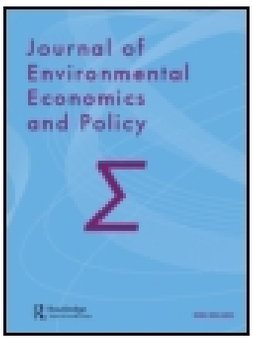

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Approach to an integral valuation of mangrove's ecosystem services in a marine protected area. Colombian Pacific region

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ABSTRACT

Colombian Pacific region is a global biodiversity hotspot. Mangroves are among the most dynamic and productive ecosystem on earth and serve many important functions providing a range of fundamental goods and services which contribute to the livelihoods, well – being, and local community's security. Integral mangroves valuation seeks to understand the socio-ecological interaction and the relationship between functional ecosystems (ecosystem services – ES), market interaction and the ability to support human well – being. Despite the importance, mangroves are continuing to be threatened and degraded because of socio-environmental conflicts such as land use change and port infrastructure which will impact on ecosystem services quality and offer. This article identifies an approach to the potential ecological, sociocultural and economic impact of a Deepwater port on the Tribugá Gulf mangroves ecosystem services offer and its effects on the well – being of Nuquí communities.

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Colombian Pacific region; mangroves; integral valuation; socio-environmental conflicts; port infrastructure; Nuquí communities

1. Introduction

Mangroves ecosystems are characterized by their high complexity and diversity. They are found in tropical and subtropical regions in approximately 123 countries of the world (Spalding, Kainuma, and Collins 2010; Mukherjee et al. 2014; Thomas et al. 2017; Alongi 2008). These ecosystems at the interface between terrestrial and marine systems, provide a wide variety of ecosystem services for local communities, such as raw materials, food, disaster control, soil erosion prevention, water quality, fishing, carbon sequestration, recreation, and spirituality, all are estimated at least 1.6 billion dollars per year (Queiroz et al. 2017) and the value per hectare is 194,000 dollars/ha/yr. (Costanza et al. 1997, 2014).

While the mangroves on tropical and subtropical countries are important in terms of conservation, currently are the most vulnerable ecosystems. Because of land use change and resource exploitation (e.g. fishing and timber) these ecosystems are increasingly reduced and fragmented. It is estimated that in the last 20 years roughly 0.16% and 0.39% have been degraded, which affects their ability to provide ecosystem services (Queiroz et al. 2017). The human activities generated greater pressure on these ecosystems are overexploitation of wood for fuel and construction (26%) and the industrial transformation of the landscape for aquaculture and agricultural

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production (Ellison 2000; Valiela, Bowen, and York 2001; Wilkie and Fortuna 2003; Duke et al. 2007; Walters et al. 2008; FAO 2010; Queiroz et al. 2017; Thomas et al. 2017).

The ecosystem services valuation seeks to capture the benefits offer to human well-being (Emerton 1996). These methodologies aim to provide decision makers with information about the social benefits and associated costs of using alternative management practices to contribute the measurement of social well-being (Bateman et al. 2013; Laurans et al. 2013; Mukherjee et al. 2014). Different methods of economic valuation have been designed to calculate the mangrove value ecosystems and services, which are implicit to the decision making of land and natural resource management (Costanza et al. 2014; Mukherjee et al. 2014; Vo, Kuenzerb, and Oppeltc 2015; Costanza and Folke 1997). Nevertheless, it is likely that the different valuation approaches yield large differences in the economic values assigned (Vo, Kuenzerb, and Oppeltc 2015). This may be due to the specific conditions of economic activities and geographic, temporal, social, and cultural context (Brander et al. 2012; De Groot et al. 2012; Salem and Mercer 2012; Vo et al. 2012, 2015). Moreover, since valuation exercises are context-dependent, the information on prices used in different scenarios and contexts for this analysis type can easily be distorted by distribution and welfare biases of local communities (Emerton 1996, 1999).

Knowing the economic value of ecosystems and their services then becomes an important tool for decision-making in the management of ecological importance areas relating to human well-being, sustainability, and benefit distribution (Costanza et al. 1997; Lal 2003; De Groot et al. 2012; Salem and Mercer 2012; Vo et al. 2012). In general, these studies rigorously assign monetary values to environmental goods and services through methods based on declared or revealed preferences and in which, they estimate the willingness to pay for the marginal increase of mangrove ecosystems (Emerton 1999; Moreno-Sánchez, Maldonado, and Gutiérrez 2013). However, in most cases, the identification of the local communities needs and perceptions is forgotten, as is the stakeholder's importance these bestow on ecosystem goods and services, which vary among individuals, social groups, and spatial–temporal scales depending on their income level and preferences (Sheil et al. 2005; Cristeche and Penna 2008; Moreno-Sánchez and Maldonado 2011; Contreras 2014).

To make an approximation to the integral valuation of protected area DRMI Tribugá Gulf and Cabo Corrientes, this paper identifies the potential ecological, sociocultural and economic impact of a Deepwater port on the mangroves ecosystem services provision and its effects on the Nuquí community's well-being (Afro descents community). Also, we demonstrate the importance of ecosystem services assessment as a tool to support the decisions making on the territory management and in protected marine areas consolidation.

2. Study area

2.1. Biophysics characterization

The Colombian Pacific region is recognized worldwide for its megadiversity of high ecological value in continental and marine fauna and flora, particularly the wide expanse of mangrove ecosystems (Velandia and Diaz 2016). The Chocó department is one of the most humid (89% relative humidity) and rainiest places of the world, with annual precipitation between 5,000 and 7,000 mm and temperatures that vary from 18°C to 30°C (IDEAM 2005). At the continental level, the tropical humid forest ecosystem predominates, while the mangrove ecosystem is prevalent at the coastal marine level, where vegetative and animal species of high ecological value like humpback whales, sea turtles, birds and endemic and migratory insects, which makes this region one of the most diverse of the country (Velandia and Diaz 2016; Gómez Cubillos et al. 2015).

Colombian Mangrove ecosystem is distributed across the Caribbean and Pacific regions, where an extension of 282,296 hectares has been estimated of which 210,779 have been distributed across the Pacific and 71,523 across the Caribbean region. On the last 60 years, it has been reported a 239,476-hectare loss (INVERMAR 2015, 2016; United Nations 2013). The mangrove

ecosystems are extremely important natural systems, have the capacity to provide a variety of ecosystem services through the characteristics, functions or processes that contribute a direct or indirect way to the human wellbeing (Costanza et al. 1997, 2014, 2017; MEA 2005; Gómez-Baggethun et al. 2010).

Mangroves perform an important ecological role since this ecosystem is highly productive, it has the capacity of being a carbon drain, bio-filters, substrate stabilizers and acts as an erosion protector for the coast. Besides, it works as shelter, nesting and feeding place for different animal species and provides benefits with timber and non-timber resources that are related with the local communities' wellbeing (INVERMAR 2015, 2016). These aquatic forests can support more than 70 human activities. The main ecosystem services are raw material use, feeding, coastal protection, erosion control, water purification, sustainable fishing, recreation, education, research and carbon sequestration (Saenger, Hegerl, and Davie 1983; Costanza et al. 1997; Rönnbäck 1999; Valiela, Bowen, and York 2001; Lal 2003; Barbier et al. 2011; Vo et al. 2012; Queiroz et al. 2017).

In Colombia, mangroves represent an important source of natural, where people obtain regulation, provision, cultural and support services. Economically, the ecosystem has been the subsistence foundation of many communities across the whole Colombian coast. One of the most relevant benefits is the hand-made fishing development, where the mangrove works as a nursery site for marine young species. In the Caribbean littoral, as much as in the Pacific, throughout the years there have been developing resource exploitation activities where thousands of families dedicated to the art of fishing recollect mollusks, crustaceans, wood and medicinal plants favouring those communities' wellbeing (MADS 2002).

Colombia uses different management tools that contribute to the conservation of these strategic ecosystems, such as Marine Protected Areas, established to protect marine areas of ecological importance that are threatened by human activities. The Regional Integrated Management District (DRMI) tool is among the main strategies implemented in the Colombian North Pacific for the conservation and sustainable use of biological diversity. Thus, contributing to the social, economic, and cultural development of the local communities.

2.2. Socioeconomic characterization

The Nuquí municipality comprises 956 km^2 and is distributed in eight villages (namely Jurubirá, Tribugá, Joví, Coquí, Panguí, Termales, Partadó, Arusí, and the urban center of Nuquí), where approximately 8,576 people, mostly afro-descendants live in territories recognized as collective land. Furthermore, indigenous communities of Emberá ethnicity (Katío and Waunana) are grouped in ancestral land, while mestizos that come from the country's interior are gathered in population centres (Alcaldía de Nuquí 2016; Velandia and Díaz 2016). Five main economic axes characterize the relationship between local communities and environment: (i) artisanal fishing, (ii) subsistence farming, (iii) mangrove-related tasks, (iv) market dynamics, and (v) ecotourism (Velandia and Díaz 2016). Throughout its history, this population has based land and natural resource management on extractive processes and improvised land planning, which generates strong pressure on the ecosystems that sustain local communities and puts the wellbeing and sustainability of future generations at risk (Pupo-García and Parada-Corrales 2015; Velandia and Diaz 2016).

2.3. Actors & governance system

Based on an associative and institutional community process, Regional Integrated Management District (DRMI) was declared as a strategy for the biological conservation and biodiversity sustainable use in Nuquí. The aim being social, economic, and cultural development in the 60,183 ha of a marine coastal protected area (Figure 1), where it is possible to foster sustainable productive and extractive activities that are controlled and regulated if the composition and functioning of strategic ecosystems are maintained (Unidad Ambiental Costera del Pacífico Norte Colombiano 2016). Additionally, this

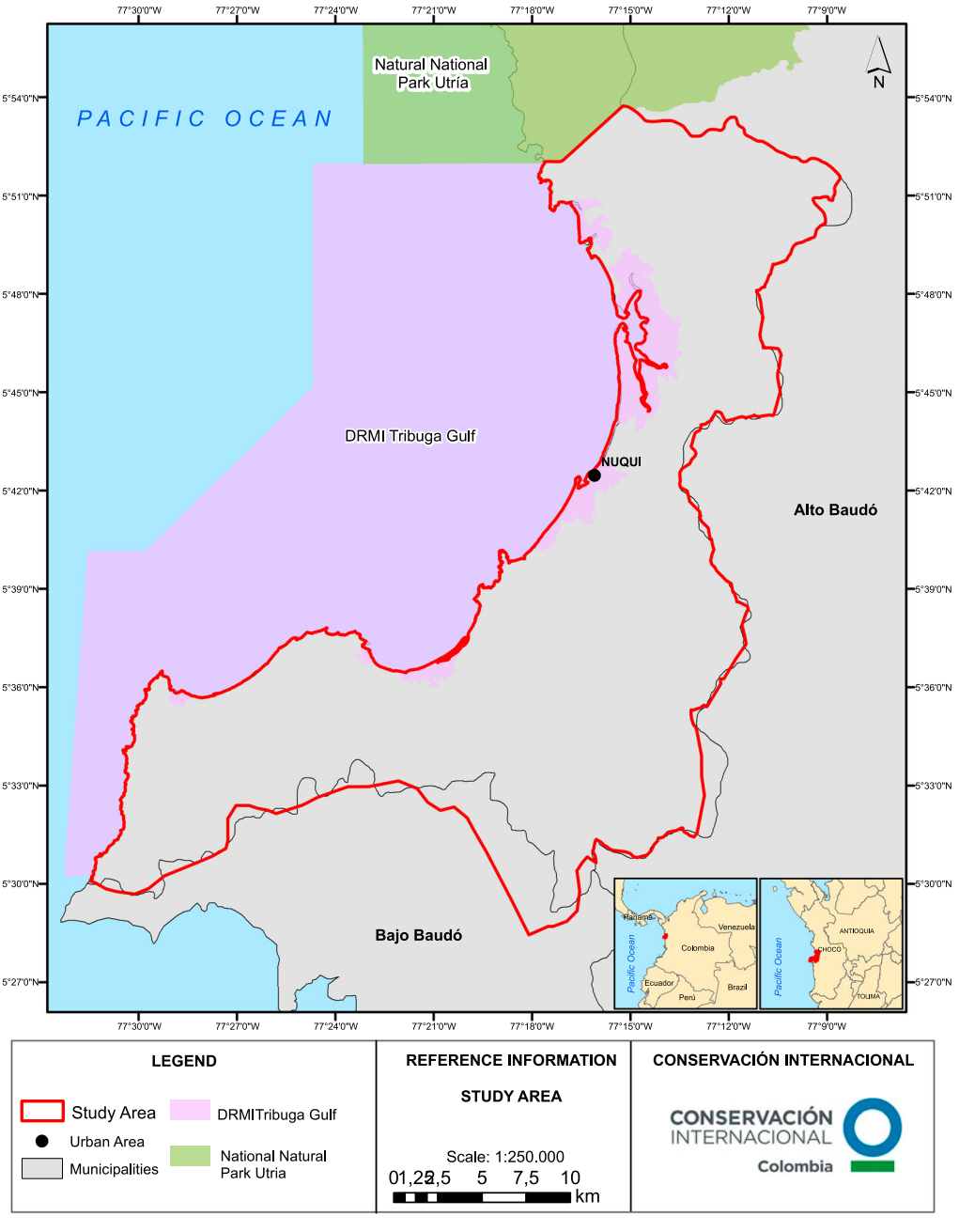

Figure 1. Study area.

type of strategy seeks to implement and boost research, environmental education, ecotourism, and recreational activities. The governance processes are developed under the guidance of the General Community Council Los Riscales, located in the Nuquí municipality (Unidad Ambiental Costera del Pacífico Norte Colombiano 2016). It is important to stress that mangrove ecosystems within the DRMI have a management plan that promotes integrated planning and use, combining traditional and scientific knowledge (Unidad Ambiental Costera del Pacífico Norte Colombiano 2016).

The Arquímedes Association (a public-private organization selected for port build) developed a proposal to build a multipurpose terminal that offers tourism services, regional cabotage, and fishery,

along with a second port that would function as a multipurpose foreign trade terminal for the handling of export and import cargo, containers, and liquid–solid bulk carriers (Cámara de Comercio de Manizales 2011; Proyecto Arquímedes 2015, 2017). This infrastructure will be located on the Tribugá Gulf southern bay, in the biggest mangrove area on the DRMI. Moreover, an electric freight train is proposed to complement the port, to connect the Nuquí municipality with Quibdó, the Chocó department's capital (Proyecto Arquímedes 2017).

2.4. Socioenvironmental conflict

The Colombian Pacific is one of the most conflictive and poor areas in the country. The Colombian government has identified on several occasions the need to propose a socioeconomic development strategy that drives Chocó communities to escape the social exclusion they face. The goal of opening the country's foreign market by working in the Pacific basin is the basis for the idea to construct a deep-water port in the Tribugá Gulf, which would function as a support to Buenaventura port, currently the greatest maritime port of Colombia (López 2009; Proyecto Arquímedes 2015). At a local scale, this infrastructure project seeks to improve the living conditions of the Chocó department population, a region with high rates of marginalization, high levels of poverty, inequality, violence, discrimination, exclusion, and social fragmentation (López 2009).

3. Methods

The mangrove and its related ecosystem services' integral assessment, was addressed by three value dimensions' approaches: ecological, sociocultural and monetary. The ecological value is linked to the ecosystem services supply capacity. The sociocultural and monetary value rely on human preferences, where its involved the ecosystem service demand (Rincón-Ruíz et al. 2014). This approximation looks at the inclusion of ecological, sociocultural and economic values of a protected marine area in the Colombian Pacific.

3.1. Ecological assessment

The ecological assessment refers to ecosystem processes and interactions related to ecosystem services provision (quantification and ponderation). Parting from this approach, the ecological assessment was addressed, analyzing changes in mangrove ecosystem habitat quality.

3.1.1. Land cover change and scenario generator

A scenario is storylines that depict future events and states. These scenarios can be expressed in a spatially explicit form related whit land cover. The land cover change scenario is important for detecting possible consequences of change driven by the port building and the effect in ecosystem services supply (InVEST 2016).

The InVEST Scenario Generator Tool was used, founded on the land aptitude and the changes generated in relatively suitable areas. The tool combines the transition probability input, physical and environmental factors that influence the change, and the number of anticipated changes under conditions of a given scenario. Based on an adequacy analysis, land cover is determined in a future scenario. A random buffer has been chosen for modelling the future scenario, considering the Biodiversity Loss Trade-off Manual.

The land cover change was calculated with a scenario generation tool for InVEST software based on land sustainability, where the principle that change of land occurs on areas that are relatively more suitable, combining stakeholder's perceptions and the transition likelihood with physical factors to generate future land cover. A comparative analysis of geographic information was carried out between the actual (Marine protected area) and future (Deepwater port) scenarios, based on the mangrove hectares' change.

3.1.2. Habitat quality assessment

The ecosystem services supply is linked with biodiversity, and the biodiversity patterns can be estimated by analyzing maps of land use cover in conjunction with expected threats. Habitat quality is not considered an ecosystem services per se, but rather represents the potential ecosystem services provision in each area, integrating into the analysis the biological condition of a system undergoing current threats (Hall, Krausman, and Morrison 1997; Lal 2004; Giri, Defourny, and Shrestha 2003).

This approach estimates the habitat extent and mangroves vegetation across the study area and their degradation state. Therefore, two patches with the same characteristics will have different habitat quality values if one of them is more exposed to current threats such as the port infrastructure. The InVEST habitat quality model combines information on land use/land cover and biodiversity threats, to produce habitat quality maps.

This assessment generates the relative extent and degradation of different habitat types in the study area across the time. Also, allows a rapid biodiversity change status assessment. This model considers the ecosystem resilience. A high-quality habitat will better support all biodiversity levels (genetic, species, and ecosystem). A low-quality habitat represents a biodiversity resilience decline.

The model allows estimating the relative impact of a threat to biodiversity resilience and compares the damage level between threats. This assessment of potential land use/land cover can measure future changes in habitat extent, quality, landscape rarity and conservation needs (InVEST 2018). The values of habitat quality range were measured by the distance between patches and threats. The measurement unit used is based on the mangrove hectares' loss.

3.2. Sociocultural assessment

Sociocultural Valuation emerges from ecosystem services demand, allows to identify which are the ecosystem services beneficiaries and generates knowledge about the needs, norms and behaviours of individuals and institutions in the study area. The technique aim includes the importance that people give to ecosystem services, reflecting the perceived realities, worldviews and belief systems of individuals and social groups (Rincón-Ruíz et al. 2014).

The participatory deliberative research method seeks to identify the local communities' perception about the ecosystem services value, and the impacts in human wellbeing. The factors considered on the decision-making process for preference and perceptions were: their subsistence economy, social processes and the integration of traditional ecological knowledge (Emerton 1996; Lina et al. 2007; Gómez-Baggethun et al. 2010; Reyes-García 2009; Moreno-Sánchez and Maldonado 2011; Martín-López 2013; Ruiz Agudelo et al. 2013).

This approach was developed through the implementation of a workshop with eight villages of the Nuquí municipality, where 101 people participate, organized in 17 groups. The participants include indigenous and afro-descendant representative and leaders of Jurubirá, Tribugá, Nuquí, Joví, Coquí, Panguí, Termales, Partadó, and Arusí villages. The technique used entailed participant observation where the communities identify the areas for ecosystem services supply.

3.2.1. Participatory deliberative assessment

The methodological framework follows the recommendations of Ruiz Agudelo et al. (2013), to identifies and characterizes territory dynamics and social-environmental conflicts. Socio-cultural, ecological and economic information was selected of a literature review. The fieldwork data sampling was conducted in two stages: 1 – Visits and meetings with local authorities and institutions to identify regional information. 2- Three (3) workshops whit the 17 groups, to identify (over the map) areas for ecosystem services supply. Finally, the participants classify the ecosystem services in terms of importance and use frequency.

3.3. Economic valuation

Two valuation methodologies were implemented to obtain an approximation to welfare and the market value, through the calculation of willingness to pay for maintaining the environmental and socioeconomic benefits of the protected area, and indirect market values, directed to estimate the mangroves total economic value. This approach is expressed in monetary units and depends on stakeholder's perceptions of ecosystem services mangroves values.

3.3.1. Literature review

A literature review was developed about the state and values of Colombia's mangrove ecosystem, through the keywords: mangroves, economic valuation, Colombia, Pacific region, benefit transfer, ecosystem services, total economic value, traditional fishing and tourism in English and Spanish. An estimated time range was not considered, studies from 1998 until 2017 were found. In total, 17 documents were compiled and systematized, distributed in 12 scientific papers and 5 technical reports. A matrix was built for the data systematization.

3.3.2. Contingent valuation

This methodology sought to estimate an individual's willingness to pay (WTP) to the ecosystem services provision conservation (Cameron and Carson 1989; Pere Riera 1994; Bateman and Jones 2003; Pagiola, von Ritter, and Bishop 2004). Two semi-structured survey models were carried out with two relevant focal groups in the decision-making and governance process. Methodologically, the goal was to obtain a sample no less than 50 surveys. However, the community and the organizations' participation were not entirely receptive to the exercise. Additionally, limitations in costs and time were present.

3.3.3. Design valuation scenarios

3.3.3.1. Current scenario. The DRMI generating a biological conservation strategy focused on social, economic and cultural development that allows improving the population's quality life. The objective and engagement of the communities are to maintain the composition and ecosystems functions, despite suffering structural modifications. This is only achieved under a shared and articulated territory use, promoting sustainable use, preservation, restoration, knowledge and ecosystem enjoyment. Along the 60,183 hectares that conform to the protected area, they can carry out productive sustainable activities, controlled and regulated extractive industries, research, environmental education, ecotourism, and recreational activities. The governance processes are performed through planning, coordination, execution, and action evaluation processes about three specific topics: fishing, mangroves and laws, and it are under the Los Riscales General Council authority (Unidad Ambiental Costera del Pacífico Norte Colombiano 2016).

The Arquímedes Association is a private corporation of mixed economy that promotes, manages, and executes the Tribugá deepwater port project. This organization's proposal is to construct a multi-purpose terminal that is put together by tourism and coastal fishing regional services port terminal and the construction of another multi-purpose terminal of exterior commerce for the use of import and export container cargo, general cargo, liquid bulks, solids and the development of a possible hydrocarbon port. The location of the project will be above the Tribugá bay. The port zone definition shows the tourism and coastal fishing port location (10.4 Has), seaport (109.3 Has), the Tribugá's populated centre redistribution (11.7 Has), the mangrove zone, protection areas and environmental services (103,4 Has), mangrove's damping zone (11 Has), ecological and economic low impact zone (96,7 Has), sea protection border (59.6 Has), equipment for domiciliary public services (12.8 Has), low impact touristic corridor (157.4 Has), social and prioritized interest residence zones (10 Has). Additionally, the Arquímedes association proposes the construction of an electric train that connects the Nuquí municipality with Quibdó, for cargo transport. This proposal

identified socioenvironmental impacts, where at the same time they propose mitigation activities (Cámara de Comercio de Manizales 2011; Proyecto Arquímedes 2015, 2017) (Figure 2).

3.3.4. Community approach

The first survey was for social leaders that take part in decisions and governance process. The semi-structured survey format was open to auction, 20 individuals were surveyed (Nuquí's community leaders), on seven towns, dedicated to the traditional fishing, agriculture, and tourism. The survey

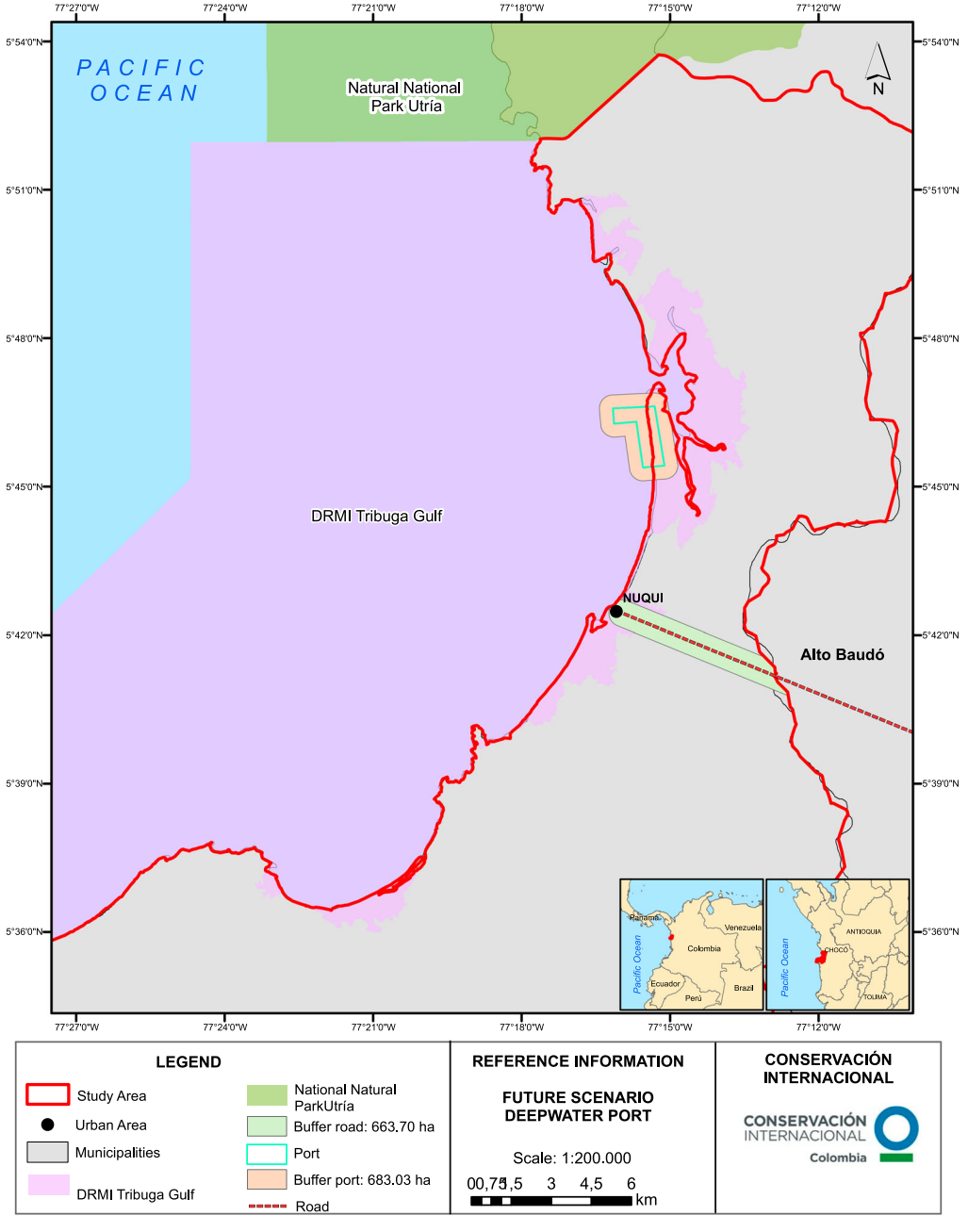

Figure 2. Footprint Deepwater port.

included 29 questions about the mangroves stakeholder's perception, the territory and port construction. The hypothetical market focused on identifying the willingness to pay to keep the environmental, sociocultural and economic benefits generate the protected area. Moreover, the willingness to pay for keeping the ecosystem services provided by the mangrove is asked (supplementary material 1).

The suggested payment was the fisherman daily income estimated in $10.52 dollars, taking the 10% a reference that is equal to a range between $ 1.05 and $ 1.75 dollars. The considered services were traditional fishing, ecotourism, and mangrove habitat quality.

3.3.5. Organizations approach

The second survey was to organizations related to DRMI consolidation, sustainable management, and territory governance. The selected organizations by expert criteria were: Los Riscales Communitarian Council, the Nuquí mayor's office, Codechocó, the GICPA, Marviva foundation, Eduardoño, AUNAP, the Nuquí's recycling Net, Fondo Acción, IIAP, PNN, WWF, Conservation International, Mano Cambiada and INVEMAR, included the 15-stakeholder's participation. The semi-structured survey format was open to auction, consisted of 21 questions about the mangroves stakeholder's perception, the territory governance, and port construction. The survey was carried out on the Survey Monkey platform. The hypothetical market focused on the willingness to pay to support and strengthen the activities carried out in the region and to guarantee the mangrove's ecosystem services for sociocultural and economic development of local communities.

The suggested payment in the survey was the expert criteria on the amount spent money on actions directed to natural resources conservation and management and the farm labour for the DRMI. These values were estimated in a range between $ 35,000 and $ 140,000 dollars per year. The valued services were traditional fishing, ecotourism, and mangrove habitat quality.

3.3.6. Benefit transfer

This method was applied as a complementary method to methods previously described (Costanza et al. 1997, 2014; Ruiz–Agudelo 2014). To transfer available information from previous studies, these must comply with the following conditions: (i) Environmental resources and ecosystem services should be similar in the two areas; (ii) Market conditions should be similar unless sufficient information is generated to determine a new market; (iii) The demographic and cultural conditions and income levels should be similar in the two areas (Cristeche and Penna 2008; Ruiz Agudelo et al. 2011).

The benefits transfer was direct, relocating the mangroves indirect market values (fishing and tourism), using central tendency measure. A systematic research model was implemented in academic journals databases (Ebsco, Host Academic, ProQuest, Science Direct, ISI Web of Science, JSTOR, SCOPUS, and BioOne) and scientific papers referred to Google Scholar and Redalyc project. Approximately 18 search criteria were used, through Boolean operators AND + OR, among keywords such as environmental economic valuation, marine, coast, contingent valuation, benefit transfer, ecosystem services, Pacific, Colombian Pacific, Tribugá Gulf, mangrove, ecosystem services, marine-coastal, contingent valuation, fishing, tourism.

Was possible demonstrate a broad scientific production related to valuation studies on marine protected areas, which about 80% involved the benefits transfer method. A data systematization matrix was carried out, prioritizing 24 studies and selecting 13 values to transferred. The values transfer was based on Costanza et al. (2014), with the purpose of estimating the strategic ecosystems total value. The transferred values are calculated from the 6% annual inflation rate, and the dollar exchange rate for March 2017.

Despite a small sample, it has been found that willingness to pay (WTP) represents an average value approximation. The willingness to pay was referential since a statistical model

couldn't be implemented because of the small sample size. Finally, the direct values transfer was implemented.

3.4. Wellbeing analysis

This analysis is being developed under three valuation focuses: ecological, sociocultural and economic, identifying the prioritized ecosystem services by local communities and the potential impact that generates the socioenvironmental conflict by the Deep-water port construction which is directly related with the local and regional wellbeing.

4. Results

4.1. Ecological assessment

4.1.1. Mangroves landcover change

In the study area, has been identified 2,408 mangrove hectares across the DRMI from Jurubirá up to Arusí region. The biggest concentration is located on Tribugá bay with 1,865.94 hectares. The potential impact of the socio-environmental conflict generated by the port construction reflected in a 916.94 hectares' loss, which becomes in secondary vegetation or in clean grass transition. Besides, the coastal zone erosion is the main causes of these changes in land cover (Table 1, Figure 3).

4.1.2. Mangroves habitat quality

Habitat quality refers to ecosystem ability to provide appropriate conditions for human wellbeing. InVEST model ranging from low to high level, based on resources available for survival, reproduction, and population persistence. Chocó still maintains the integrity of strategic ecosystems, preserving the constant ecosystem services flows. Habitat with high quality is related to intact areas (InVEST 2016). The levels with a bigger habitat quality are related to mangrove ecosystem in the study area, especially in the Tribugá gulf. Habitat quality depends on habitat's proximity to human land uses and the land uses intensity. Generally, habitat quality is degraded as the intensity of nearby land-use increases (InVEST 2016). The impact on the 916.94 mangrove hectares by the Deep-water port construction, results in 909.72 hectares' whit low-quality levels, affecting the ecosystem's services supply and the local communities' wellbeing. This quality decrease will be reflected in landcover changes, where the secondary vegetation and clean grass will dominate (Figure 4).

The mangrove ecosystem services supply of Tribugá Gulf depends on the dynamic, and ecosystem resilience capacity. The habitat's quality changes of Tribugá gulf because of the Deep-water port construction generates a potential impact on the communities' wellbeing, as well as make the region vulnerable to climate change effects.

Table 1. Land cover potential changes in a future scenario.

Land cover	Current Scenario (ha)	Future Scenario (ha)	Loss (ha)
High-dense forest	105,484	105,484	0
Open forest	6,086	6,003	83.03
Secondary/ transition vegetation	3,328	3,992	−664.24
Mangroves	2,407	1,490	916.94
River	1,721	1,805	−83.03
Arboreal grasses	39.71	43.32	−3.61
Clean pastures	1,504	1,267	−212.99
Crop Mosaic	184.11	220.21	−36. I
Sand	166.06	166.06	0
Urban	32.49	32.49	0
Road	32.49	32.49	0
Total	120,537	120,537	999.97

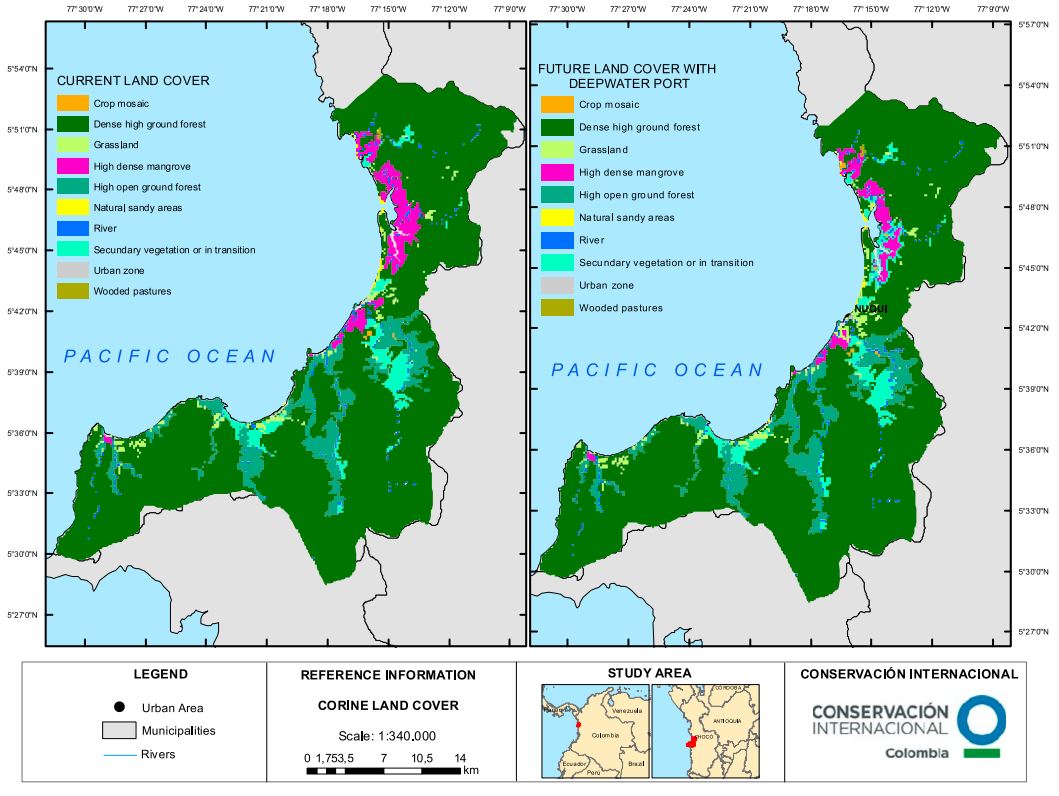

Figure 3. Mangroves land cover change.

4.2. Sociocultural assessment

The deep-water port construction in one of the regions of utmost importance and environmental and cultural wealth confronts a scenario that favours the infrastructure development against the natural ecosystem that characterizes the biogeographic Chocó. The construction would favour the country economy but doesn't ensure that it can favour the local communities' wellbeing that depends on a direct way of ecosystem services offer. Because of this, a socio-environmental conflict should be identified in the region (Environmental Justice Atlas 2018).

The Tribugá Gulf through social leaders that make part of Los Riscales Communitarian Council and is supported by a government, non-government and academic institutions, identify and define the zone's management figure as a governing, co-responsibility and teamwork strategy, for the conservation of the coastal-marine resource, around the mangrove and the traditional fishing management.

The Nuquí communities base their economy on the traditional fishing, subsistence agriculture, and informal ecotourism development. It's because of this that main conservation objectives are focused in: (i) the marine-coastal ecosystems' preservation and restoration that are found between the Tribugá Gulf and Cabo Corrientes, where activities like mating, reproduction, and breeding of the humpback whale, endemic and migratory birds, dolphins, sea turtles, among others; (ii) To keep the mangroves' structural and functional attributes, among other marine-coastal ecosystems, with the objective to guarantee the biological connectivity and the ecosystem services supply; (iii) To maintain hydro-biologic resources sustainability of and other ecosystem services that support the fishing production, the region's extractive, touristic and recreational use, for enjoyment and well-being for the local and touristic communities; And finally, (iv) to contribute the strengthening of

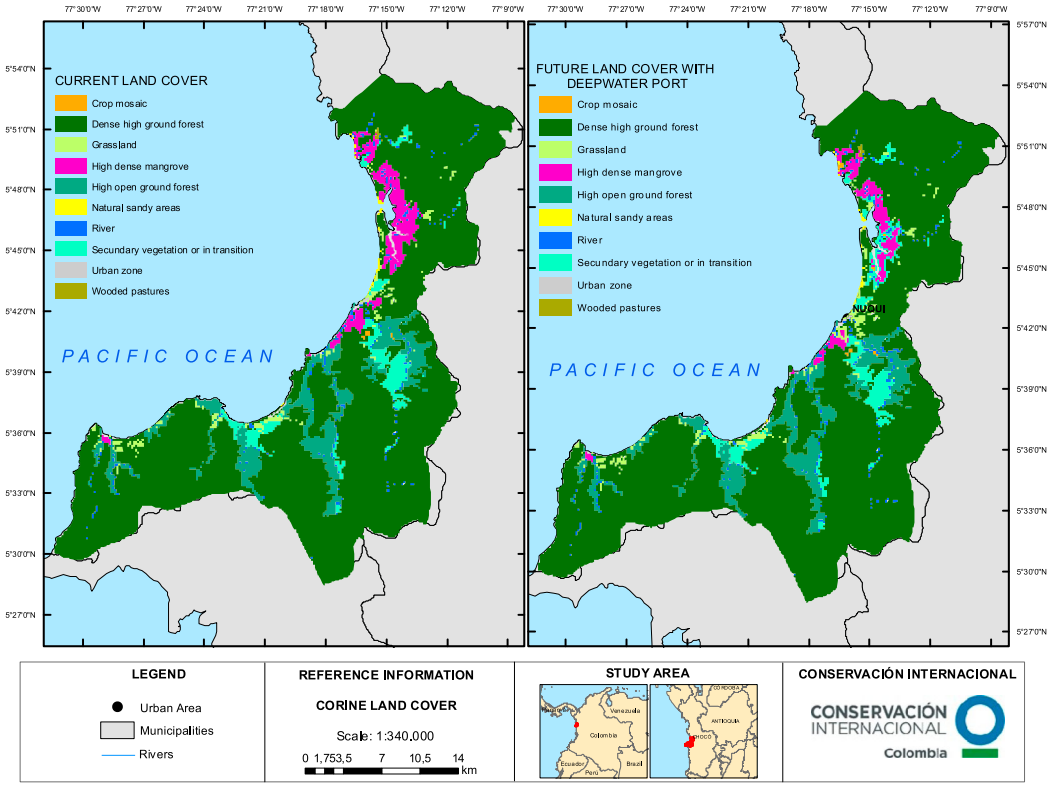

Figure 4. Mangroves habitat quality change.

cultural dynamic of native and black communities that depend on ecosystem services supply and that through their ancestral knowledge and sustainable practices, contribute to protection and management of the natural capital heritage.

The deliberative assessment that was developed with representatives from eighth (8) small towns across the Nuquí municipality, identified and conceptualized a 25 ecosystem services presented to community (Ruiz Agudelo et al. 2011), of which 17 were related to mangrove ecosystems like water provision, decorative products, fishing, agriculture, raw materials, water quality, air quality, carbon/oxygen, erosion and landslide control, habitat quality, disaster control, flooding regulation, soil fertility, recreation, tourism, natural medicine, and landscape.

These ecosystem services were qualified on a scale of 3 to 1, being 3 the highest score and 1 the lowest, per importance and use. For the importance category, the community considers the most relevant services are water provision, water quality, air quality, fishing, agricultural products, habitat quality, soil fertility, and raw materials.

This classification manages to identify and confirm the importance for subsistence that mangroves have for Nuquí communities. From these ecosystems, they obtain food (fishes, mollusks and crustaceans), wood for house construction, firewood for cooking and medicinal plants. Besides, it offers protection and mitigation to storm effects, erosive processes, and flooding, to which are more vulnerable the coastal populations. In economic terms, mangroves are full of habitats with important species for handmade fishing development, scenic beauty, recreation, and culture.

The fishing ecosystem service is the main economic activities of the region, generating different dynamics based on the available resource exploitation directed to environmental, social, economic and cultural sustainability. Most of the population benefits from fishing as a source of economic income and self-supply. This service is currently protected under the responsible fishing

management, the development of fishing monitoring and interinstitutional agencies for the take of decisions about the laws and development of traditional fishing.

Per up, the deep-water port construction can be considered as a threat to different territory scenarios, the mangroves' ecosystem services supply, and the local communities' wellbeing that depends on and supports this offer. The main potential impacts of the port construction identified and pointed out by the Environmental Justice Atlas are mainly social and economic.

Regarding the potential environmental impacts, it has been identified: Air pollution, biodiversity loss, desertification/drought, fires, flood, food insecurity, genetic contamination, global warming, loss of landscape/aesthetic degradation, noise pollution, soil contamination, soil erosion, waste overflow, deforestation and loss of vegetation cover, surface water pollution/decreasing water quality, groundwater pollution or depletion, large scale disturbance of hydro and geological systems, reduced ecological/hydrological connectivity.

The identified potential socioeconomic impacts are: Displacement, increase in violence and crime, lack of work security, labour absenteeism, firings, unemployment, loss of livelihood, loss of traditional knowledge, practices and culture, militarization and increased police presence, social problems such as alcoholism and prostitution, and dispossession and loss of landscape/sense of place.

4.3. Economic valuation

Mangroves are fundamental for human wellbeing, the assessment interests of ecosystem services have been growing since it is expected that through this instrument, lineaments are generated that allow the decision makers and support the ecosystems use and management (Costanza et al. 1997, 2014; MEA 2005; Mukherjee et al. 2014). One of the first approximations to the ecosystem services' global value was estimated in US$ 33 trillion per year (Costanza et al. 1997), and in 2014 Costanza et al. (2014), updated this value in US$ 247 trillion per year. In the specific mangrove case, the estimated value by Costanza in 1997 was around US$ 14,000/ha/year, increasing in 2014 to US$ 194,000/ha/year (Costanza et al. 2014).

The mangroves economic studies are currently focused on conservation promotion, generating alternate managing, human wellbeing and environmental tradeoffs (Lal 2003). Different economic research has been designed to calculate mangrove ecosystem values (Costanza et al. 2014; Mukherjee et al. 2014; Vo, Kuenzerb, and Oppeltc 2015). Nevertheless, it is likely that the different valuation approaches generated big differences in the assigned economic value (Vo, Kuenzerb, and Oppeltc 2015), This can happen because the specific conditions of economic activities, geographical, social and cultural context (Brander et al. 2012; De Groot et al. 2012; Salem and Mercer 2012; Vo et al. 2012, 2015). Usually, the mangrove ecosystems tend to be undervalued, even if they offer indispensable services for communities' wellbeing that depend directly or indirectly on them. The undervaluing of its ecosystem services has different reasons, which are found the resource open access and lack of awareness of its value (Saenger 1999).

In Colombia, there exists an important number of related studies with the marine-coastal ecosystem services assessment, utilizing from declared preference methods up to a benefit estimation. However, these studies at most are developed by the Caribbean region and in a small proportion for the Pacific region. The valued ecosystem services in the studies are (i) The total economic value; (ii) tourism service; (iii) carbon stock; (iv) fishing; (v) protected area conservation and the benefits they produce. The most implemented methodologies have been: (i) market prices; (ii) contingent assessment; (iii) benefit transfer, among others.

The studies that value the total economic value estimate this service in between USD$ 3,590 ha/yr. and USD$ 254,487 ha/ year (Carbal Herrera 2010; Carbal Herrera, Carbal Muñoz, and Solar Cumplido 2015; Prato and Reyna 2015; Prato and Newball 2015; Vergara, Serpa, and Carbal 2016; Conservation International 2017). The fishing service is estimated between USD$ 1,384 income/yr. and USD$ 720 million income/yr. (Maldonado et al. 2013; Prato and Reyna 2015; Prato and Newball 2015; Contreras Araque 2016; Conservation International 2017). The tourism service is estimated

Table 2. Mangroves ecosystem services economic valuation results.

Ecosystem services	Valuation technique	Minimum value estimation	Maximum value estimation
Total economic value	Benefit transfer Market prices Opportunity cost Participatory assessment Contingent valuation	USD$3,590 ha/yr.	USD$ 254,487 ha/yr.
Fishing	Benefit transfer Market prices Bio economic model Participatory assessment Contingent valuation	USD$ 1.4 million income/yr.	$ USD720 million income/yr.
Tourism	Benefit transfer Market prices Choice experiments Participatory assessment Contingent valuation Travel cost	USD$ 50,295 income/yr.	USD$ 1.4 million income/yr.
Carbon	Opportunity cost Market prices	USD$ 21,081 Ton/yr.	USD$ 32 million Ton/yr.

between USD$ 50,295 income/yr. y USD$1.495 million income/yr. (Maldonado et al. 2013; Castaño-Isaza et al. 2014; Pupo-García and Parada-Corrales 2015; Prato and Reyna 2015; Prato and Newball 2015; González, Ledesma, and Niño Martínez 2016; Romero Castañeda and Cárdenas Muñoz 2017; Conservation International 2017), and finally, the carbon stock in between USD$ 21,081 Ton/yr. and USD$ 32 million Ton/yr. (Lozano Torres 2007; De La Peña, Rojas, and De La Peña 2010; Maldonado et al. 2013; Zarate-Barrera and Maldonado 2015; Conservation International 2017) (Table 2).

4.3.1. Contingent valuation

The local community willingness to pay (WTP): Of the 20 individual leaders and representatives of the 8 Nuquí villages that are dedicated to artisanal fishing, tourism, and agricultural activities, 80% are willing to pay an economic contribution between USD$1.05 and USD$1.75 per month. This contribution would be aimed at benefits conservation related to a self-governance system led by Los Riscales Community Council, artisanal fishing, community tourism, and mangrove sustainable use provided by the DRMI to local communities. This is equivalent to USD$22,654 and USD $37,758 per year, considering that roughly 1,798 Nuquí households are willing to pay for the 12 months of the year. The remaining 20% of the sample is distributed into 5% of individuals unwilling to pay and 15% that do not know or do not respond. The artisanal fisheries, community tourism, and the sustainable use of mangrove ecosystem services were individually assessed. Artisanal fisheries being the most valued by the community at USD$37,358 per year. Community tourism and the mangroves sustainable use were valued at USD$22,654 each one. The economic contribution would be meant to support and finance the DRMI and the mangrove management plans. These activities must conservation strategic ecosystems by maintaining ecosystem service supply and ecological connectivity. In addition, they must strengthen cultural dynamics and traditional knowledge to support the economic and extractive activities practiced in the region.

Organizations' willingness to pay (WTP): Of the 22 stakeholders invited, only 50% answered the semi-structured survey. The 100% of respondents would be willing to pay a monetary and/or non-monetary contribution to maintain the protected area and different benefits provide to local communities. Of the respondents, 60% would be willing to pay an economic contribution to strengthen the activities carried out in the DRMI, if the constant ecosystem services flow and sustainable use is guaranteed. The remaining 40% of the group is willing to provide a voluntary non-monetary contribution of technical, scientific, or entrepreneurial nature aimed at the local communities' social, economic, and cultural development. The main reason these respondents are not willing to pay a monetary contribution is their distrust of economic resource 's use. The stakeholders' willingness

to pay is distributed in 60% with USD$35,000 annually and 40% between USD$70,000 and USD $105,000 annually. This is equivalent to a range of USD$168,000 and USD$252,000 per year if the organization's contribution is considered in the DRMI management decision making.

This approximation presented different restrictions that range from the sample size, which was lower than 50, for the two cases. Additionally, the communities that did not show interest to respond to the Survey. However, with a relatively low sample of 20 individuals, it has been found that the availability range to pay (WTP) for the two social groups represents an approximation to an average value. These value ranges are clearly referential, a reason why it is not possible to implement a statistical model. These WTP ranges are estimated for the communities in USD$ 22,654, USD$30,206 and USD$37,758 per year, and for the organizations is estimated in USD$168,000, USD$ 210,000 and USD$252,000 per year (Table 3).

4.3.2. Benefit transfer

Twenty-seven studies on ecosystem services economic valuation of protected marine areas in the Pacific and Caribbean regions between 2006 and 2016 were selected. In total, 28 transferred values in four categories were obtained: (i) total economic value, (ii) visits income, (iii) fishing income, and (iv) household/month. The ecosystem services most valued for the region per the literature consulted were tourism, fishing, and the total economic value of mangroves. More than 80% of the studies implemented benefits transfer for ecosystem valuation. Most of these studies indicated gaps in knowledge in different geospatial, socioeconomic, and/or methodological categories.

Few studies have been done in the Colombian Pacific since most studies have focused on the evaluation of marine-coastal services in the Caribbean region, which presents greater economic and social development. Therefore, these studies were considered to estimate the value of artisanal fisheries and community tourism in the Tribugá Gulf and Cabo Corrientes DRMI. The benefits transfer method tends to cause overestimation bias and low accuracy level due to the differences between studies on the landscape unit, development, the local community's socioeconomic situation, and access to natural capital.

Direct transfer for fishing. The fishing value for the region was estimated for the annual income unit from the studies of The Nature Conservancy (2014), AUNAP (2014), and Contreras (2014). The average income value from the original studies is USD$ 2,712 per year/fisherman. In Nuquí, nearly 400 fishermen are registered, who are exclusively dedicated to artisanal fishing. In Nuquí there are 400 traditional fishers currently registered, which would be equivalent to an annual loss of USD$1 million per year.

Direct transfer for tourism. The annual value for the visiting unit was estimated from the studies of Maldonado et al. (2013), García, Prato and Reyna (2015), and Carbal Herrera, Carbal Muñoz, and Solar Cumplido (2015). The average visit value for original studies was USD$7.01. The income loss by tourism service is equivalent to USD$52,579 per year for the 7,500 Nuquí visitors every year.

Direct transfer for the total economic value. The mangrove hectare value was estimated, using the study of Prato and Reyna (2015). The value in the original study was of USD$ 253,617 per hectare/yr. The study area present 2,048 mangroves hectares of which is equivalent to USD$ 6.10 million per year. The loss of 916.94 mangrove hectares because the deep-water port construction is equivalent to USD$ 232 million per year.

Table 3. Contingent valuation value approach.

Social group	Ecosystem services	Minimum value (USD/yr.)	Average value (USD/yr.)	Maximum value (USD/yr.)
Communities	Maintain DRMI benefits: artisanal fishing, community tourism, and sustainable mangrove use	$ 22,654	$ 30, 206	$ 37,758
Organizations	Financing to maintain ecological, Social and economic DRMI benefits	$168,000	$ 210,000	$ 252,0000

5. Discussion

The marine protected area DRMI Tribugá Gulf and Cabo Corrientes is a territorial organization that allows local communities to develop their own governance system, based on traditional ecological knowledge (Gómez-Baggethun 2009; Reyes-García 2009; Gómez-Baggethun et al. 2010), cultural knowledge and the local economy. The Changes in this complex socio-ecological system (Anderies, Janssen, Ostrom 2004; Ostrom 2009; Martín-López, Gómez-Baggethun, and Montes 2009), through the different interactions between the communities and the environment, has repercussions on the wellbeing perception.

The protected area's integral assessment DRMI Tribugá Gulf and Cabo Corrientes looks to conceive the territory as a socio-ecological system, where interactions are made between the ecological, social and economic systems becoming in a tool and an important supply for the management and mangroves use from the reconnaissance of local context, the associated stakeholders and inclusion of different assessment methodologies. The territories where the socio-environmental conflicts related to vulnerable populations with high poverty and inequality levels are evident are considered pertinent scenarios for the implementation and inclusion of ecosystem services' integral valuation. These approximations allow comprehending in a clearer way these interaction and affectation processes by including an ecological, sociocultural and economic dimension under deliberative participative processes and taking of decisions that make evident the ecosystem's multi-functionality.

The different valued languages addressed in this study searched to contextualize about the actual state of Tribugá Gulf and its capacity to supply ecosystem services of which depends on the local communities' wellbeing. Following this, it looked to comprehend the dynamic between the ecologic and sociocultural system, from the value perception and local communities' wellbeing, defining which of the ecosystem services are of most importance and most frequent use. Finally, the ecosystem value is approximated from the perception and willingness to pay from the social groups or relevant stakeholders in the management.

5.1. Information availability

The information available and the obtained is currently low, so it doesn't allow us to integrate in an analytical way the three assessment results. The main recommendations refer to necessary information requirements to advance integral assessment studies, a database creation that is available to the public is necessary about the assessment studies of Colombia's mangroves, allowing the standardization of the compiled information by applying strict methodologic protocols. These databases' foundation will allow the access to data in gross to feed specific models for detailed regions from grouped data, reducing like that regionalization mistakes.

With a national platform that can systematically compile the economic assessment research, is possible information search comparable and robust, facilitating the benefits transfer development with better-adjusted models and trusted results that can be considered in the socio-economic politics formulation. Besides, can provide information in multiple contexts with a much better tropical system comprehension and the user preferences in developing countries.

5.2. Method limitations

Despite a high dependency existing in the socioeconomic system and the ecological system in the DRMI Tribugá Gulf and Cabo Corrientes, there are different threats and identified impacts in the territory that have made that the degradation and transformation levels increase, affecting in a direct way the wellbeing of the local communities. The logic behind the integral assessment is to show the importance of the biodiversity and ecosystem services to allow its incorporation in the process of making decisions for the territory management (Rincón-Ruíz et al. 2014).

Nonetheless, the different limitation has been found in the valuation methods. The deliberative assessment is important for knowing the communities' perceptions, we found that the prioritized ecosystem services by the community don't fit with the economic assessment studies that are found in the literature. This allows to evidence the necessity of considering this approximation in future studies with the goal of guiding formal economic assessment exercises in the local preferences and perceptions.

The economic valuation has a fundamental role in correcting market failures under a common measurement unit, the monetary unit. These methodologies look to quantify in a monetary manner the goods and services offered by the mangroves that might be or not be in a market. However, this methodology is not always sufficient, which opens the possibility to include other kinds of methodologies that complement the analysis since these assessment exercises tend to be dependent contexts and rely on a certain way from socio-environmental conflicts that are generating in the territory. The contingent assessment is the most adequate method to estimate the economic value on this exercise (costs, time and the actors' disposition), where the most relevant in the study. It is recommended to rely on bigger sample size to generate scenarios with even bigger pertinent participation, where it can achieve to involve an even larger number of actors.

The benefits transfer, despite being one of the methods with bigger controversies, is the most used. Even so, it is important to highlight that this methodology is not precise and its context dependent, which generates an approximation instead of real value.

6. Conclusion

The ecological valuation shows the actual state of the mangrove ecosystem, where the 2,408 hectares show a habitat quality high level. The 916.94 hectares' loss because of deep-water port construction above the Tribugá Gulf, would limit the mangrove ecosystem services supply.

The deliberative assessment prioritized the ecosystem services with the local stakeholders in terms of importance and use, among them, there are water provision, quality air, fishing, agricultural products, carbon stock, soil fertility, natural medicine, habitat quality, and raw materials. Nevertheless, in the literature revision, the most valued are the ones that have a market like tourism and fishing, and the total economic value estimation, with weaknesses in the method implementation and in the access to primary and secondary information. In most of them, there doesn't exist a correlation between the locals' interests and the formal economic assessment studies.

The literature assessment allows to find out that for Colombia's mangroves, the most valued services are fishing, tourism, carbon, and total economic value, with different estimated value ranges in (i) Fishing: USD$ 1.4 million income/yr. and USD$ 720 million income/yr.; (ii) Tourism: USD$ 50,295 /yr. and |USD$ 1,495 million income/yr.; (iii) Carbon: USD$ 21,081 Ton/yr. and USD$ 32 million Ton/yr. The information keeps being scarce, diverse and dependent context, but it's considered as an approximation to Colombia's mangroves valuation.

The economic valuation which was addressed from the contingent valuation and benefits transfer had important limitations: it wasn't possible to apply statistical models because of the sample size and the universe that was counted with was restricted of information. On their behalf, the contingent assessment was not possible to develop in its own group because of the methodological limitations, the available obtained ranges for the willingness to pay (WTP) shows us that there is an interest from the communities and the organizations to maintain the mangroves' status quo. For the benefits transfer approximation, there is the possibility to use the ecological assessment information on the mangroves net loss. This means that the 916.94 mangrove hectare loss is equal to approximately USD$ 232 million /yr.

For future studies in the mangrove integral valuation be considered: (1) the use of a better biophysics information that allows characterizing the ecosystem and the capacity to supply ecosystem services; (2) consider the communities and organizations' preferences and perceptions that depend on the ecosystem services and the ecosystem quality, with the objective to approach these studies to

local realities; and lastly, (3) the generated primary information must be developed under economic valuation conventional methods.

The ecosystems loss for construction of a deep-water port is directly reflected in the ecosystem services loss and benefits offered by the current protected area.

This is an economic value approach of the Colombia Pacific region and the results obtained are important enough by themselves to analyze each one. The challenge is to convert this result into incentives for decision-makers and other relevant stakeholders, like Arquímedes Association. If the future scenario is real, this approach can be used by land managers, economic agents and decision makers to identify and priority areas for conservation and to identify potential conflicts associated with new management practices.

If the hypothetic future scenario is real, the economic agents must use these results to understand the environmental and socioeconomic context, prioritize conservation areas, quantifying trade-off, and create a pertinent environmental compensation plan for the territory intervention, to avoid irreversible effects over mangrove ecosystem.

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References

Alcaldía de Nuquí. 2016. Plan de Desarrollo Municipal de Nuquí 2016-2019. Nuquí, 94 p.

Alongi, D. M. 2008. "Mangrove Forests; Resilience, Protection from Tsunamis, and Responses to Global Climate Change." *Estuarine, Coastal and Shelf Science* 76: 1–13.

Anderies, J. M., M. A. Janssen, and E. Ostrom. 2004. "A Framework to Analyze the Robustness of Social-ecological Systems from an Institutional Perspective." *Ecology and Society* 9 (1): 18. [online]. http://www.ecologyandsociety.org/vol9/iss1/art18/.

AUNAP. 2014. *Valoración económica de la actividad pesquera de enero a junio y de noviembre a diciembre de 2014*. Santa Marta: SEPEC.

Barbier, E. B., S. D., Hacker, C. Kennedy, E. W. Koch, A. C. Stier, and B. R. Silliman. 2011. "The Value of Estuarine and Coastal Ecosystem Services." *Ecological Monographs* 81 (2): 169–193. doi:10.1890/10-1510.1.

Bateman, I. J., A. R. Harwood, G. M. Mace, R. T. Watson, D. J. Abson, B. Andrews, A. Binner, et al. 2013. "Bringing Ecosystem Services into Economic Decision-Making: Land Use in the United Kingdom." *Science* 341: 45–50.

Bateman, I. J., and A. P. Jones. 2003. "Contrasting Conventional with Multi-Level Modeling Approaches to Meta-Analysis: Expectation Consistency in U.K. Woodland Recreation Values." *Land Economics* 79: 235–258.

Brander, L. J., A. S. Wagtendonk, S. Hussain, A. McVittie, P. H. Verburg, R. S. De Groot, and S. Van Der Ploeg. 2012. "Ecosystem Services Valuation for Mangroves in Southeast Asia: A Meta-Analysis and Value Transfer Application." *Ecosystem Services* 1: 62–69.

Cámara de Comercio de Manizales. 2011. Proyecto Arquímedes. 26 p. http://www.ccmpc.org.co/ccm/contenidos/32/PUERTO%20DE%20TRIBUGA.pdf.

Cameron, Mitchell R., and Richard T. Carson. 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method McGraw-Hill Series in Industry Resources for the Future 463 pages.

Carbal Herrera, A. 2010. Valoración económica de los bienes y servicios ambientales - Caso Ciénaga La Caimanera Coveñas, Sucre. Sistema de universidades estatales del caribe SUE Caribe Universidad de Cartagena. Tesis de grado. Universidad de Cartagena.

Carbal Herrera, A., J. Carbal Muñoz, and L. Solar Cumplido. 2015. Valoración económica integral de los bienes y servicios ambientales ofertados por el ecosistema de manglar ubicado en la ciénaga de la virgen. Cartagena, Colombia. Saber, Ciencia y Liberal Vol. 10, No. 1.

Castaño-Isaza, J., R. Newball, B. Roach, and W. Lau. 2014. "Valuing Beaches to Develop Payment for Ecosystem Services Schemes in Colombia's Seaflower Marine Protected Area." *Ecosystem Services*, doi:10.1016/j.ecoser.2014.10.003i.

Conservación Internacional Colombia. 2017. Aproximación a la valoración integral del DRMI Golfo de Tribugá y Cabo Corrientes.

Contreras, A. 2014. Valoración económica del servicio ecosistémico de soporte a la pesquería provisto por el ecosistema de manglar en la Ciénaga Grande de Santa Marta. Revista Economía del Caribe. No. 18.

Contreras Araque, A. 2016. Valoración económica del servicio ecosistémico de soporte a la pesquería provisto por el ecosistema de manglar en la ciénaga grande de Santa Marta. revista de economía del caribe n°. 18.

Costanza, R., R. De Groot, L. Braat, I. Kubiszewski, L. Fioramonti, P. Sutton, S. Farber, and M. Grasso. 2017. "Twenty Years of Ecosystem Services: How Far Have We Come and How Far Do We Still Need To Go?" *Ecosystem Services* 28 (Part A): 1–16.

Costanza, R., R. de Groot, P. Sutton, S. van der Ploeg, S. J. Anderson, I. Kubiszewski, S. Farber, and R. K. Turner. 2014. "Changes in the Global Value of Ecosystem Services." *Global Environmental Change* 26: 152–158.

Costanza, R., and C. Folke. 1997. "Valuing Ecosystem Services with Efficiency, Fairness and Sustainability as Goals." In *Nature's Services: Societal Dependence on Natural Ecosystems*, edited by G. Daily, 49–70. Washington, DC: Island Press.

Costanza, R., D. A. Ralph, R. D. Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, et al. 1997. "The Value of the World's Ecosystem Services and Natural Capital." *Ecological Economics* 25 (1): 3–15.

Cristeche, E., and J. Penna. 2008. Métodos de valoración económica de los servicios ambientales. Estudios Socioeconómicos de la sustentabilidad de los sistemas de producción y recursos naturales. Instituto Nacional de Tecnología Agropecuaria. Argentina. No. 3. 58 p.

De Groot, R., L. Brander, S. Van Der Ploeg, R. Costanza, F. Bernard, L. Braat, M. Christie, et al. 2012. "Global Estimates of the Value of Ecosystems and Their Services in Monetary Units." *Ecosystem Services* 1: 50–61.

De La Peña, A., C. A. Rojas, and M. De La Peña. 2010. Valoración económica del manglar por el almacenamiento de carbono, Ciénaga Grande de Santa Marta Clío América. Colombia. Enero - junio 2010, Año 4 No. 7, pp. 133–150.

Duke, N. C., J. O. Meynecke, S. Dittmann, A. M. Ellison, K. Anger, U. Berger, S. Cannicci, et al. 2007. "A World Without Mangroves?" *Science* 317: 41b–42b.

Ellison, J. 2000. "How South Pacific Mangroves May Respond to Predicted Climate Change and Sea-Level Rise." In *Climate Change in the South Pacific: Impacts and Responses in Australia, New Zealand, and Small Island States*, edited by A. Gillespie and W. Burns, 289–300. Dordrecht: Springer.

Emerton, L. 1996. Participatory Environmental Valuation: Subsistence Forest Use Around the Aberdares, Kenya. African Wildlife Foundation. Applied Conservation Economics Discussion Paper No. 1 ACE-DP-1.

Emerton, L. 1999. Economic Tools for the Management of Marine Protected Areas in Eastern Africa. IUCN— The World Conservation Union, Eastern Africa Regional Office.

Environmental Justice Atlas. 2018. Colombia: Puerto de Tribugá-Chocó. https://ejatlas.org/conflict/puerto-de-tribuga-choco-colombia.

FAO. 2010. "Global Forest Resources Assessment 2010 Main Report." *Fao Forestry Paper* 123: 244.

Giri, C., P. Defourny, and S. Shrestha. 2003. "Land Cover Characterization and Mapping of Continental Southeast Asia Using Multi-Resolution Satellite Sensor Data." *International Journal of Remote Sensing* 24 (21): 4181–4196.

Gómez-Baggethun, E. 2009. Perspectivas del conocimiento ecológico local ante el proceso de globalización. Revista Papeles de relaciones ecosociales y cambio global. Icaria, 57 p.

Gómez-Baggethun, E., S. Migorria, V. Reyes-García, L. Calvet, and C. Montes. 2010. "Traditional Ecological Knowledge Trends in the Transition to a Market Economy: Empirical Study in the Doñana Natural Areas." *Conservation Biology* 24 (3): 721–729.

Gómez Cubillos, C., L. Licero, L. Perdomo, A. Rodríguez, D. Romero, D. Ballesteros-Contreras, D. Gómez-López, et al. 2015. Portafolio "Áreas de arrecifes de coral, pastos marinos, playas de arena y manglares con potencial de restauración en Colombia". Serie de Publicaciones Generales del Invemar No. 79, Santa Marta, 69 p.

González, C. J. L., J. Ledesma, y L. M. Niño Martínez. 2016. "Valoración económica de los recursos naturales de Islas del Rosario y San Bernardo." *Estudios y perspectiva en turismo* 25 (2016): 241–254.

Hall, L. S., P. R. Krausman, and M. L. Morrison. 1997. "The Habitat Concept and a Plea for Standard Terminology." *Wildlife Society Bulletin* 25 (1): 173–182.

IDEAM. 2005. Atlas climatológico de Colombia. Bogotá, 217 p.

INVERMAR. 2015. Informe del estado de los ambientes marino y costeros 2015.

INVERMAR. 2016. Informe del estado de los ambientes marino y costeros 2016.

InVEST. 2016. Habitat Quality Model. http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/habitat_quality.html.

InVEST. 2018. InVEST Models. https://naturalcapitalproject.stanford.edu/invest/.

Lal, P. 2003. "Economic Valuation of Mangroves and Decision Making in the Pacific." *Ocean & Coastal Management* 46 (9-10): 823–844.

Lal, R. 2004. "Soil Carbon Sequestration Impacts on Global Climate Change and Food Security." *Science* 304: 1623–1627.
Laurans, Y., A. Rankovic, R. Bille, R. Pirard, and L. Mermet. 2013. "Use of Ecosystem Services Economic Valuation for Decision Making: Questioning a Literature Blindspot." *Journal of Environmental Management* 119: 208–219.
Lina, T., W. De Jong, D. Sheil, T. Kusumanto, and K. Evans. 2007. "A Review of Tools for Incorporating Community Knowledge, Preferences, and Values Into Decision Making in Natural Resources Management." *Ecology and Society* 12 (1): 5.
López, Daniel Gómez. 2009. *El pacífico colombiano: problemática regional e integración del Gobierno Nacional en los últimos veinte años. 1987-2007 / Daniel López Gómez. —Facultad de Ciencia Política y Gobierno y de Relaciones Internacionales*. Bogotá: Editorial Universidad del Rosario.
Lozano Torres, Y. 2007. "Los sumideros de carbono: Un análisis de la potencialidad económica en un bosque de manglar del Pacífico colombiano." *Revista de Ingeniería de los Recursos Naturales* 6: 82–93.
MADS (Ministerio de Ambiente y Desarrollo Sostenible). 2002. Programa Nacional para el Uso Sostenible, Manejo y Conservación de los Ecosistemas de Manglar en Colombia.
Maldonado, J., R. Moreno-Sánchez, T. Zárate, C. Barrera, R. Cuervo, C. Gutiérrez, A. Montañez, and M. Rubio. 2013. Valoración económica del subsistema de Áreas Marinas Protegidas en Colombia: un análisis para formuladores de política desde un enfoque multi-servicios y multi-agentes. CEDE. Universidad de los Andes. Vol 52, 67 p.
Martín-López, B. 2013. Evaluación de los servicios de los ecosistemas suministrados por cuencas hidrográficas: Una aproximación socio-ecológica. Universidad Autónoma de Madrid. Presentación, 32 p.
Martín-López, B., E. Gómez-Baggethun, and C. Montes. 2009. "Un marco conceptual para la gestión de las interacciones naturaleza-sociedad en un mundo cambiante." *Ciudades* 9 (3): 229–258.
MEA (Millennial Ecosystem Assessment). 2005.
Moreno-Sánchez, R., and J. Maldonado. 2011. Enfoques alternativos en la valoración de los ecosistemas: explorando la participación de los usuarios locales. Ambiente y Desarrollo. Vol. XV, No-29. Julio-diciembre. Bogotá, Colombia.
Moreno-Sánchez, R., J. Maldonado, and C. Gutiérrez. 2013. Valoración de áreas marinas protegidas desde la perspectiva de los usuarios de recursos: conciliando enfoques cuantitativos individuales con enfoques cualitativos colectivos. Documentos CEDE. Universidad de los Andes. Noviembre. No. 55. Bogotá, Colombia.
Mukherjee, N., W. J. Sutherland, L. Dicks, J. Hugé, N. Koedam, and F. Dahdouh-Guebas. 2014. "Ecosystem Service Valuations of Mangrove Ecosystems to Inform Decision Making and Future Valuation Exercises." *PLoS ONE* 9 (9): e107706. doi:10.1371/journal.pone.0107706.
Ostrom. 2009. "A General Framework for Analyzing Sustainability of Social-Ecological Systems." *Science* 325: 419–422.
Pagiola, S., K. von Ritter, y J. Bishop. 2004. *Assessing the Economic Value of Ecosystem Conservation*. Washington, DC: World Bank Environment Department. 48 p.
Pere Riera. 1994. Manual de Valoración Contingente. CEPAL, 112 p.
Prato, J., and R. Newball. 2015. Aproximación a la valoración económica ambiental del departamento Archipiélago de San Andrés, Providencia y Santa Catalina – Reserva de la Biósfera Seaflower. Secretaría Ejecutiva de la Comisión Colombiana del Océano SECCO, Corporación para el desarrollo sostenible del Archipiélago de San Andrés, Providencia y Santa Catalina -CORALINA. Bogotá, 170 p.
Prato, J., and J. Reyna. 2015. Aproximación a la valoración económica de la zona marina y costera del Caribe colombiano. Secretaría Ejecutiva de la Comisión Colombiana del Océano. Bogotá, 184 p.
Proyecto Arquímedes, S. A. 2015. Portafolio www.arquimedes.com.co/docs/portafolio-proyectos-septiembre-2015.pdf.
Proyecto Arquímedes, S. A. 2017. Información Técnica del Proyecto.
Pupo-García and Parada-Corrales. 2015. "Valoración económica de los bienes y servicios ecosistémicos del Golfo de Tribugá-Colombia." *INVEMAR. Universidad de Cartagena* 23: 39–54.
Queiroz, L., S. Rossi, L. Calvet-Mir, I. Ruiz-Mallén, S. García-Betorz, J. Salvà-Prat, and A. J. Andrade Meireles. 2017. "Neglected Ecosystem Services: Highlighting the Socio-Cultural Perception of Mangroves in Decision-Making Processes." *Ecosystem Services* 26: 137–145.
Reyes-García, V. 2009. Conocimiento ecológico tradicional para la conservación: dinámicas y conflictos. Revista Papeles de relaciones ecosociales y cambio global. Icaria, 39 p.
Rincón-Ruíz, A., M. Echeverry-Duque, A. M. Piñeros, C. H. Tapia, A. David, P. Arias-Arévalo, y P. A. Zuluaga. 2014. *Valoración integral de la biodiversidad y los servicios ecosistémicos: Aspectos conceptuales y metodológicos*. Bogotá, DC: Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAvH). 151 p.
Romero Castañeda, J. A., and C. R. Cárdenas Muñoz. 2017. Valoración económica de los servicios ecosistémicos del PNN Tayrona mediante los métodos de valoración contingente y costos de viaje como aproximación al valor total. Tesis de Maestría. Universidad Santo Tomás, 87 p.
Rönnbäck, P. 1999. "The Ecological Basis for Economic Value of Seafood Production Supported by Mangroves Ecosystem." *Ecological Economics* 29: 235–252.
Ruiz Agudelo, C. A., C. Bello, M. C. Londoño Murcia, H. Alterio, J. N. Urbina Cardona, A. Buitrago, J. E. Gualdrón-Duarte, et al. 2011. Protocolo para la valoración económica de los servicios ecosistémicos en los Andes colombianos,

a través del método de transferencia de beneficios. Reflexiones sobre el Capital Natural de Colombia No. 1. Conservación Internacional Colombia. Bogotá, DC, 53 p.

Ruiz Agudelo, C. A., M. L. Zarate, A. M. Cortés Gómez, C. Bello, G. Tirado Muñoz, J. E. Gualdrón Duarte, C. A. Riveros, et al. 2013. Hacia Una economía verde en Colombia: Diseño e implementación de un esquema de Pago por Servicios Ecosistémicos (PSE) en el marco del ordenamiento territorial. Fases de diseño e implementación temprana. Caso cuenca del rio Ranchería. Departamento de la Guajira – Colombia. Reflexiones sobre el Capital Natural de Colombia No. 3. Conservación Internacional Colombia. Bogotá, DC, 196 p.

Ruiz–Agudelo, C. A. 2014. "¿El valor de algunos servicios ecosistémicos de los Andes colombianos?: transferencia de beneficios por meta-análisis." *Universitas Scientiarum* 19 (3): 301–322. doi:10.11144/Javeriana.SC19-3.vase.

Saenger, P. 1999. "Sustainable Management of Mangroves." In *Integrated Coastal and Marine Resource Management: Proceedings of International Symposium, Batu, Malang, Indonesia, 25–27 November, National Institute of Technology (ITN) Malang in Association with Bakosurtanal and Proyek Pesisir*, Malang, Indonesia, edited by J. Rais, I. M. Dutton, L. Pantimena, R. Dahuri, and J. Plouffe, 163–168.

Saenger, P., E. J. Hegerl, and J. D. S. Davie. 1983. "Global Status of Mangrove Ecosystems." *The Environmentalist*.

Salem, M. E., and D. E. Mercer. 2012. "The Economic Value of Mangroves: A Meta-Analysis." *Sustainability* 4: 359–383.

Sheil, D., P. Rajindra, I. Basuki, M. van Heist, R. Liswanti, I. Rachmatika, and I. Samsoedin. 2005. "Recognizing Local People's Priorities for Tropical Forest Biodiversity." *AMBIO: A Journal of the Human Environment* 35 (1): 17–24.

Spalding, M., M. Kainuma, and L. Collins. 2010. *World Atlas of Mangroves*. London: Earthscan.

The Nature Conservancy. 2014. Valoración económica de bienes y servicios del Canal del Dique y sus ecosistemas marinos adyacentes (bahía de Cartagena, bahía de Barbacoa y ciénaga de la Matuna). Cámara de Comercio de Cartagena.

Thomas, N., R. Lucas, P. Bunting, A. Hardy, A. Rosenqvist, and M. Simard. 2017. "Distribution and Drivers of Global Mangrove Forest Change, 1996–2010." *PLoS ONE* 12 (6): e0179302.

Unidad Ambiental Costera del Pacífico Norte Colombiano. 2016. DRMI Golfo de Tribugá – Cabo Corrientes. http://chocouac.com.co/drmi.html.

United Nations. 2013. System of Environmental-Economic Accounting 2012. Experimental Ecosystem Accounting. UN World Bank, 204 p.

Valiela, I., J. L. Bowen, and J. K. York. 2001. "Mangrove Forests: One of the World's Threatened Major Tropical Environments." *BioScience* 51: 807–815.

Velandia, M. C., y J. M. Diaz. 2016. Atlas Marino-Costero del Pacifico Norte Colombiano. Fundación MarViva, Bogotá, 130 p.

Vergara, J. J., I. F. Serpa, and A. E. Carbal. 2016. "Análisis de los métodos de valoración de costos ambientales: una mirada desde la investigación contable ambiental. Caso: Construcción de la doble calzada vía al mar Cartagena-Barranquilla, tramo 1." *en Sotavento mba* 27: 86–92. doi:10.18601/01233734.n27.06.

Vo, Q. T., C. Kuenzer, Q. M. Vo, F. Moder, and N. Oppelt. 2012. "Review of Valuation Methods for Mangroves Ecosystem Services." *Ecological Indicators* 23: 431–446.

Vo, T. K., C. Kuenzerb, and N. Oppeltc. 2015. "How Remote Sensing Supports Mangrove Ecosystem Service Valuation: A Case Study in Ca Mau Province, Vietnam." *Ecosystem Services* 14: 67–75.

Walters, B. B., P. Rönnbäck, J. M. Kovacs, B. Crona, S. A. Hussain, R. Badola, J. H. Primavera, E. Barbier, and F. Dahdouh-Guebas. 2008. "Ethnobiology, Socio-Economics and Management of Mangrove Forests: A Review." *Aquatic Botany* 89: 220–236.

Wilkie, M. L., and S. Fortuna. 2003. "Status and Trends in Mangrove Area Extent World-Wide." Working Paper FRA 63, Forest Resources Division, Forestry Department, UN-Food and Agriculture Organization, 292 p.

Zarate-Barrera, T. G., and J. H. Maldonado. 2015. "Valuing Blue Carbon: Carbon Sequestration Benefits Provided by the Marine Protected Areas in Colombia." *PLoS ONE* 10 (5): e0126627. doi:10.1371/journal. pone.0126627.