Model of governance for an urban mangrove in a context of ungovernability and social exclusion

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Abstract

A governance model called Triad is proposed according with the results of an integrated assessment of the urban mangrove ecosystem located along the waterways in the city of Cartagena de Indias, Colombia. The assessment shows the fragile state of this socio-ecological system. This model is based on the concept of ecosystem-based governance and is designed for a city with governability and social exclusion crises. The designed model was implemented through the participation of professionals, community groups, and businessmen in the design of a pilot productive project (PP). The selected PP was based on the available natural and social capital and the influence it may have on the city's sustainable development. The PP was carried out by the implementation of seven strategies within three lines of action: education, entrepreneurship, and participatory planning. Several indicators are proposed to evaluate the impacts of the seven strategies. The obstacles and challenges for PP implementation are also commented and discussed.

1. Introduction

The mangrove ecosystem forms “ecotones,” or ecological transition zones, where the stages of life history of many marine, brackish, and fresh water species experience daily and seasonal variations in salinity and temperature as a result of tides and water runoff. A large number of these aquatic organisms constitute an important part of both the artisanal and industrial fishery sectors, and some of them are prey to a great number of endemic and migratory bird species. In addition to its role in the production of goods and services (Van Oudenhoven et al. 2015; Barbier 2016), the mangrove ecosystem also acts as a natural protective barrier and as an adaptation area against the variability of environmental factors associated with extreme weather events driven by changes in global climate (Kauffman et al. 2013; Yáñez-Arancibia et al. 2014).

The mangrove ecosystem has experienced rapid changes worldwide, driven primarily by anthropogenic threats (Friess et al. 2019) such as urban development (Richards and Friess 2016; Thomas et al. 2017). Some urban centers have developed uncontrollably in areas of Latin America previously covered by mangroves. The loss of mangroves in an area exercise strong pressure on the remnants of the natural ecosystem (Barragán and De Andrés 2016), producing negative effects on local environmental (e.g. water quality) and biological (e.g. biodiversity, biological productivity) factors. Surviving mangroves within an urban area must be managed using complex social and ecological models. These models are based on the concepts of natural resource governance (Bielschowsky and Torres 2018) or adaptive governance for urban green spaces (Green et al. 2016).

The protection and management of mangroves have been well documented in literature (Van Lavieren et al. 2012). The latest publications suggest that management efforts must not only include interdisciplinary knowledge provided by scientists and professionals from non-governmental (Börger et al. 2018) and governmental (Culwick et al. 2019) organizations, but must also consider traditional or ancestral empirical knowledge provided by native communities (Romañach et al. 2018; Cains and Henshel 2019). This combined knowledge is fundamental for the success of any management intervention (Unesco 2012) and is needed to resolve challenges around urban sustainability.

Any selected model must contribute to the sustainability of local communities by including the development of community-managed projects in forestry, aquaculture, recreation, or tourism. This type of model is called Community Based Mangrove Management (CBMM), and it is used widely in South Asia, but very little in South America and Africa (Datta et al. 2012). These authors believe that this model has not yet been included in the
planning of some cities with urban mangrove systems because this model appears antagonistic to market forces. On the other hand, Biermann et al. (2019) consider that the instability of many local governments is the reason for this model's reduced application. These authors suggest that the adaptive governance model must be adjusted to local conditions using innovative actions under the Earth System Governance project. This network organization works under a scientific scheme of academic creativity, moving from disciplinarity to transdisciplinarity, with the engagement of different stakeholders and with a concept of governance that is unmarked from ‘environmental politics.’

Furthermore, Barbier (2016) points out that none of the studies have considered the influence of social, cultural, and political aspects in managing this type of ecosystem. He then suggests filling this gap in the literature by conducting research not only on those aspects, but also on the economic aspects surrounding the management of those ecosystems. This article aims to fill this gap by designing a model for urban mangrove ecosystem management in the context of a city (Cartagena de Indias, Colombia) with weak governance, strong social exclusion, high environmental and biological deterioration, high cultural diversity, and prominent economic inequality. Likewise, this article contributes to previous literature by showing the way in which the results of the implementation of the model can be incorporated into existing government structures (Bodin 2017).

2. Integrated Assessment Of The Mangrove Ecosystem In Cartagena De Indias

The city of Cartagena is divided by two interconnected waterways, Caño de Juan Angola and the man-made channel parallel to the airport runway, into one undeveloped inland littoral zone and one dynamic commercial coastal zone. The shores along the two waterways are covered by a line of mangroves connecting Cartagena Bay and Ciénaga de la Virgen, which are the city's most important bodies of water (PNUMA 2009). A historical comparison of environmental (land use change, water quality) and biological (the number of fish species and individuals) records by season were analyzed. In addition, an analysis was done on biological data (the number of bird species and individuals, and the number of mangrove species). Finally, the socio-economic dimension was analyzed using data collected during interviews done by FUNCICAR et al. (2019) and information on the city's current state of affairs.

2.1 Land use data

The city's urban development has skyrocketed in the last nine decades thanks to what the local government was able to accomplish after Law 62 of 1937 was passed. This law empowered the local government to fill and urbanize the shores of the city's waterways and construct avenues between urbanizations located across those waterways. Although this law was supposedly passed to beautify the city and improve traffic, it gave the local government power to encourage low income communities to convert areas covered by mangroves into dry, empty land. This process took place within a framework where people were allowed to cut down mangroves from areas where water flow was easily restricted. These new areas were later filled with debris and sold to companies that took charge of their urban development. The destruction of vast areas of mangroves created a trade-off between the ecosystem's ecological value and the commercial value of the newly acquired dry land. The ecosystem's deterioration has ultimately had a negative effect on the city's resilience to future man-made and natural catastrophes (Figure 1).
According to available historical data, the land around the Caño de Juan Angola went from 30% urban, 30% mangrove, and 40% forests and wetlands in 1948 (Figure 2 and Figure 3 top) to 85% urban, 5% mangrove and 10% wetlands in 2019 (Figure 2 and Figure 3 bottom). On the other hand, the man-made channel parallel to the airport runway was built after 1949, when the connection between Caño de Juan Angola and Ciénaga de la Virgen was eliminated in order to build the airport’s runway. The land around the man-made waterway went from 15% mangrove and 85% forest and wetlands in 1949, to 40% mangrove in the 1980s, and 20% mangrove, 40% forest and wetlands, and 40% urban in the last few years. For the latter case, the growth of the urban area has been controlled due to risks associated with building near the area of operation and takeoff of aircrafts. Despite the loss of mangrove coverage and the increase in urban areas, four species of Colombian Caribbean mangroves and many tropical dry forest species were found along the three sampling transects in this study (Figure 4). The dry forest species are adapted to the saline and flooded shore soils.

2.2 Water quality data

The quality of marine water was determined in four sampling stations in 2019, using a marine water quality indicator called ICAM (Table 1), which was proposed by the Institute for Marine and Coastal Research of Colombia (INVEMAR 2014). This indicator takes into account values of Dissolved Oxygen, DO; Nitrates, NO-3; Total Suspended Solids, TSS; Thermotolerant Coliforms, TEC; acidity level, pH; Biochemical Oxygen Demand, BOD5; and Phosphates, PO4-3. According to the indicator value, the water quality is classified as optimal (100-90), adequate (89-70), acceptable (69-50), inadequate (49-25), and poor (24-0). Two of the stations showed results in the poor range in the dry season, and barely inadequate in the other two stations. In the semi-humid season, with the first rains, this indicator improved to acceptable, but it never reached the adequate or optimal level. Despite the intermediate water quality levels, the quality drastically improved in the semi-humid season from the values found in 2016. In general, the intermediate quality levels must be causing a deterioration of the ecosystem, negatively affecting the life of its species.

Table 1. ICAM indicator values by sampling station (E1, E2, E3, E4).

| Year   | Season        | E1  | E2  | E3  | E4  | Average |
|--------|---------------|-----|-----|-----|-----|---------|
| 2016   | Semi-humid    | 37.17 | 55.43 | -  | 13.19 | 35.26   |
| 2019   | Dry           | 17.98 | 13.57 | 41.28 | 37.24 | 27.52   |
| 2019   | Semi-humid    | 59.01 | 66.49 | 52.50 | 56.60 | 58.90   |

Source: the authors and FUPAC & IHSA (2016)

2.3 Fishing data

During the semi-humid season of 2019, 25 individuals from 3 fish species were caught, whereas during the same season in 2016, 126 individuals from 26 fish species were reported by FUPAC & IHSA (2016). Although this data was collected in sampling areas of different sizes, the number of individuals and species of fish decreased considerably from 2016 to 2019 (Table 2). Despite the fact that there is no data to compare for the dry season in 2016, it is important to mention that 41 individuals from 6 fish species were caught during this season in 2019.

Table 2. Number of individuals and species of fish caught during the FUPAC & IHSA (2016) study and this study.
### Table 3. Number of individuals and species of fish observed in the area of study in 2019.

| Year 2019       | No. of individuals | No. of species |
|-----------------|--------------------|----------------|
| Dry season      | 506                | 54             |
| Semi-humid season | 762              | 45             |

#### 2.4 Bird sighting data

During this study, 506 individuals of 54 species and 762 individuals of 45 species were observed during the dry and semi-humid seasons of 2019, respectively (Table 3). This variation in the number of bird species could be an indication of their annual migration that is known to occur in the area of study. Comparison of the historic number of birds was not done because no previous studies of birds were found in the area of study.

#### 2.5 Socioeconomic data

The Caño de Juan Angola acts as a natural boundary between two contrasting socioeconomic sectors in Cartagena de Indias (Figure 5). One of the sectors is associated with a community involved in booming industries, five-star tourism, and evident port activity, while the other sector is related to a community living in misery and poverty (low strata). The socioeconomic aspects of these heterogeneous communities in a dual city are dynamic and are linked to the environmental quality of the mangroves (Van Kempen 1994; Barrera and Guillén 2017). The city’s extreme duality is supported by numerous studies that compare data based on socioeconomic issues among cities within the country. The city’s social vulnerability value was found to be higher than those of the other thirteen most prominent cities in the country (Ayala and Meisel 2019; Valdemar 2017). This city had the highest Unsatisfied Basic Needs (UBN) index among the six largest cities in the country for the period 1993-2005 (Pérez and Salazar 2007), and currently, its monetary poverty rate (29.1) is higher than the national average (DANE 2018). Several authors explain the social reality of the city as a result of a “Dual Cartagena,” where part of the city is shown and another is hidden (Barrera and Guillén 2017). The phenomenon of uprooting or exile (Gutiérrez-Magallanes 2001; Abello and Flórez 2015), private interests, exclusion and marginality (Ayala and Meisel 2019) are evident in the city.

In order to socioeconomically characterize the area associated with the Caño Juan Angola in Cartagena de Indias, the results of the study by FUNCICAR et al. (2019) about the project “Cruising the city of Cartagena de Indias” were analyzed. This study carried out a semi-structured survey of 46 community leaders in an area of 8 districts, with an estimated population of 102,490 inhabitants. Within this group of interviewees, 59% and 41% were men and women, respectively. All age groups, including 15% of young people, and all social strata from high to low income communities were represented in this survey. The majority of interviewees do not identify with any ethnic group; only 22% identifies themselves as being of African descent, with leadership capacity in the districts, and well educated (97% with college studies). However, this segment of the population has a high unemployment rate, close to 20%, which represents almost twice the city’s unemployment (11.8%; DANE 2018). About 60 small
informal businesses were located within the urban mangrove ecosystem and were classified in the sector of subsistence economy. Some of these traditional businesses have been on existence for more than five years.

In this representative socio-ecological system, the community has a two-way economic relationship with the environment. On one hand, businessmen benefit by illegally occupying natural public areas in the city at no cost, where they are cooler than in their own homes. On the other hand, many of these businessmen throw their daily waste into the Caño de Juan Angola and expand their businesses by cutting down vegetation and building permanent infrastructure (Sánchez et al. 2012). Despite receiving services from the ecosystem, the businessmen appear to disregard those services and continue to cause irreparable harm to the ecosystem. During the interviews, however, some interviewees showed interest in the ecological restoration of the natural system and revealed their desire for the waterways to return to how they were during their childhood. They recall their childhood when they used to fish, sail, and swim in the waterways. The community leaders claimed to have an interest in the development of a sustainable project that takes advantage of the natural system.

2.6 Current state of affairs in the city

Political corruption in the city has created political instability during the last twenty years, with 11 failed mayors including incumbents and officials in just nine years (Tuirán 2019). This state of affairs supports what Camou (2001, 2010) calls a governance crisis. This crisis is characterized by the conjunction of unexpected or intolerable imbalances between social demands and governmental responses in various aspects of daily life.

3. The Bases For Selecting The Triad Model Of Governance

Two main government models for democracies were developed in the mid-20th century. The first of these two models, called subgovernments, gave more influence to the elite than to ordinary citizens in the decision process. The second model, called the iron triangle, was applied during the cold war in the United States, focusing on two main permanent stakeholders: the North American defense industry and the agroindustry (Estévez 2014). This type of state-carried hierarchical command and control-based approaches (Sattler et al. 2018), however, were not related to social needs, rather they were connected in some way with society's different interest groups.

Unlike the previous models, the model of governance that we propose, called Triad, is a community-based approach (Sattler et al. 2018). In general, it is based on the combined influence that state, markets, and society have on social equity, sustainable development, and cooperative governance (Chiesa et al. 2013; Bárbara 2014). This model of governance requires cooperation and interaction among actors in a complex web of public and private interest (Prats 2001) to pacifically resolve their conflicts in a variety of negotiation scenarios (Feldman 2001). This kind of model requires thinking about how the relation between the community and its environment is based on the concepts of environmental conflict sociology (Fontaine 2005), environmental governance (Barriga et al. 2007), territorial governance (Figueredo 2016), and the governance model of the commons (Ostrom 2009).

This new vision must bring opportunities to the whole community by considering people's capacities as well as their fundamental rights and freedoms (Prats 2001; Sen 2009). This approach will create a smart state that confronts poverty successfully and achieves social wellbeing and justice (Kliksberg 1998) for members of the local community. Under these considerations, and for the particular case study of highly impacted mangrove ecosystems in an urban setting, with high social exclusion and a lack of governability, we propose a mangrove management model that includes natural and social capital as the basis for the city’s sustainable development.
3.1. Triad model architecture

The proposed model is based in the idea that non-state actors (private and civil society) must participate in the deliberation process. The architecture of governance for this study's model is proposed with actors building practical solutions from three key concepts: 1) sustainable development based on the services offered by the ecosystem, which is supported by the concept of ecosystem adaptation (Lhumeau and Cordero 2012; Álvarez et al. 2018); 2) natural heritage as a common (Ostrom 2000) and cultural (Mertins 2005; Massiris 2008) resource; and 3) social or human capital (Adler and Know 2002; Meisel 2009), which is an intangible resource available for collaboration among the different community actors. These fundamental concepts are used to determine the mechanisms to integrate the diverse actors in the application of governance (Feldman 2001) and seek the redistribution of wealth for the wellbeing of the poorest communities of a prosperous, but uneven city.

The conception of this study's model architecture started with the formulation and execution of the artisan fishing project called “Fishermen School” in the Canal del Dique region near the city of Cartagena de Indias (Sánchez 2005). The Blue Planet Foundation managed this project in 2006, and its main objective was to preserve fishermen's ancestral activities by proposing new alternatives to improve their quality of life. In this context, the foundation was later invited in 2015 to be a part of a project recognizing the sustainable use of the natural heritage from the city's coast are by Cartagena University and Manchester Metropolitan University. This new project's main objective was to achieve social justice for marine and freshwater fishermen communities, based on the sustainable use of ecosystems and their services, from a sustainable development perspective (UN 2012).

This project required an architecture model that allows a process of negotiation on the different actors' common interest. These actors combined their efforts in the formulation of productive projects which allow the self-sustainability of the processes, bearing in mind the mangrove ecosystem's ecological resilience (Lozano et al. 2019). The construction of the model was based on what Barriga et al. (2007) demonstrated about the importance of the existence of sufficient social capital in five key components to facilitate the promotion of this kind of governance. The five components are: 1) effective governance, 2) participatory planning, 3) sustainable financing mechanisms, 4) adaptive management and learning, and 5) public and private partnerships. During the implementation of the model for this specific project, public institutions were not included because of the city’s current situation of ungovernability and corruption.

The purpose of the selected model was to generate synergy among three groups of actors (professionals, community leaders, and philanthropists or investors) by searching for mutual interest of work, wisdom, and wealth (3W, Fig. 6). Work is defined as the time spent on an activity. Wisdom is described as the acquisition of scientific and empirical knowledge. And wealth is interpreted as not only economic wealth, but also as human and social capital to initiate new productive and management processes (Cronin and Dearing 2017). An important part of the project includes a negotiation among the three groups of actors in which they pacifically recognize their common interests in a productive project (PP) supported by the 3W. These new business opportunities must be tied to the community’s traditional business as well as to those of the region's businessmen.

Professionals from multidisciplinary backgrounds are in charge of leading the process by creating bonds of trust among community leaders and helping them in the selection of economically viable products offered by the
ecosystem. During the joint selection of viable products, the professionals are able to assess the local community's ability to develop a sustainable and inclusive PP. After determining the community's competence in the selected PP, the professionals offer this PP to the philanthropists or investors in order to create partnerships between local communities and regional businesses in response to their own levels of exigency, but under their own community's capacities. This type of cooperated endeavors intends to generate economic opportunities regionally which, in turn, help in the redistribution of wealth, the elimination of social marginalization, and the increase in trust among the main community actors which ultimately foster a culture of peace.

In the context of a fragile governance and with enough signs of corruption, the PP was kept away from the local government to avoid any risk of getting involved in acts of corruption. Any involvement in acts of corruption could produce long-lasting damage to confidence in the PP. Only when the PP's maturation process is well advanced will it be prudent and recommendable to establish a connection with the local government. The PP must be directed to coincide with the local government's plans and programs which, in turn, allow the PP to achieve social incidence and empower participatory democracy. Only in this phase do the public-private participatory partnerships become a fundamental component for the social capital in the promotion of the governance (Barriga et al. 2007). In general, the model used in the development of this PP offers the actors multidimensional wellbeing that includes the happiness and the pleasure of achieving their interests and goals, beyond merely economic satisfaction. A person's reward is evaluated not from the point of view of income, but from her capacity of having a real opportunity to live (Sen 2009).

3.2. Model application for the development of a pilot PP

During the application of the model, we suggested three lines of action and seven strategies to follow as the professional group began to interact with the other two actors. Initially, the group of professionals were in charge of the education of local community members. This line of action must be executed in all social intervention processes and must be followed by another two lines of action related to entrepreneurship and participatory planning (Fig. 7).

**Line of action I: Education**

This line of action responds to the following questions: What do young people know about their neighborhood? What can they do as students to teach the whole community about the value of ecosystems and the reasons to take care of them? To respond to these questions, a robust pedagogy section was included in the model following the environmental pedagogy proposed by Álvarez (2015). This model works under the concepts of complex thinking and transdisciplinarity (Morín 1996; Moreno et al. 2002; Barberousse 2008; Serna 2016) as the fundamental elements of educational and pedagogical processes. These elements not only express the quality, amount, and type of knowledge to transmit, but also determine the type of current society and the role of the people that intervene in the act of education. This pedagogical focus must be harmonized between the people and their surroundings from relational, conceptual, attitudinal, and procedural development aspects according to the degree of maturation of boys, girls, and youth. Also, it must go beyond the traditional formal education that raises awareness and sensitizes, towards an education for action, with approaches such as participatory action research (Fals-Borda 1999) and citizen sciences (ECSA 2015).

Under this focus, the Multiplier Environmental Group (MEG) was created in the year 2015. This group was made up of students from public and private high schools, through a program called pedagogical pact. The permanent
focus of this group was to confront major problems such as the abandonment of mangrove areas where garbage and waste are deposited, and the lack of knowledge and culture in relation to the goods and services provided by nature (Friess et al. 2019). This environmental high school project (PRAES) breaks formal education paradigms. It changes the scheme of classes in rooms for meetings outside in open fields, homework for multiplier exercises, and student isolation to comply with academic obligations for the student interaction with community members to confront their social reality. What the students learned was transmitted to their social network (e.g. family, classmates, neighbors) using playful and cultural teaching techniques. These innovative techniques played an important role in the students’ multiplier work in the first three years of the project. In the fourth year, the process became more established when the young ones showed greater appropriation of their role as generators of change. Table 4 shows the indicators that could be used to evaluate the effect of the activities related to environmental and biological strategies.

Table 4
Indicators to monitor the model Line of action I: Education

| Lines of action | Strategies                          | Activities                       | Indicators of the impact       | Units    |
|----------------|------------------------------------|----------------------------------|--------------------------------|----------|
| I - Education  | Waste management monitoring        | Organic materials (OM)           | Composting micro-plants        | N*       |
|                |                                    |                                  | Total weight                   | Kg       |
|                |                                    |                                  | Weight of OM used for fertilizer| Kg       |
|                | Recycled materials                 | Door to door                     | N*                             | Kg       |
|                |                                    | Selective routes                 | N*                             | Kg       |
|                |                                    | Weight of materials              |                                 |          |
|                | Oil and grease                     | Amount of oil                    |                                 | L        |
|                | Debris                             | Debris fields                    | N*                             | Kg       |
|                |                                    | Weight of debris                 |                                 |          |
|                | Biological and environmental       | Flora diagnosis                  | Index of coverage              | M²       |
|                | monitoring                         |                                  | Biodiversity index             | Dimensionless |
|                |                                    | Fauna diagnosis                  | Biodiversity index             | Dimensionless |
|                |                                    | Water quality                    | ICAM Index                     | Dimensionless |

Line of action II: entrepreneurship

This line responds to the following questions: What do the people in Cartagena know, think, and do with respect to urban mangroves as a natural system? What do the people in the eight neighborhoods think about their economic activities and, in general, their relationship with the mangroves?

The best commercial and environmental practices were proposed for the development of a sustainable pilot PP based on both traditional community activities and an innovative business based on the services provided by the mangrove ecosystem. To begin, and as a product of the negotiation between the three type actors, the project
Sailing Through Cartagena (Navegando por Cartagena) was born. This PP takes advantage of possibility of navigation provided by the channels of the mangrove ecosystem as a basis for the so-called innovative, conscious tourism (Castillo-Montesdeoca et al. 2017). The development of these activities may be evaluated using the indicators in Table 5.

### Table 5

| Lines of action | Strategies                          | Activities                                         | Indicators of the impact | Units |
|-----------------|-------------------------------------|----------------------------------------------------|--------------------------|-------|
| II Entrepreneurship | Support for Entrepreneurship        | Analysis of the monitoring lists                   | Records fill out and achievements of improvement | %     |
|                 | Entrepreneurship of traditional business | Tracing of the list to qualify for quality seals | Business with different quality seals | N° per seal |
|                 | Entrepreneurship of new business     |                                                    | New business with different quality seals | N° per seal |

**Line of action III: Participatory planning**

This line responds to the questions: Under what conditions and when should we hold workshops to define common interests? How do we articulate the results of lines I and II with the local government’s plans and programs to avoid the risk of losing credibility of the community and potential acts of corruption?

Proceeding with workshops of understanding among stakeholders until the pilot PP was agreed was proposed. Then, the process of having meetings with institutions would begin. This process could be evaluated using the indicators in Table 6.

### Table 6

| Lines of action | Strategies                          | Activities                                         | Indicators of the impact | Units |
|-----------------|-------------------------------------|----------------------------------------------------|--------------------------|-------|
| III Participatory planning | Application of the Triad Model | Achievement of common interests | Productive projects | N° |
|                 |                                     |                                                    | Joint work agreements   | N°    |
|                 |                                     |                                                    | Allies                   | N°    |
| Joint work with government institutions | Work agreements with government offices | Joint work agreements with the local government | N° |

**3.3. Triad model engineering**

Figure 8 shows the chronological systematization of the seven strategies used to develop the three lines of action of the pilot PP until its maturation, during the 4 years of work in the city of Cartagena de Indias.

**3.4. Triad model implementation**

The Triad model was designed according to the integrated assessment of the urban mangrove ecosystem located along the waterways of Cartagena de Indias. Despite the low water quality, loss of mangrove habitat, and
a reduced number of fish, the natural system appeared to support a considerable number of individuals of a
variety of bird species. Regardless of this city’s current socioeconomic, biological, environmental, and political
crieses, the triad model’s three lines of action and seven strategies were carried out to assess the services offered
by the ecosystem’s current state and the community’s social capital. Traditional activities executed individually by
community groups were analyzed and contrasted until the areas of common interest among all community
sectors were identified. During the course of this process, public and private sectors of the community gained
awareness of their role toward a bottom-up redistribution of wealth within the city. At the end of the process, a
suitable pilot PP called *Sailing Through Cartagena* was designed to take advantage of the services provided to
the community by the mangrove ecosystem (Barbier et al. 2010). Furthermore, this project contributes to the
conservation of the mangrove forest and therefore recognizes its role in the process of carbon sequestration
(Howard et al. 2017).

This PP has the potential to improve the quality of the ecosystem which, in turn, increases the city’s resilience to
the effects of extreme weather events associated with climate change. This PP could be included in plan 4C,
which Cartagena adopted to adapt to climate change. The improvement of the city’s resilience will not only be
beneficial for the landowners and their property values, but could also boost the recreation and tourism industry.
After Cartagena de Indias was declared a world heritage site by the UNESCO in 1984 for its architectural beauty
and historical importance, the city’s economy became mainly associated with the tourism sector. This economic
sector rapidly acquired a great number of properties located along the waterways and water bodies within the
city. The most plausible opportunity was to develop a plan in which artisan fishermen could take tourists on their
boats to navigate along the restored waterways of Cartagena de Indias. The fishermen could not only benefit by
driving their boat, but could promote the city to their audience. During the time the boat is transporting tourists,
the fishermen may transfer their local knowledge to the tourists about the city’s history, traditional activities (e.g.
fishing), biodiversity, and culture (e.g. music, food). As the PP develops, the city’s businesses will benefit by
having additional tour guides around the city. This pilot PP fit into the concept of Conscious Tourism (Castillo-
Montesdeoca et al. 2017) and adheres to other proposals such as Nature-based Solutions (IUCN 2019). Thus, the
Triad model with its PP manages to envision a second generation of market policies with a social approach.
Instead of conditional cash transfer programs, the private sector, civil society organizations, and local
communities could agree on new forms of collaboration, production with social innovation (Bárcena 2014).

Among the main obstacles for the development of these kind of projects are the absence of environmental
sensitivity from an important part of community, the scarcity of private investment in waterways, the local
government’s inability to effectively manage projects based on sustainable development of ecosystems, the
government’s lack of interest in maintaining law and order for the protection of the city’s wetlands, and
insufficient self-control of the political class.

Two challenges remain. Firstly, the actual implementation of the pilot PP must be technically and economically
feasible. Secondly, the implementation of the project must be accompanied by a monitoring plan based on data
collection from the fulfillment of the seven strategies (Tables 4, 5, and 6), to track the changes in the socio-
ecological system, and thus demonstrate the model’s operability to improve social and environmental conditions.

**Declarations**
Ethics approval and consent to participate: This paper does not contain any study with human participants or animals performed by any of the authors.

Consent for publication: The authors declare their willingness to transfer the publication rights of this original paper.

Availability of data and materials: The authors declare that the main primary data supporting the findings of this study are available within the article. The sources of secondary data are described within the article.

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Figures

Figure 1

Environmental aspects in the waterways of Cartagena de Indias
Figure 2

Historical changes in the proportion of land use in the areas along the Caño de Juan Angola (JA) and the man-made parallel channel (CP) between 1948 and 2019. Source: The authors with satellite images from the Instituto Geografico Agustin Codazzi (IGAC).
Figure 3

Historical changes in land use around the Caño Juan Angola in satellite images between 1948 (top) and 2019 (bottom). Source: Instituto Geográfico Agustin Codazzi (IGAC).

Figure 4

Proportional presence of red (Rizophora mangle), white (Laguncularia Racemosa), black (Avicenia germinates), and Zaragoza (Conocarpus erectus) mangroves, and numerous tropical dry forest species 2019. Source: the authors.

Figure 5

Social stratification around the Caño de Juan Angola in Cartagena de Indias. Source: MIDAS, https://midas.cartagena.gov.co
Figure 6

Triad model conception. Source: the author based on Feldman (2001) and Loyo (2002).

Figure 7

Explanatory diagram of the Triad model: three lines of action and seven strategies for the application of the model to find the PP.
Figure 8

Triad model engineering. Educative process (yellow); entrepreneurship process (blue); participative planning (red).
Source: The author, based on Loyo (2002).