Discussion of results	Discuss and find answers to the decisions they made in the experimental economic game.	The CSF team will discuss and explore the people in the community regarding the decisions made in the game. For that, there will be general topics to discuss that will be trigger questions and the answers will be written down on paper. The themes or questions that trigger will try to answer: 1) What did you think when you made your decision regarding the number of mojarras to explode on the board? 2) What did you think when contributing to the common fund? 3) Are the decisions of the game similar to those that happen or could happen in real life? 4) What could we do to change the decisions you made in the game? 5) Is livestock, mangrove extraction or fishing resources more important?	Markers, sticky notes, large blank papers
12:30 - 13:30	Construction of an ideal future scenario for the La Mojarra community	Know the perception of the different actors of the community and agree on the generation of an ideal future scenario with the community	The community will be divided into groups of 5-8 people each. The teams will be formed according to affinities, positions or positions of authority, age and gender. (accommodation in tables 10 min) The dynamic consists of three steps. The objectives of the dynamics will be announced. Step 1 To arrive at the construction of a future scenario, the first step is to identify the current context of livelihood strategies, use and management of mangroves, as well as aspects of community organization.	Colored markers Post it colors Blank paper

Time	Topic	Objectives	Activities	Materials
Paso 1 **1 h**			Participants will be asked to freely describe their daily lifestyle, their livelihood strategies, their activities, their community, their space, their mangroves (conservation, management and use, including current monitoring).	
14:30 - 15:30 **Paso 2** **1 h** **15:30-16:45** **Paso 3** **1 h**		Continue activity: Know the perception of the different actors of the community and agree on the generation of an ideal future scenario with the community	Step 2 After considering their current context, participants will be asked to relax, close their eyes and clear their minds; They are going to start a trip to the future. The facilitator will tell the guide the participants through a vision of the future. Example script: Let's go back to the future, when I finish counting to 20, you are bigger. Their children have grown, the community has changed and has improved. Life has improved a lot, the community is happier. The problems have been solved. When you open your eyes, you will continue here, but 20 years in the future. Step 3 At the end of the activity all the papers will be pasted. A member of each team will spend to share the ideal future scenario of their team. They will be asked to discuss among themselves and compare the different perspectives. After the group discussion, a list of ideas will be placed on a piece of paper. They will be asked to place a grade (between 1 and 5 maximum) next to the idea they consider most relevant. At the end of the activity, the score will be counted.	Colored markers Sticky notes Large format paper / posters
16:45-17:00	Closing of session and agreements for day 2 of work	Present the mechanics of work for the next day.	The facilitators will appreciate the participation of the people, highlighting the importance of these activities. They will be invited to participate on the second day and the dynamics of the activities will be briefly explained.	-

Time	Topic	Objectives	Activities	Materials
10:10-10:30	Preparation of space and registration of attendees	Prepare space and materials Start registration of participants	Prepare the workshop space with chairs and tables, as well as materials. Start the registration of assistants in lists.	
10:30-10:40	Introduction	Introduce the dynamics for the day	The conclusions of day 1 will be briefly reviewed and the objectives and mechanics of day 2 will be presented.	-
10:40 – 11:20 **Paso 1** **40 min** **11:20 - 12:00** **Paso 2** **40 min** **12:00-13:00** **Paso 3** **1 h**	Planning strategies to achieve the ideal jfuturo scenario.	Identify and establish objectives to achieve the ideal future scenario. Reflect on the positive and negative aspects; as well as scenarios and actors that intervene (or could) in the fulfillment of the objectives.	Step 1 Based on the activity of the previous day, in this step the five best voted ideas will be used, if considered necessary, more ideas can be integrated. They will be asked to make a comparison of the present context and the vision that one wants to reach in the future, as well as to identify differences (20 min). Step 2 Development of strategies to achieve objectives An example of the strategy approach will be developed. Then work groups will be formed again in order to promote discussion and the generation of agreements. Each group will generate a strategy based on the obstacles or missing elements. Step 3 Discussion in plenary Each group will present its strategy in plenary (10 min each group). It will be analyzed and discussed to adjust the strategy with the participation of the whole community (30 min).	Plot of format for the elaboration of strategies and fulfillment of objectives. Plot Gantt type diagram Plot of indicators Blank paper
13:00 - 13:30			**Break**	

Time	Topic	Objectives	Activities	Materials
13.30-14:30 **Paso 1** **1 h** **14:30 – 15:15** **Paso 2** **45 min**	Participatory community map of use, management and conservation of mangrove resources.	Recover, dialogue and reflect on the community's perception of the most important productive activities, goods and ecosystem services for the community. Recover, prioritize and reflect on the management of resources in the mangroves of the Alvarado Lagoon System.	1. To know the current context of the community, you will be asked to identify and mark with markers of different colors the most important ecosystem goods and services for them (use different colors for services). For example, water bodies, fishing zone, beekeeping, livestock, agriculture, silvicultural management, hunting, UMA, mangrove, etc. 2. According to the above, they will be asked to identify and mark with colored markers those areas destined for ecological restoration and conservation. 3. Finally, with the colored markers you will be asked to identify and mark the areas with the most important productive activities, according to the weighting done in the previous year. Step 2 The activity will be concluded showing the maps prepared by the different groups. One person from each team will present the results of their table in plenary.	2 or 3 printed maps of the community of 100x120 cm Prints that represent productive activities, goods and ecosystem services Colored markers (be sure to carry several colors for each map)
15:15-15:30	Cierre del día 2	Thank the attendance and participation in the workshop. Comment on the project process.	They will be thanked for their participation in the workshop and will comment on the process and where we are now in the project with the IDB. The mechanism for the next working day will be explained, which will involve the exchange with authorities of the municipal government. It will be recommended to select from the community a group of representatives who will be able to present the main conclusions of the workshops held with the authorities.	
10:10-10:30	Preparation of space and registration of attendees	Prepare space and materials. Start registration of participants.	Prepare the workshop space with chairs and tables, as well as materials. Start the registration of assistants in lists.	Tables, chairs, projector table, extensions, multi-contact, white canvas.
10:30-10:50	Welcome and presentation of participants	Welcome the attendees.	The attendees will be welcomed, their participation will be appreciated. They will be asked to introduce themselves; in the case of the authorities that state their position and their interest to attend the session.	-

Time	Topic	Objectives	Activities	Materials
10:50-11:30	Introduction	Give an introduction to the project and the session	A brief presentation will be given that includes the objectives of the project with IDB and the main results of the experimental economic games. A brief presentation will be given that includes the objectives of the project with IDB and the main results of the experimental economic games.	Computer and projector
11:30-12:00	Presentation of conclusions and agreements of the community	Present the results, conclusions and main agreements of the workshops on day 1 and 2.	The representatives selected by the community will present to the authorities their perspectives towards a community management plan for the mangroves. Its main results, conclusions and agreements will be presented, resuming the activities of the workshops.	Materials generated in the previous sessions.
12:00-13:00	Exchange with the municipal authorities	Local authorities and community representatives exchange perspectives and generate agreements.	The authorities present will be given the floor. They are invited to give their perspective to what the community presented. They are asked to also present their activities and program in the subject matter. All are invited to propose ways of collaboration that allow both the conservation of mangroves, as well as their use and sustainable management.	Paper to write down agreements (if necessary)
13:00 13:30	Closure of activities	Closing of the working day and follow-up agreements.	Everyone's participation is appreciated, as well as the collective effort. The way in which the workshops and the project with the IDB will follow up is presented.	-

APPENDIX 2. Goals and Objectives From the Participatory Workshop Identified in the Management Plan

Table A2.1 Goal 1 Objective 1. Management of Fishing Resources

Obstacles	Opportunities	Actions	Time scale and duration	Responsibilities	Evaluation
Non-compliance with agreements by other communities	Internal organization in cooperatives, including one that is formed by women. Relationship with other communities and the Acula municipal government. The people of La Mojarra respect the agreements and carry out activities for the protection and conservation of their resources.	Strengthen the organization within the community of La Mojarra and with other communities and cooperatives. Supports during the closure to people totally dependent on fishing.	Short term Permanent	La Mojarra and other nearby communities. Individual fishermen Acula municipal government	Fishing yield and production after 6 months
The lack of effectiveness on the part of the authorities and the corruption of those in charge of surveillance.		1. Strengthening the internal organization of the community and other communities 2 Seek subsidies such as CONANP's PROVICOM program for community surveillance	1. Short term Permanent 2. Medium term temporary	Fishing organizations of the Mojarra and other communities. Individual fishermen. Technicians Civil society organizations	Reduction of fires in mangrove restoration and conservation areas Decrease in wood theft.
1. The lack of sale of mojarra (perch) by the demand on the quality of products by regular buyers Lack of identification of new buyers.	Mojarra of good size by the number of mesh that is used.	1. Improve the roads to facilitate access to potential buyers. It would benefit in the transfer of the product, it would be economic and would increase the possibility of finding new clients. 2. To improve the quality of the genetic diversity of mojarra, it was proposed to enter 1 million fingerlings in the mojarra population in Poza Honda and Abrevadero. 3. Hydrological restoration in the channels to reduce sargassum and improve the quality of the mojarra	1. Short to Long term Permanent 3. Long term Temporary	Municipal government of Acula, community of La Mojarra / Arturo Valencia	Better quality and sale of mojarra (perch)

Objective	Obstacles	Opportunities	Actions	Time scale and duration	Responsibilities	Evaluation
	The lack of cleaning channels to recover the water flow	The people of La Mojarra participate in channel cleaning activities	The cleaning of channels of the turtle, Agua Azufre, Las Minas, from La Oreja and Manglitos to the Tigre and Vayivengue. Search for subsidies with the Temporary Employment Program (PET) and the support of the Acula municipal government.	Short term Permanent Annual	The community of La Mojarra and other communities. Coordination by Arturo Valencia Acula municipal government	Reduction of fires More fishing and better quality
	Fires		1. Make firebreaks breaches around mangrove conservation and restoration zones. 2. Sign signage with logos of government institutions to strengthen the protection of their properties. 3. Carry out workshops to raise awareness, disseminate and make agreements for the regulation of fires. 4. Community surveillance with subsidy from PROVICOM of CONANP 5. Cleaning of channels with PET support and Acula municipal government	Short term Permanent	La Mojarra and communities such as El Talladero Azizintla, Poza Honda, Las Flores among others. Support of technicians Municipal Government of Acula	Reduction of fires, especially in the months of May and June.
	You can not use some bodies of water		It was proposed to formalize agreements directly with the people responsible for the use of bodies of water. Hydrological restoration to recover the water flow	Short term Temporary	Independent fishermen and cooperatives, Civil Society Organizations, municipal government of Acula and CONAGUA	Use the bodies of water Recover the water flow

Table A2.2. Goal 1. Objective 2 Legal sale of wood and mangrove coal

Obstacles	Opportunities	Actions	Time Scale and Duration	Responsibility	Evaluation of Effectiveness
Lack of sales due to the buyer's distrust of the origin of wood and coal.	1. They have permission to use wood. 2. They have the infrastructure and knowledge for the production of mangrove coal. 3. They have a permit that allows the legal sale of wood (SEMARNAT). 4. They have potential clients that require verification of the legal origin of the products to complete the sale.	1. To check the legal origin of the wood and coal with a label with the permit number of the UMA. 2. Register with the finance secretary to strengthen the confidence and legality of the product.	1. Short term Permanent. 2. Medium term Permanent.	La Mojarra- responsable Alfredo	Constant sale by current customers. More sale
Fire and wood theft in the grounds by neighboring communities		1. Make firebreaks breaches around mangrove conservation and restoration zones. 2. Place signage with institutional logos to strengthen the protection of their properties. 3. Carry out awareness-raising talks and formalize agreements for fire control 4. Projects for community surveillance with the PROVICOM program of CONANP. 5. Channel cleaning with PET support from CONANP	1. Short term Permanent. 2. Short term Permanent. 3. Short term Permanent. 4. Short term Permanent.	Coordination of La Mojarra with the following communities; The Azizintla Talladero, Poza Honda, Las Flores among others.	Reduction of fires, especially in the months of May and June. Decrease in wood theft Controlled fires
Unawareness of the community about whom to go with in case of wanting to report to people or illegal practices.		Strengthening of community surveillance; 1. Organization within the community of La Mojarra and with other communities. 2. Project for community surveillance with the PROVICOM program of CONANP.	1. Short term Permanent. 2. Medium term temporary	Organizations of La Mojarra and other communities. Individual fishermen. Technicians to support subsidies, supports and projects.	

Table A2.3. Goal 1 Objective 3. Production and sale of honey

Obstacles	Opportunities	Actions	Time scale and duration	Responsibility	Evaluation of Effectiveness
Lack of consistent sales and clientele	They have the technical knowledge, equipment and facilities to keep 20 boxes of honey. They know the conditions and physical and biological characteristics appropriate for the selection of sites for beekeeping (good areas with plants such as black mangrove). They also know the flowering seasons of the plants of interest.	Continue attending forums and events on apiculture They will develop a market strategy to identify potential buyers, products and the development of a brand.	Short term Permanent	La Mojarra Pronatura Veracruz A.C.	Increase in the number of consistent customers and sale of honey
Lack of infrastructure and materials	Experience in the search and application for financing	They will continue to seek financing for infrastructure, purchase of equipment and increase the number of frames	Short term Permanent		Better production and sales of honey
Laboratory evaluation of honey quality	Impressions are that the honey is of very high quality	Have honey evaluated by a laboratory. Place results on an official label for the honey	Long term Temporary	Universities and research institutes such as the Universidad Veracruzana, Instituto de Ecología A.C.	Results of testing

Table A2.4. Objective 4 Goal 1. Production and sale of handicrafts from water lily and cattail, women's collective (modified and translated from the original=).

Obstacles	Opportunities	Actions	Time scale and duration	Responsibilities	Evaluation
Need to obtain the raw materials.	1. Cleaning plants from canals can provide material 2. Employment support program from Natural Areas Commission. 3 Invasion of aquatic lily that could be used for the elaboration of the products. 4. Goods could be transported by water	1. To obtain raw material, cleaning can be done in the lagoon. Employment subsidies from CONANP 2. Carry out awareness talks and agreements to clean channels annually.	1. Short term Temporary 2. Long term Permanent	Acula Municipal Government La Mojarra Community	Assistance for clearing of canals and channels.
Lack experience to make handicrafts with lily and cattail	Relationship of Arturo Valencia and Pronatura Veracruz A.C. with the M.C. Blanca Elizabeth Cortina Julio from the Universidad Veracruzana	Conduct trainings for those interested in learning how to make crafts with lily and cornea	Short term Temporary	Expert guidance from the Universidad Veracruzana	Production of crafts
Need for market strategy, potential customers and brand.ing	People within the community have knowledge and experience in business administration	Training for the elaboration of a market strategy l.	Short term Temporary	Pronatura Veracruz Business Expert, Community Representative	Find market Identification of clients
Lack of a paved road for transportation of goods and for customers.	Good relationship with the municipal government of Acula.	Construction of roads. Cleaning the dirt road prior to construction, (dry season). Employment assistance for road cleaning from Acula municipal government and Ministry of Communications and Transportation.	Short term Temporary	Acula Municipal Government La Mojarra Community Secretary of Communications and Transportation.	Assistance for road. Building of road

Table A2.5. Goal 1 Objective 5. Providing sustainable ecological tourism

Obstacles	Opportunities	Actions	Time Scale and Duration	Responsibility	Evaluation of Effectiveness
The cost per person during the tour was $ 2,000. 00 pesos MXN; spent, $ 1,000.00 pesos in gasoline during the entire trip from Tlacotalpan and $ 300.00 pesos in food. The final profit was $ 600.00 MXN pesos. According to Arturo Valencia, the profit obtained is not profitable enough.	1. They know the sites that could be attractive for tourism. 2. The work team of the Acula municipal government has people specialized in tourism. 3. They have conserved sites with diversity of birds and other types of fauna. 4. They have a bird guide of the Lagunar de Alvarado System, easy to use, they know the flora and fauna. Important and useful information to become community guides. 5. Use of social networks to promote and offer their tourism services. 6, They have enough equipment and facilities to organize a small group of tourists.	To increase profitability, the route could start at La Mojarra. For this, it requires the construction of a road that allows access to tourists.	De corto a largo. Permanente	Municipal Government of Acula - Arturo Valencia La Mojarra Community Secretary of Communications and Transportation	Increase in the profit due to the decrease in transportation costs
Construction of a wall at the edge of the lagoon to ensure the retention of the land and facilitate the descent and ascent to the boats. They also require investment in infrastructure and equipment.	They have experience in finding financing	Search for financing to invest in infrastructure (construction of a place to eat, cabins) and equipment (engines, boats). PET of CONANP supports sustainable tourism projects.	Mediano. Temporal	La Mojarra- Arturo Valencia Comunidad La Mojarra	Maintenance of the shore of the lagoon
Currently, tourists do not know La Mojarra or its mangroves	1. The work team of the Acula municipal government has a specialist in tourism and maintains good relations with the municipal government of Tlacotalpan. 1. They can take advantage of social networks to promote themselves.	Alliances could be generated with the municipal government of Tlacotalpan to make visits to the mangroves.	Mediano. Permanente	Municipal Government of Tlacotalpan and Acula. Specialist in tourism of the municipal government of Acula Arturo Valencia de la Mojarra.	Increase in tourism in the area

*Table A2.6- **Goal 3 Objective 1: Conservation of mangroves***

Obstacles	Opportunities	Actions	Time Scale and Duration	Responsibility	Evaluation of Effectiveness
Excessive growth of cattail (*Typha* spp.) in the lagoons. Negative effects on fishing in the area and mangrove regeneration.	Ongoing participation by the communities of Poza Honda and Abrevadero.	5. Removal of cattail 2. Reforestation with mangrove to reduce the growth of cattail. This is needed in the Popoyeca lagoon.	1. Short term. Permanent (Annual Sep. And Oct.) 2. Medium Term. Temporary	La Mojarra	Opening of the lagoon and the ease of developing fishing activities in the area .
The low participation of people from the communities during the cleaning of channels.	Good relationship with the Acula Municipal Government and other communities.	Program of temporary employment through government.		SEMARNAT and or Acula Municipal Government . La Mojarra	
		To strengthen the conservation of the mangrove, they mention the removal of silt in channels from La oreja to Tigre and from Mangluitos to Tigre; Reconnect the two lagoons by Vayivengue.	1. Medium term. Temporary	La Mojarra and neighboring communities	