UAB
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THE VALUE OF WETLANDS IN URBAN AREAS

Lida Díaz-Pinzón

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An Integral Approach

Author
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Dissertation
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The Value of Wetlands in Urban Areas:

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To my daughters

and their future descendants,

whose voices I cannot hear today

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Summary

Urban growth has significantly impacted natural ecosystems, particularly wetlands. This situation disrupts the valuable contributions of nature, leading to socioeconomic consequences. It is crucial to assess the benefits of wetlands, especially in developing countries, in which these resources face challenges with institutional, social and physical-ecological barriers. This dissertation examines the value of urban wetlands across different dimensions among three research papers in Cali (Colombia), including economic and socio-cultural values within their social-ecological system. Firstly, a monetary valuation of ecosystem services and an exploratory analysis of the governance system is performed. Secondly, an analysis of the social-ecological system and the ecosystem services involved is presented, to identify successful governance actions in their management. Thirdly, a socio-cultural non-monetary and monetary valuation is performed, to achieve sustainable outcomes and joint working between actors and governance systems. Data collection is based on primary research sources from 33 interviews and 276 surveys for the second and third research, as well as secondary sources such as the Ecosystem Services Valuation Data Base for the first research. This dissertation contributes to highlighting the economic significance of wetlands for the city and its inhabitants. In addition to underlining the need for community-public systems to achieve success in the management of urban common-pool resources, it also emphasizes institutional facilitators, community initiatives, and challenges arising from social-ecological factors. Furthermore, it demonstrates significant differences between urban and peri-urban wetlands across different income levels, underscoring the influence of socioeconomic factors on non-monetary and monetary valuation. Management implications should focus on integrating institutions and community to promote equity in the access and use of ecosystem services in different areas where wetlands are located.

Keywords: ecosystem services, governance, social-ecological system, urban wetlands, valuation

CHAPTER 1: Introduction

1.1. Problem statement

Human well-being and livelihoods rely on wetlands (Ramsar, 2021), which provide benefits that society obtains either directly or indirectly from these ecosystems. Those benefits are called ecosystem services (ES), as described by Costanza et al. (1997). Alternatively, they can be referred to as nature's contributions to people, which is a broad concept that considers both the benefits and detriments of nature, where stakeholders and governance play a close role, as highlighted by Díaz et al. (2015). In line with this, the contributions of wetlands include providing fresh water, food, raw materials, services related to climate change mitigation (such as flood risk prevention and carbon sequestration), and cultural ES related to mental health, among others (MEA, 2005; Ramsar, 2021). However, agricultural activities, livestock, urban expansion, climate change, pollution, and other human actions have led to the loss of wetlands. For instance, in Latin America, between 1970 and 2015, the area of wetlands decreased by 59% (Ramsar, 2018). Despite the crucial role of wetland management in achieving sustainable cities, urban wetlands persistently face loss and degradation due to the undervaluation of their benefits, exclusion from planning processes, and inadequate governance (Ramsar, 2021). This is evident in Colombia, and particularly in Cali in which this dissertation is settled. The city of Cali is characterized by its abundant water resources and rich biodiversity. However, its urban and peri-urban wetlands suffer from soil impermeabilization, changes in land use, and ecosystem deterioration (DAGMA, 2018; Ramsar, 1996; Ricaurte & Olaya-Rodríguez, 2017). This situation highlights a mismatch between institutions and ecological systems that affect the management of, and emphasizes the importance of, this dissertation.

The recognition of the benefits of wetlands, as well as their ES, assessment, and integration with actors and policymakers, has been of interest to intergovernmental organizations such as the Convention on Wetlands (Ramsar), the Millennium Ecosystem Assessment (MEA), The Economics of Ecosystems and Biodiversity (TEEB), and the Intergovernmental Science-Policy

Platform on Biodiversity and Ecosystem Services (IPBES). Accordingly, broad research has been carried out on ES, predominantly focused on the Global North, while the Global South, particularly South America, remains underrepresented in scientific literature (Brander et al., 2024; Haase et al., 2014; Nazmul Haque & Sharifi, 2024). From an anthropocentric view, approaches in studies have ranged from economic valuation based on natural capital to holistic perspectives based on the pluralism of values that incorporate different dimensions, such as socio-cultural domain (Costanza et al., 2017; Ghermandi et al., 2010; Hernández-Blanco et al., 2020; Langemeyer & Connolly, 2020; Rincón-Ruiz et al., 2019; Zafra-Calvo et al., 2020). However, none of these fully integrates the interactions between ES and the social-ecological system (SES), which encompass resources, actors, governance, and sustainable outcomes (Ban et al., 2015; Partelow & Winkler, 2016). Additionally, regarding urban ES, research in South America and Colombia has primarily focused on forests, urban parks, mapping, and valuing ES, with limited insight into urban wetlands or urban-blue infrastructure (Bonilla-Bedoya et al., 2020; Escobedo et al., 2015, 2020; Nazmul Haque & Sharifi, 2024; Ordóñez & Duinker, 2014; Ramírez & Fennell, 2014; Scopelliti et al., 2016). Thus, further research is needed to consider urban wetlands in South America's growing cities involving ES valuation, actors, governance, and emerging outcomes, consequently this dissertation contributes to filling this gap.

This research is carried out with an institutional economic approach, which is a proposal that combines two structures that analyze the social system and the ecological system that provide services to society: i) the SES framework (Ostrom, 2009, 2011); and ii) the Integrated Assessment and Valuation of Ecosystem Services (ES framework) (De Groot et al., 2002). The aim of this approach is to achieve a comprehensive analysis, involving actors, governance, monetary and non-monetary components as well as sustainable outcomes. This serves as a starting point for wetlands policies and management, using the city of Cali as a case study.

1.2. Main objectives of the research and research questions

Considering an integrative paradigm, this dissertation takes a positive and normative approach to assess the integral valuation of wetlands in Cali. The research questions that guide this project include:

Chapter 2

- What are the benefits of wetlands in Cali and what is their economic value?

Chapter 3

- What have the successful actions in wetlands governance been between the community and public bodies in Cali?
- In what way and how are the ecosystem services of wetlands in Cali perceived, and what is their relationship with self-organization activities?

Chapter 4

- What are the socio-cultural values of wetlands in Cali and how are these related to sustainable outcomes?

To tackle these questions, this dissertation develops the following specific objectives:

Chapter 2

With the aim of performing a monetary valuation of the urban and peri-urban wetlands of Cali:

- Determine and value the ecosystem services of the wetlands.
- Explore governance characteristics for the management of the wetlands.

Chapter 3

With the aim of establishing which actions in governance have been successful in the urban and peri-urban wetlands of Cali:

- Identify ecosystem services and their connections with collective actions and variables of the social-ecological system and sustainable outcomes.
- Evaluate factors that potentially affect collective actions and sustainable outcomes.

Chapter 4

With the aim of assessing a socio-cultural valuation of the urban and peri-urban wetlands of Cali:

- Evaluate perceptions of value or importance of cultural ecosystem services of wetlands.
- Assess the economic valuation of cultural ecosystem services through evaluating willingness to pay to visit the wetland.
- Identify factors that enhance collective actions and ecological outcomes in wetlands.
- Assess how the importance of cultural ecosystems services, willingness to pay and collective actions influence ecological outcomes.

1.3. Conceptual Framework

The Institutional Analysis and Design framework, developed by Ostrom and her colleagues (Ostrom, 2009, 2011) establishes guidelines for understanding the management and governance of natural resources (Cumming et al., 2020). This encompasses social and ecological factors, along with formal and informal institutional components. Within this context, natural resources, or common-pool resources share the characteristics of subtractability of private goods and the difficulty of exclusion of public goods (Ostrom, 2010,

2011). That is to say, if these resources are depleted, present and future generations to whom they are freely accessible will also be affected. This framework also draws the roadmap for the understanding of institutions that are located within SES, which are understood as ecological systems closely linked to and affected by one or more social systems that require the design of dynamic institutions (Anderies et al., 2004). Figure 1 shows that the SES framework is composed of resource units, resource systems, governance systems and interacting actors generating outcomes that describe the impact of formal and informal institutions on the ecological and social system that shapes them. Resource units refer to common-pool resources (e.g. wetland or a component of a wetland). The resource system is the grouping of resources in a delimited entity (e.g. urban and peri-urban wetlands of Cali). The governance system includes rules, policies and activities (e.g. organization that manages wetlands). The actors have certain property-rights over the resources (e.g. users who benefit from the wetlands). Finally, outcomes are translated into measures of social, ecological and other externalities (e.g. effects on sustainable development, restoration, conservation or deterioration of wetlands and their impact on climate change) (Ostrom, 2009, 2011).

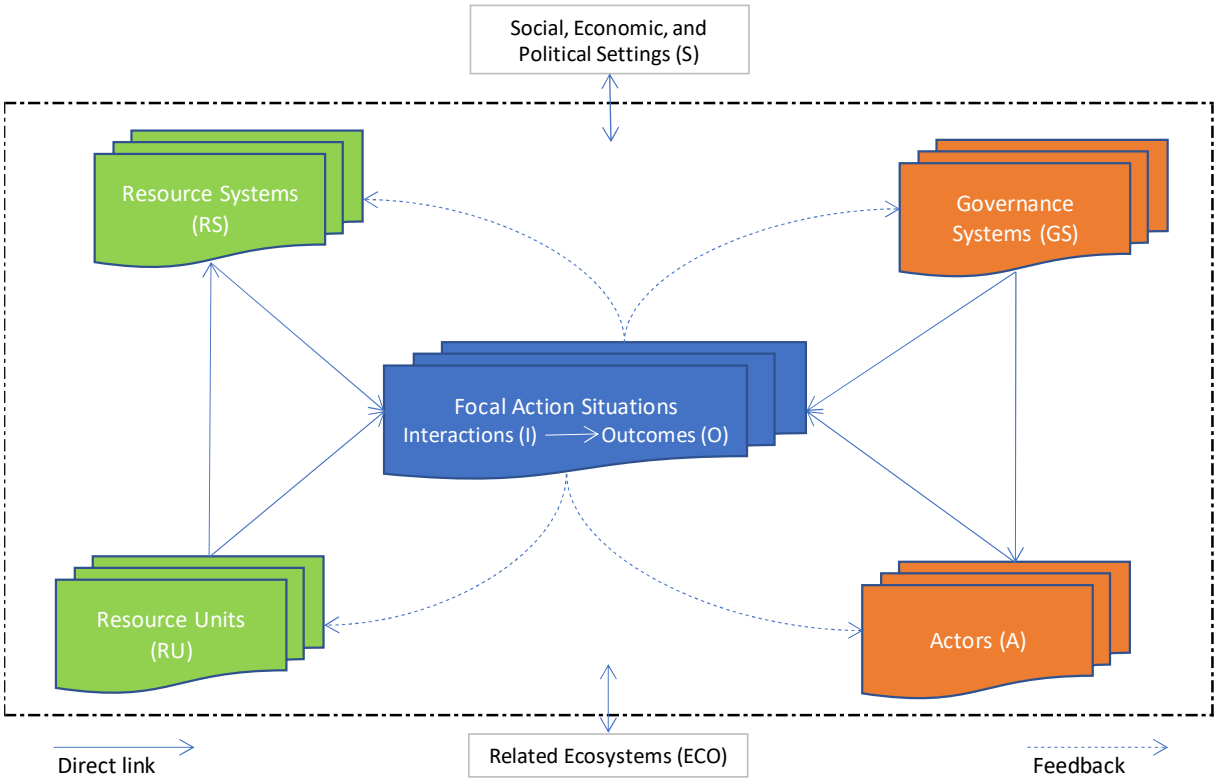

Figure 1. Structure of the social-ecological systems (SES) framework.

Note: Adapted from McGinnis & Ostrom (2014).

The SES framework includes: i) the macro level (governance system) influencing the micro level (actors) and vice versa, ii) an anthropocentric view, since the ecological system provides benefits to society, iii) reciprocity between the social system and the ecological system where actors take resources impacting the ecological system, causing externalities that revert to the social system, affecting its performance, and iv) analysis-orientated, that allows the formulation of research questions and provides a framework for the selection of variables that describe its dynamics (Binder et al., 2013).

From the point of view of ecological economics, ecosystem structures and processes interact to generate functions that are translated into ES (De Groot et al., 2002). Figure 2 shows that the ES framework proposes the ecological system and its link with the social system through the ES. The ecological system includes natural processes where the biotic and abiotic

components interact to generate functions that benefit society (De Groot et al., 2002). The social system is manifested through users who assign values, where economic, socio-cultural, ecological, and total values are included (Binder et al., 2013). The first is based on efficiency and cost-benefit analysis, the second includes perceptions of culture and social justice, the third includes ecological sustainability, and the total value includes the previous three (De Groot et al., 2002). Finally, this structure of analysis is interested in the connection between ES and different valuation methods in order to contribute to better informed decision making that feeds back into the ecological system (De Groot et al., 2002).

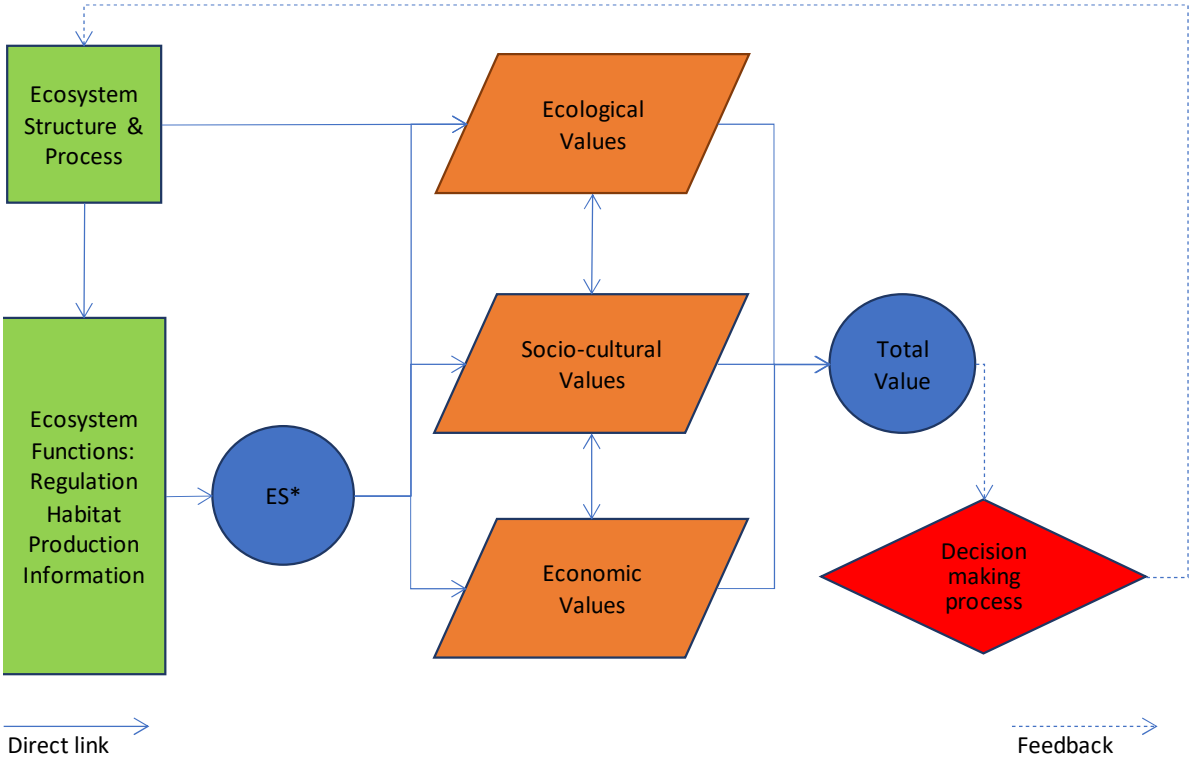

Figure 2. Structure for integrated assessment and valuation of ecosystem services (ES) framework.

Note: Adapted from De Groot et al. (2002). Note: *Ecosystem services.

The ES framework includes: i) the requirement that the use of ES should be limited to sustainable use levels, as the social system affects the ecological system; ii) an anthropocentric

view since the ecological system provides benefits to society; and iii) an analysis-oriented approach that provides research questions and a methodological framework with defined valuation methods (Binder et al., 2013).

1.4. Conceptual setting

This dissertation links the SES framework with the ES framework to propose the integral valuation of urban and peri-urban wetlands of Cali, as seen in Figure 3. This approach should be understood as wetlands that provide ES, which are in turn connected to the ecological system. Actors within the social system assign value to such ES, which feeds economic, socio-cultural, and ecological values towards an integral valuation within the context of a governance system that feeds back into decision making towards a sustainable management of wetlands. Within this context, this dissertation comprises 3 papers. The first research (Chapter 2) corresponds to the economic valuation of urban and peri-urban wetlands including the identification of ES, together with the governance characteristics. The second research (Chapter 3) involves applying the SES framework including factors that encourage collective actions and sustainable outcomes. This analysis focuses on urban and peri-urban wetlands, actors, governance systems, and ES. The third research (Chapter 4) includes monetary and non-monetary valuation of socio-cultural values of urban and peri-urban wetlands, together with collective actions and ecological outcomes. However, as the approach of this dissertation is anthropocentric it does not examine ecological values in depth.

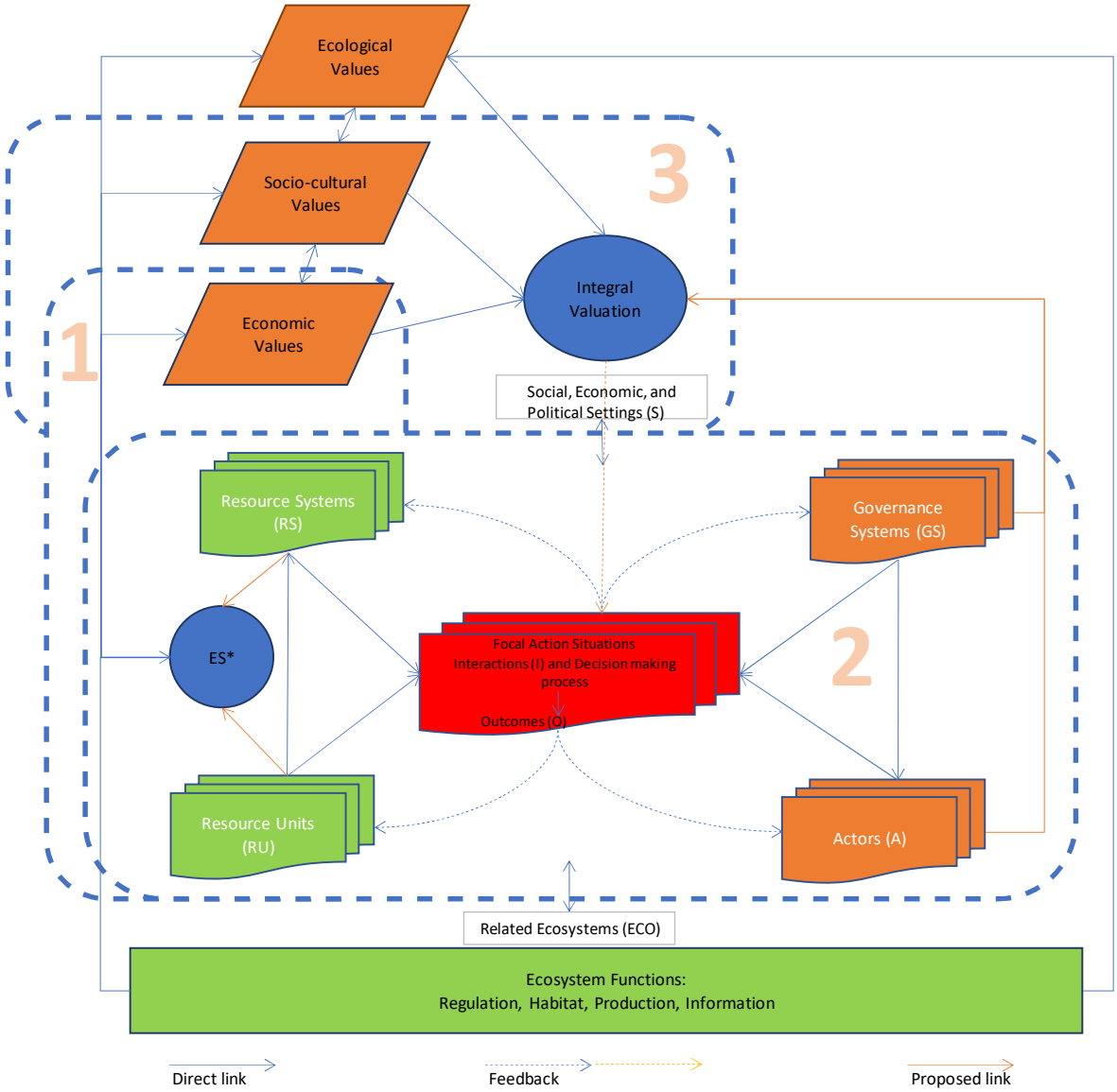

Figure 3 Conceptual approach to integral valuation of wetlands.

Note: Adapted from De Groot et al. (2002) and McGinnis & Ostrom (2014). Note: *Ecosystem services.

1.5. Structure of the dissertation and contributions

This dissertation is developed in five parts. In Chapter 1, the general introduction is presented, which includes the problem statement, objectives, research questions, conceptual framework, conceptual setting, document structure, and contributions. Following this, Chapter 2 provides an economic valuation of ES and an exploratory analysis of the governance of wetlands in Cali. Moving on to Chapter 3, this delves into a deep analysis of community-public

governance and associated ES. Chapter 4 focuses on a monetary and non-monetary valuation of cultural ES, along with the sustainable management involved. Finally, Chapter 5 presents the overall conclusions, integrating the three research components of the doctoral project.

Chapter 2 presents a monetary valuation of ES and an exploratory analysis of the governance of the urban and peri-urban wetlands of Cali. The methodology includes a benefit transfer (BT) method using the Ecosystem Services Valuation Data Base (ESVD) with a geographical information system (GIS), and an exploratory analysis of environmental, regulatory, and land use documents. Results showed that a total value for 11 ES of urban wetlands was USD 2,388,942 (72,825 USD/ha/year), while the value for peri-urban wetlands was USD 6,254,641 (28,773 USD/ha/year). In addition, 76% of the total value of wetlands is provided by ES of existence and bequest values, as well as maintenance of the life cycle of migratory species and water supply. The remaining 24% of the value corresponds to provisioning, regulating and other cultural ES. Moreover, urban areas are identified where users benefit more than areas where the population exerts greater pressure on wetlands. Lastly, weak governance is found due to the disarticulation between regulation, land use planning, and the social-ecological system. There are challenges related to property-rights, cost-benefit balance, collective agreements, monitoring, and user-centric institutions. Regulations covering sanctions, conflict resolution, and organizational rights are highlighted. The contribution of this research relies on assigning monetary values to ES of urban and peri-urban wetlands. This study also highlights the economic significance of such resources to the city and its inhabitants. This research applies the GIS-supported BT method to perform an economic valuation of wetlands as a methodology which can be easily replicated in other growing cities in Colombia and Latin America. Finally, emphasis is made of the necessity of long-term institutions that facilitate better coordination between environmental regulations, land use planning, and the social-ecological system of the city.

Chapter 3 presents an analysis of the social-ecological system and the ES involved, to identify successful governance actions in the management of urban and peri-urban wetlands of Cali. The methodology includes a case study with primary research sources from 33 semi-structured interviews and analysis of environmental, regulatory, and land use documents, as well as investments reports of the city. Results showed the identification of 22 ES from the wetlands of Cali. The ES perceptions at personal level primarily focused on livelihoods or cultural ES. At the same time, regulating, habitat and cultural ES are linked at neighborhood, community, and city levels. In addition, barriers affect collective actions and result in negative sustainable outcomes. These barriers include the large size of the resource, involvement of heterogeneous actors, exclusion of socioeconomic groups, pollution, conflicts, issues with property-rights systems, and diminished resource dependence. Conversely, facilitators promote positive outcomes through effective leadership, the understanding of SES dynamics, history of past experiences, engagement with government entities, high social capital, and community-operational choice rules. Lastly, provisioning, and cultural ES are linked with rural and urban perceptions, environmental conflicts, property-rights systems, and self-organizing activities, thus affecting sustainable outcomes. The contribution of this research focuses on highlighting the need for community-public systems to achieve success in the management of urban common-pool resources, in addition to categorizing barriers and facilitators of collective actions that positively or negatively affect urban and peri-urban wetland management in Cali. Moreover, the role of institutional facilitators and community initiatives in driving wetland recovery, as well as the barriers posed by institutional, social, and physical-ecological factors is highlighted, together with the application of the SES framework jointly with ES as a methodology to analyze urban common-pool resources in growing cities.

Chapter 4 performs a socio-cultural non-monetary and monetary valuation, to achieve sustainable outcomes and joint working between actors and governance systems. The

methodology includes primary research sources from the measurement of perceptions of value, the willingness to pay (WTP) to visit the wetland, self-organization activities and perceptions of ecological outcomes by means of 276 analyzed surveys, using bivariate and multivariate methods. The results showed that wetland location consistently exerts an effect across non-monetary valuation, monetary valuation, collective actions, and sustainable outcomes. Regarding ES, people's perceptions recognized regulating over cultural ES and socio-cultural values were perceived differently between peri-urban and urban wetlands, in addition, their perceptions recognized inspiration for culture, art and design over existence and bequest values. Considering sustainable outcomes, their perceptions also recognized the condition of the resource due to its use as the most relevant within ecological outcomes. Moreover, individual travel cost serves as a proxy for the WTP to visit the wetland ranging from USD 0.95 to USD 3.94 depending on wetland location. Furthermore, collective actions impact both non-monetary and monetary valuation. Conversely, collective actions do not impact the relationship between valuation and outcomes. Lastly, there is a positive and significant relationship between non-monetary valuation and ecological outcomes. The contribution of this research relies on providing empirical evidence of how wetland location affects perceptions of cultural ES, WTP, collective actions, and ecological outcomes. It reveals significant differences in responses between urban and peri-urban wetlands across different income levels, highlighting the influence of socioeconomic factors on non-monetary and monetary valuations, while additionally demonstrating that non-monetary valuation significantly impacts outcomes, with positive influence on their sustainability, and yielding a greater impact compared to monetary valuation. Finally, while confirming the connection between collective actions and sustainable outcomes in wetland management, their impact on valuation and outcomes nevertheless yields contrasting results which need further research.

Addressing the sustainable development goals (SDGs) adopted by the member states of the United Nations in 2015[1], this dissertation contributes to several key objectives. First, it focuses on SDG 3: Health and Well-being by emphasizing the appreciation and value of wildlife and green spaces. Users will benefit from improved quality of life through pleasant environments, which can positively impact health conditions and reduce social discontent. Second, the dissertation aligns with SDG 6: Clean Water and Sanitation by promoting wetland conservation. This effort contributes to caring for bodies of water and reducing pollution. Third, within the context of SDG 11: Sustainable Cities and Communities, wetlands are recognized for their value and their role in economic development. Fourth, SDG 13: Climate Action is addressed, as wetlands play a crucial role in capturing carbon and mitigating climate change effects. Finally, the dissertation supports SDG 15: Life on Terrestrial Ecosystems by advocating for the conservation of wetland animals and plants.

Furthermore, this dissertation relates to the policy guidelines of the Ministry of Environment and Sustainable Development of Colombia[2,] which highlights the importance of ecosystems and their impact on productive sectors and human welfare. It also seeks to generate social appropriation of contributions through DAGMA[3] for the recovery, restoration, and conservation of wetlands. Finally, this study provides added value to Cali, highlighting the benefits of wetlands, and a contribution to its sustainable development while favoring the social inclusion of the underprivileged population.

[1] As a member of the United Nations, Colombia is implementing the SDGs through its public policies.
[2] National Policy for the Integrated Management of Biodiversity and its Ecosystem Services (PNGIBSE).
[3] Administrative Department of Environmental Management of Cali.

CHAPTER 2: The Economic Value of Wetlands in Urban Areas: The Benefits in a Developing Country

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The Economic Value of Wetlands in Urban Areas: The Benefits in a Developing Country

Abstract

Urban growth has impacted natural ecosystems such as wetlands. This situation destabilizes the beneficial contributions of nature, generating a socioeconomic effect. There is a need to quantify the benefits of wetlands in developing countries and urban areas, where the growth of cities is fastest. This is the first valuation study of urban and peri-urban wetlands in Cali (Colombia). The methodology includes a benefit transfer method with a geographical information system and an exploratory governance analysis. Because there are few studies on the economic valuation of urban wetlands in Latin America, we present a methodology of interest, which can be easily replicated in other cities of this subcontinent. Based on an economic approach, our results find that 76% of the total value of wetlands is provided by ecosystem services of existence and legacy values, followed by maintenance of the life cycle of migratory species and water supply. Urban areas are identified where users benefit more than areas where the population exerts greater pressure on wetlands. Weak governance is found due to the disarticulation between regulation, land use planning, and the social-ecological system. This research contributes to urban wetland management policies, as well as to sustainable solutions in cities.

Keywords: *benefit transfer, urban ecosystem services, valuation, wetlands*

2.1. Introduction

Wetland systems support human livelihoods and are critical to sustainable development (Ramsar, 2018). Despite this, 50% of the total area of wetlands in the world has been lost

because of agricultural activities, cattle ranching, mining, the growth of cities, and other human actions (Ramsar, 2018). As a result of the degradation of wetlands in Colombia, the floods that occurred between 2010 and 2011 affected 31% of the country, generating considerable economic losses (Ricaurte & Olaya-Rodríguez, 2017). In the Cauca River Valley, 88% of the wetlands were lost, mainly because of drainage activities, land reclamation, river-channel regulation, and pollution (Ramsar, 1996). The city of Cali has 61 wetlands within its urban area and 175 peri-urban wetlands, which have been affected by change of use and a deterioration of their ecosystems (DAGMA, 2018). As in other regions and countries, the pursuit of short-run human well-being has been detrimental to biodiversity (MEA, 2005; Wang et al., 2018). With the deterioration of the wetlands in Cali, some ecosystem services (ES) have been lost (e.g., carbon sequestration—thus increasing greenhouse gases). This situation must be quantified because it means that the loss or gain of values will ultimately be reflected in society. Therefore, if the value of the benefits provided by nature is understood, we can move closer to the development of sustainable cities (Filho et al., 2020).

Although there are some studies, reports, and inventories of wetlands (Hu et al., 2017) in South America, there are few studies on the economic valuation of wetlands in Colombia (Sierra et al., 2021), none of which are conducted on urban ES valuation. A knowledge gap has therefore been identified regarding the valuation of urban wetlands in developing countries, since most of these have mainly been conducted in Europe, North America, and China (Haase et al., 2014).

ES valuation research, within the economic approach, recognizes that many of the services provided by nature are not found in the market and, therefore, their benefits have been underestimated, generating uncertainty with regard to their value (Costanza et al., 1997). In other words, it recognizes a market failure, which arises within the biodiversity field for several reasons: the market cannot make an efficient allocation of resources; there is no clear definition

of property-rights; and there are externalities that have not been included in economic models (Heal, 2020). In this research, the benefits provided by wetlands (positive externalities) are determined to construct an estimated value to facilitate their understanding and their contribution to society.

From an institutional perspective, it has been suggested that natural resources should be understood as common-pool resources (Ostrom, 2010). In other words, they are rivalrous in terms of consumption because natural resources become depleted. Nor can they be excluded because they are freely accessible to people. There is a need to develop institutional rules within social-ecological systems that allow the development of institutions that achieve optimum levels of cooperation from stakeholders (Ostrom, 2010).

This work performs a monetary valuation of urban and peri-urban wetlands of Cali from an economic approach with two specific objectives; i) to determine and value the ES of the wetlands in Cali, and ii) to explore governance characteristics for the management of the wetlands. To carry out the first, we use a benefit transfer (BT) method with a geographical information system (GIS). To the second, we apply the principles of institutional design proposed by Anderies et al. (2004).

It should be clarified that primary research is the first-best strategy in project evaluation, but when there are difficulties in carrying this out, as in the case of Cali, the benefit transfer methodology is the second-best alternative to evaluate management and policy impacts (Rosenberger & Loomis, 2000). Benefit transfer is understood as the estimation of a value from a study site to be applied to a policy site, where the former has similar characteristics to the latter (Champ et al., 2003). GIS is a technique that integrates geographically referenced information (Liu et al., 2010). Beyond using a constructive replication of the GIS-supported benefit transfer method to achieve an economic valuation of wetlands in Cali, this research proposes a starting point to apply this methodology in urban wetlands in Latin America.

The results of this study provide a basis for policy implementation in urban wetland management in developing countries. In addition, this research provides information for assessment of land use change and the impact of climate change on the city, cost-benefit analysis, ecosystem services compensation assessments, and social appropriation of knowledge, among other applications.

2.2. Materials and methods

We have based our methodological proposal on Champ et al. (2003) and Dupras et al. (2015) to create Chart 1. We merged the methodological steps and propose a new step (step 7) in our research:

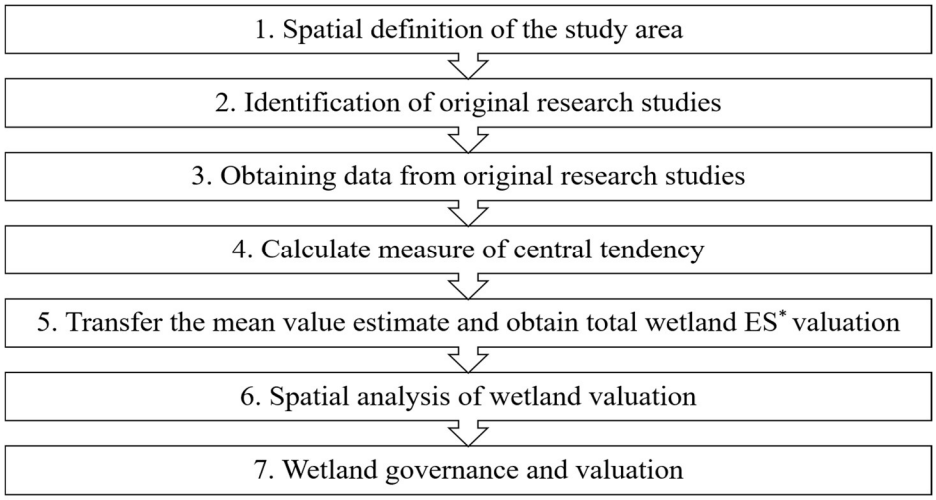

Chart 1. Methodological steps for economic valuation of wetlands in Cali.

Note: *ES: Ecosystem services. Source: Adapted from Champ et al. (2003) and Dupras et al. (2015).

Step 1: Spatial definition of the study area. First, we worked with the files of the wetland inventory maps provided by the Administrative Department of Environmental Management of Cali (DAGMA) and Spatial Data Infrastructure of Cali (IDESC). Next, the data were obtained in the R programming language with the assigned attributes in terms of wetland type (urban or

peri-urban), name, location, and area. Then we proceeded to superimpose the maps of the urban perimeter, *comunas* (a group of neighborhoods within a city), *corregimientos* (a territorial area, the jurisdiction of which depends on the municipality), rivers, streams, and wetlands to define the study area set out in Section 2.2.1.

Step 2: Identification of original research studies[4]. ES that benefit Cali were proposed by Tabares-Mosquera et al. (2020). This, therefore, was our point of reference as established in Section 2.2.2. ES-estimated values from the study site are taken from Ecosystem Services Valuation Database (ESVD) (De Groot et al., 2020). ESVD gives the values in USD/ha/year, which were standardized in 2020 in international dollars. This database includes ES from inland wetlands that fall within The Economics of Ecosystems and Biodiversity (TEEB) classification and Common International Classification of Ecosystem Services (CICES) V.5 (Haines-Young & Potschin-Young, 2018; TEEB, 2010). Therefore, the ESVD is defined as a reliable source for benefit transfer applied to this research. In addition, we have taken into account the study of Dayathilake et al. (2020) to refine our valuation of the carbon sequestration service. Last, we differentiate the value per hectare of urban and peri-urban (rural) wetlands, following the study of Chaikumbung et al. (2016), who state that urban wetlands are more valuable than rural wetlands. The authors explain these findings both by income differences and by the willingness to pay to protect wetlands among urban and rural inhabitants.

Step 3: Obtaining data from original research studies. The TEEB (2010) classification is used as a reference to obtain the estimates of ES values of the study site. To obtain values from studies with similar characteristics to the policy site, the ESVD was filtered in terms of geographic coordinates, selecting those studies located within 23° north latitude and 23° south latitude (Tropical zone between the Tropic of Cancer triangle and Tropic of Capricorn triangle

[4]Literature review is available upon request due to its size. This is in response to an external reviewer of the dissertation.

to which the Cali wetlands belong). Next, those values obtained through primary research were selected. Those corresponding to inland wetlands with local study scale located in developing countries were also selected. Moreover, aboveground and belowground carbon stock indicators from Dayathilake et al. (2020) were taken and valued. Finally, considering that the coefficient on urban wetlands of meta-regression proposed by Chaikumbung et al. (2016) is positive and statistically significant, we have taken into account this coefficient to differentiate the value of urban and peri-urban wetlands in Cali. See Section 2.2.4.

Steps 4, 5, and 6: Calculate measure of central tendency, transfer the mean value estimate, obtain total value, and spatial analysis of wetland valuation. Once the studies with the best fit for the conditions in Cali had been identified, the mean of the values obtained for each ES was calculated in USD/ha/year. Then we proceeded to calculate the total value of urban and peri-urban wetlands using Equation (3) in this paper. Next, the value of each wetland was calculated, and the maps of *comunas* and *corregimientos* were superimposed, obtaining the total valuation by zone. Last, the per capita value was obtained, considering the projected population in 2020. The results are presented in Section 2.3.

Step 7: Wetland valuation and governance. An exploratory review of the governance system in Cali was taken. The results are presented in Section 2.3.5, followed in Section 2.4.3 by the proposal of a link between economic valuation of wetlands in Cali and governance.

2.2.1. Study area

This research is located in the Valle del Cauca region in southwestern Colombia, which is one of the most biodiverse countries on Earth[5]. The River Cauca runs through the region from south to north, where swamps and marshes are common as a result of river flooding. It has fertile land suitable for agriculture, natural pastures, and livestock (DAP, 2017). Toward the

[5] See https://www.un.org/es/cr%C3%B3nica-onu/celebrando-y-salvaguardando-la-biodiversidad-para-evitar-la-siguiente-pandemia (accessed on 12 May 2022) for more information.

flat region of the valley is Cali, which stands out for its richness in bird species, which include 487 breeding residents, 72 migratory species, and 2 introduced species (Palacio et al., 2018).

The city of Cali extends into 56,168 hectares. This is located at latitude 3°27′26″ N and longitude 76°31′42″ W and lies 1079.5 m above sea level. The average temperature is 24.3 °C, and the average annual relative humidity is 77.2%. By 2020 Cali had a projected population of 2,496,442 inhabitants with a gross density of 44.56 inhabit/ha (DAP, 2019, 2020). In 2019, its GDP per capita was USD 6,474 (this value is used as a proxy in the absence of municipal accounts, which is reported by the Administrative Department of Planning of the city) (current prices) with a 4.5% share of national GDP. In 2018, the access of the population to outdoor recreational areas was 0.52 m^2/inhabitant (DAP, 2019). This figure is below the recommendations of the World Health Organization (9 m^2/inhabitant) (Camps-Calvet et al., 2016).

The research area is located within the social-ecological structure of Cali, which was defined by Tabares-Mosquera et al. (2020) taking into account land cover as a unit of analysis, as well as the urban-functional and ecological-biophysical factors of the region. Figure 4 shows the study area with 61 urban wetlands and 175 peri-urban wetlands with 33 ha and 217 ha respectively. The urban wetlands of Cali are similar in extension to the London Wetland Centre, UK (42 ha) and Kranji Marshes, Singapore (56.8 ha). The peri-urban wetlands of Cali are similar in extension to the wetlands in Sydney Olympic Park, Australia (175 ha) (WWT Consulting, 2018).

The proportion of inland waters in Colombia by thousands of hectares corresponds to 3,225 ha (inland wetlands included) compared to 2043 ha in Mexico and 38,648 ha in Latin America and the Caribbean (CEPAL, 2021).

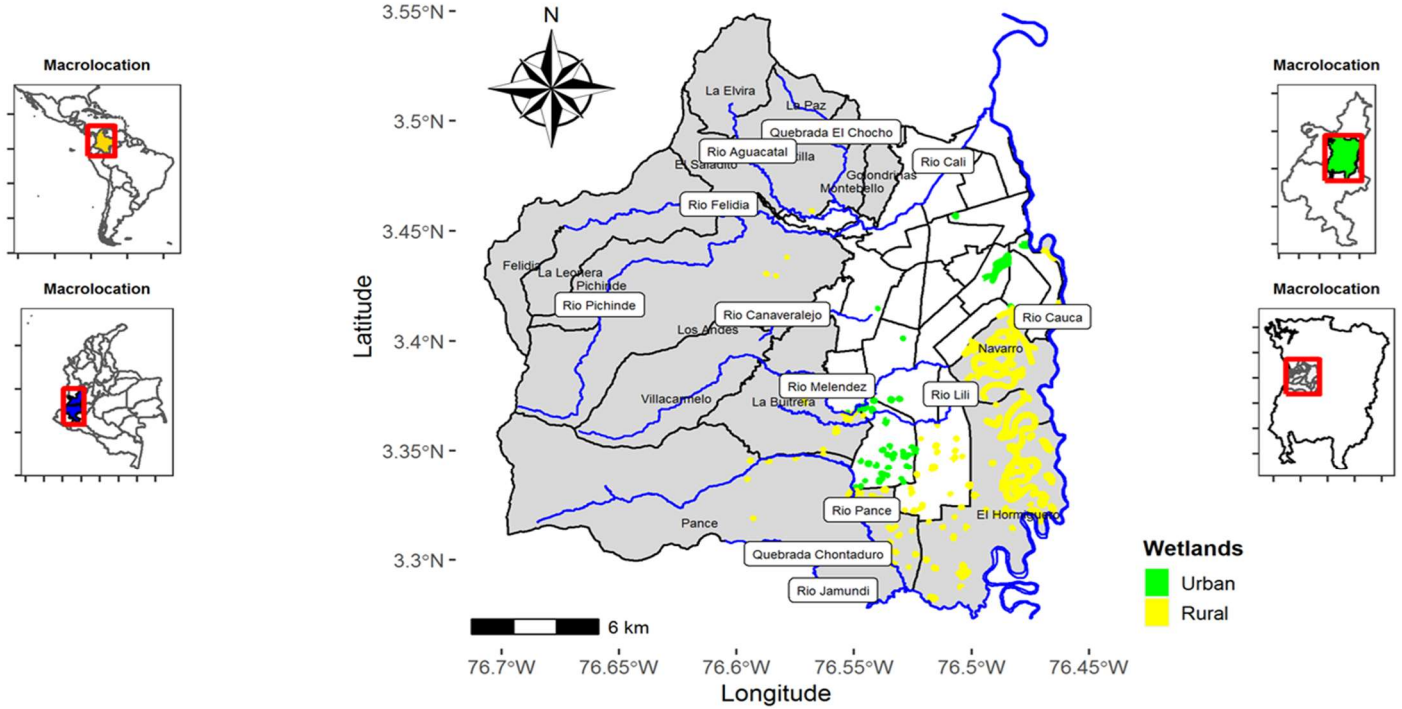

Figure 4. Study Area located in Cali (Colombia).

Note: The geographic coordinates were provided by the Spatial Data Infrastructure of Cali and the resolution 055 of 2018 by the Administrative Department of Environmental Management of Cali. The red frame corresponds to the study site at national, regional and local level. The green color in the red frame corresponds to the social-ecological structure of Cali proposed by Tabares-Mosquera et al. (2020). Both *comunas* of Cali (urban zone) and the urban expansion zone are shown in white. *Corregimientos* (peri-urban zone) are shown in gray. Rivers are shown in blue. Sixty-one urban wetlands are located in *comunas* and shown in green; 175 peri-urban wetlands are located in *corregimientos* and the urban expansion zone. These are shown in yellow. Note that most of these are small in their extension. The inventory of urban and peri-urban (rural) wetlands in Cali is available upon request.

2.2.2. Ecosystem services

Different ES taxonomies have been developed by the scientific community in conjunction with intergovernmental entities such as the Millennium Ecosystem Assessment (MEA), TEEB, European Environment Agency (EEA), and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). The economic valuation of ES of this study is based on TEEB classification with the categories: provisioning, regulatory, cultural, and habitat services (TEEB, 2010).

The characterization of ES of the wetlands in Cali is taken from the study by Tabares-Mosquera et al. (2020). This performs a non-monetary valuation of ES based on a consulting panel of experts regarding the capacity to provide and demand ES within the social-ecological system of the city. The authors propose ES of the CICES V.4.3 classification (Haines-Young & Potschin, 2013) that are applicable to the land within the area of the city.

Table 1 shows the ES valued. Note that the value estimates used correspond to 11 ES. We did not value other ES proposed by Tabares-Mosquera et al. (2020) because of a lack of data. This situation impacts the economic valuation of wetlands in Cali because there are unvalued ES.

Table 1. Ecosystem services valued in wetlands of Cali.

Group	Description*
Provisioning	Food
	Water
	Raw material
Regulation and maintenance	Climate regulation**
	Regulation of extreme events
	Water flow regulation
	Waste treatment
Habitat	Maintenance of life cycle of migratory species
Cultural	Aesthetic information
	Recreation and tourism
	Existence and legacy values

Note: *Based on the description of TEEB (2010) ecosystem services classification; **this ecosystem service relates to carbon sequestration.

2.2.3. Benefit transfer method

Benefit transfer is the application of values and/or data from one V_{Sj} study site to another that has little or no information, known as the V_{Pj} policy site (Rosenberger & Loomis, 2000). Among the categories of benefit transfer are value transfer, including measure of central tendency, point estimate and administratively approved estimate, and function transfer, including benefit function and meta-regression analysis function (Champ et al., 2003).

Benefit transfer has been widely applied in the ES valuation literature as a tool to inform policy makers (Campos et al., 2021; Zhou et al., 2020). This methodology complemented with GIS is applied in this study to perform a cross-sectional valuation. Benefit transfer with GIS includes bio-geophysical and sociodemographic elements applicable to the policy site; therefore, it is a viable alternative in the valuation of environmental goods and services (Wilson & Hoehn, 2006).

To value urban and peri-urban wetlands in Cali, a central tendency is used following the methodology of Champ et al. (2003). This is based on taking the average value from studies of the literature, which can be defined as shown in Equation (1):

$$V_{Pj}|Q_{Pj} = \bar{V}_S|\bar{Q}_S \qquad (1)$$

where V_{Pj} is the measure needed for the policy site j, given the characteristics of policy site Q_{Pj}. $\bar{V}_S$ is the measure of central tendency of the studies of study site, given the characteristics of the study site $\bar{Q}_S$. The unit of measurement of the studies is in this case USD/ha/yr.

If the measure of the central tendency being worked on is the mean as shown in Equation (2), then:

$$\bar{V}_S|\bar{Q}_S = VC_{kj} \qquad (2)$$

where VC_{kj} is the mean value of each ES for the policy site j and category k.

The total ES value of wetlands is calculated following the methodology of Dupras and Alam (2015). This is done by multiplying the total hectares by the mean value of each ES, as shown in Equation (3):

$$ESV_k = \sum_j A_k \times VC_{kj} \qquad (3)$$

where ESV_k corresponds to ES value of wetlands for category k (urban or peri-urban), A_k hectares of wetlands for category k, and VC_{kj} is the average value of each ES j in the category k.

2.2.4. Data

The ESVD and Dayathilake et al. (2020) provided the original studies presented in Table 2, which served as the basis for the benefit transfer in Cali. There are 29 studies located in 18 developing countries.

Table 2. Studies selected for the benefit transfer in Cali.

Authors°	Country	Name of wetland	USD/ha/yr*
Hanafi et al. Year 2014	Indonesia	Tapin District	72,967.5
Midora y Anggraeni. Year 2006	Indonesia	Batang Gadis National Park	38,360.0
Mukherjee. Year 2008	India	Kalobaur beel (oxbow lake)	32,955.7
Eaton y Sarch. Year 1997	Nigeria	Hadejia-Nguru wetlands	16,077.4
Ibarra et al. Year 2013	Mexico	Xochimilco	13,796.4**
Emerton et al. Year 1998	Uganda	Nakivubo	10,019.8
Kadigi et al. Year 2005	Tanzania	Usangu wetland and floodplain	6531.9
Nalukenge et al. Year 2009	Uganda	Pallisa District wetlands	5754.9
Nuva. Year 2009	Indonesia	Gunung Gede Pangrango National Park	4580.4
Karanja et al. Year 2001	Uganda	Namatala	3475.0
Kakuru et al. Year 2013	Uganda	Pallisa District wetlands	318.8
		Kyoga plains	2818.3
		Southwestern farmlands	2208.0
		Lake Victoria crescent	2205.5
Gerrard. Year 2004	Laos	That Luang Marsh	2662.4
Dayathilake et al. (2020)	Sri Lanka	Kolonnawa wetland and Thalawatugoda wetland park	1522.8***
Hap et al. Year 2000	Cambodia	Muk Kompul and Ponheur Leu Districts	320.5
Barbier et al. Year 1991	Nigeria	Hadejia-Nguru	311.2
Sención (2002)	Guatemala	Petexbatůn	244.3

Authors°	Country	Name of wetland	USD/ha/yr*
Munasinghe. Year 1993	Madagascar	Mantadia National Park	228.9
Le et al. Year 2016	Vietnam	Tam Dao National Park	137.7
Siima et al. Year 2012	Tanzania	Kilombero	77.9
Turpie et al. Year 1999	Mozambique	Barotse floodplain	75.9
		Lower Shire wetlands	21.2
Angella et al. Year 2014	Uganda	Dohu Rice Irrigation system	52.3
Abila y Othina Year 2006	Kenya	Yala Wetland	51.2
Loth. Year 2004	Cameroon	Waza Logone	42.6
Kasthala et al. Year 2008	Tanzania	Mtanza-Msona village wetlands	15.2
Mireri et al. Year 2008	Kenya	Tana River Delta	7.5
Geta et al. Year 2015	Ethiopia	Dechatu drainage basin	3.9
Roy et al. Year 2012	India	Bhomra Beel	0.6
Setlhogile et al. Year 2010	Botswana	Makgadikgadi wetland	0.6
Manlosa et al. Year 2013	Philippines	Layawan Watershed	0.1

Note: *International dollars. Year 2020; **this value includes carbon sequestration valuation = 421.34 USD/ha/yr; ***aboveground carbon stock = 46.63 tC/ha, belowground carbon stock = 7.24 tC/ha and price EU allowances (EUA) = 28.27 USD/t; °studies and data are taken from the Ecosystem Services Valuation Database by De Groot et al. (2020) and Dayathilake et al. (2020).

Notice that the study site valuations differ widely. Despite their location in developing countries, only two have been performed in Latin America (Mexico and Guatemala). This situation confirms the need to carry out valuations of urban wetlands in South America. Furthermore, these studies are evaluating different kinds of ES. For this reason, the methodology of BT adopted by this research takes into account the mean value of each ES (94 value estimates in our case), as was explained in Section 2.2.3.

As we have mentioned before, the literature indicates that the economic value of urban wetlands is different from rural wetlands, being that urban wetlands more valuable (Chaikumbung et al., 2016). This is why we carried out our urban wetland valuation taking into account the estimated coefficient of urban wetlands from meta-regression economic valuation by Chaikumbung et al. (2016). That is 2.531 (statistical significance at the 5% level of subgroup without marine); this coefficient shows that if there are urban wetlands, wetland values increase by approximately 2.531 times. See results in Section 2.3.1.

2.3. Results

2.3.1. Valuation

The benefit transfer method allowed us to obtain the mean for 11 ES and 94 value estimates, whose description was taken from TEEB (2010). Table 3 and Table 4 present the results of the Cali urban and peri-urban wetland valuation, which is USD 8,643,583. On one hand, the total value of urban wetlands is USD 2,388,942 (72,825 USD/ha/year). On the other hand, the total value of peri-urban wetlands is USD 6,254,641 (28,773 USD/ha/year). Urban and peri-urban wetland valuations represent 28% and 72% of total value, respectively. The lower proportion of the value of the former is a consequence of their smaller quantity and extension.

Table 3. Total value of urban wetlands in Cali.

ES*	N**	Minimum USD/ha/yr °	Maximum USD/ha/yr	St. Deviation USD/ha/yr	Mean USD/ha/yr	Total° Urban (33 ha)
Provisioning						
Food	24	0.52	65,000	13,904	5003	164,102
Water	23	0.10	81,073	22,955	9261	303,807
Raw material	25	1.03	40,692	8518	3342	109,636
Regulation and maintenance						
Climate regulation	2	1066	3854	1971	2460	80,709
Regulation of extreme events	1	0.37	0.37	NA ***	0.37	12
Water flow regulation	3	4.87	449	253	156	5128
Waste treatment	7	11	24,509	9210	3627	118,973
Habitat						
Maintenance of life cycle of migratory species	2	348	33,379	23,356	16,864	553,195
Cultural						
Aesthetic information	1	1.02	1.02	NA***	1.02	33
Recreation and tourism	4	5.14	11,593	5725	3008	98,684
Existence and legacy values	2	29,019	29,185	118	29,102	954,662
	94	30,457	289,736		72,825	2,388,942

Note: *Ecosystem services; **number of value estimates; ***does not apply; °international dollars. Year 2020.

Table 4. Total value of peri-urban wetlands in Cali.

ES*	N**	Minimum USD/ha/yr °	Maximum USD/ha/yr	St. Deviation USD/ha/yr	Mean USD/ha/yr	Total ° Peri-Urban (217 ha)
Provisioning						
Food	24	0.20	25,682	5494	1977	429,647
Water	23	0.04	32,032	9069	3659	795,416
Raw material	25	0.41	16,077	3366	1320	287,044
Regulation and maintenance						
Climate regulation	2	421	1523	779	972	211,309
Regulation of extreme events	1	0.15	0.15	NA***	0.15	32
Water flow regulation	3	2	177	100	62	13,425
Waste treatment	7	4	9684	3639	1433	311,492
Habitat						
Maintenance of life cycle of migratory species	2	138	13,188	9228	6663	1,448,356
Cultural						
Aesthetic information	1	0.40	0.40	NA***	0.40	87
Recreation and tourism	4	2	4580	2262	1189	258,371
Existence and legacy values	2	11,465	11,531	47	11,498	2,499,462
	94	12,034	114,475		28,773	6,254,641

Note: *Ecosystem services; **number of value estimates; ***does not apply; °international dollars. Year 2020.

The highest valuations obtained are those of existence and legacy values (40%), maintenance of the life cycle of migratory species (23%), and water supply (13%). The first results can be understood as the heritage of future generations. In line with this, the land use plan of Cali (POT, 2014) includes wetlands as conservation and environmental protection areas. The second findings can be interpreted as the evidence of having shelter for animals. This is why bird watching is a common activity in Valle del Cauca[6]. The latter results suggest that wetlands in Cali have the potential to provide water for the inhabitants.

The following services are in lower proportions (24%). These values are understood as the potential to provide natural resources (11%), regulation services (9%), and cultural services

[6] See https://ebird.org/region/CO-VAC?yr=all (accessed on 10 May 2022) for more information.

(4%) to the city. Addressing regulation services, it should be clarified that carbon sequestration (climate regulation service) represents 3% of total valuation. This finding shows that the more wetlands are lost, the more greenhouse gas emissions increase. Moreover, in 2018, Latin America and the Caribbean reported 32% of greenhouse gas emissions by agriculture (CEPAL, 2021). Thus, loss of wetlands and agricultural activities in the Valle del Cauca region are probably responsible for a greater impact of climate change at the local level.

The differential between the value of urban and rural wetlands can be explained by ecosystems found in peri-urban areas, which are subject to greater pressures caused by the occupation of territories by new housing developments, different types of governance, and different preferences between rural and urban inhabitants (Hassan et al., 2019; Mombo et al., 2014; Nagendra & Ostrom, 2014). Additionally, perceptions of ES change from being perceived as livelihoods and local cultural amenities, in the case of rural wetlands, to aesthetic and recreational activities in urban areas (D'Souza & Nagendra, 2011; Garnett, 2012).

2.3.2. Spatial analysis

The valuation of wetlands in Cali is analyzed by taking into account their distribution by *comunas* and *corregimientos*. Figure 5 shows that the highest total value areas are between 445,879 and 3,906,323 USD/year. The lowest total value areas are between 663 and 5,809 USD/year. These findings can be interpreted as the more wetlands there are, the more ES are available to Cali. Furthermore, the findings show from which places ES are supplied—in other words, which are the critical ecological zones. For instance, *Comuna* 22 has 50 urban wetlands and *Comuna* 13 has the biggest urban wetland in the city; thus, those wetlands have the highest ES valuation. Moreover, those wetlands have a potential to improve the quality life of people and biodiversity by promoting cultural services and shelter for species.

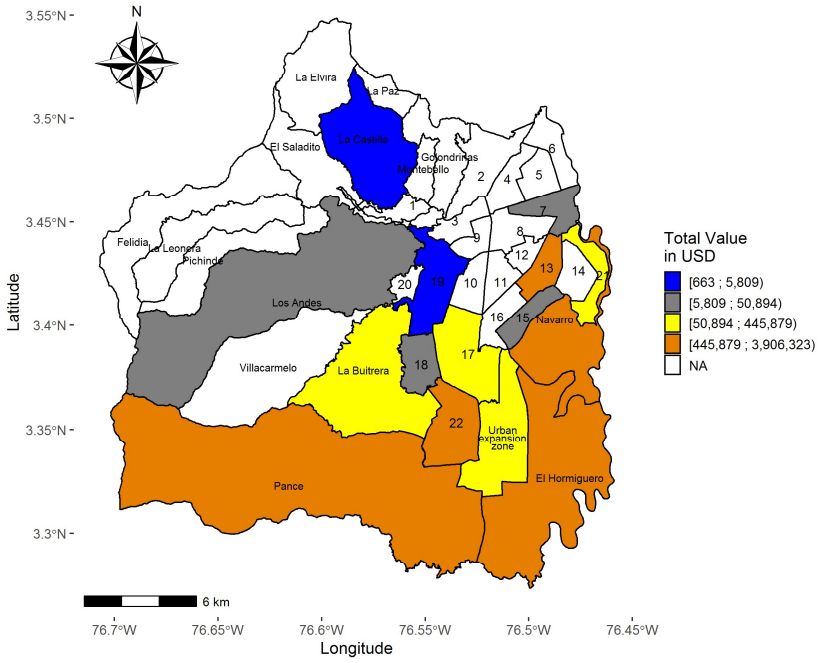

Figure 5. Total valuation of wetlands by *comunas* and *corregimientos*.

Note: The high-value areas are highlighted in brown. The low-value areas are highlighted in blue. Note that *comunas* are numbered between 1 and 22. The *corregimientos* are indicated by their proper name. There are no wetlands in zones that are shown in white.

In addition, in Figure 6, we analyze and show the distribution of the value of the wetlands among the population of the *comuna*s, *corregimientos*, and urban expansion zone. Note that Figure 5 and Figure 6 show a change in the incidence of the value that is due to the number of inhabitants in each zone. For instance, in Figure 6, the incidence of the value of wetlands is higher in *Corregimientos* La Castilla and Los Andes, owing to its low population density. Moreover, in *Comunas* 13, 15, and 17, which have the highest population concentrations in the city, the incidence of the value of wetlands is lower. This can be interpreted as the existence of areas where users enjoy greater benefits compared to others, where the population exerts greater pressure on the wetlands. Last, the per capita value of the urban expansion zone is likely to decline if housing projects threaten wetlands.

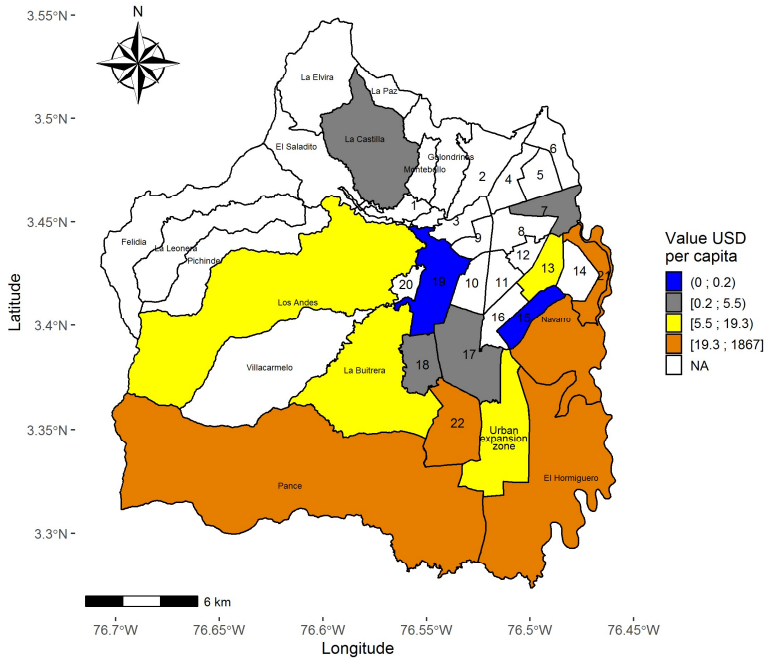

Figure 6. Valuation of wetlands per capita.

Note: The high-value and low population density areas are highlighted in brown. The low-value areas and high population density are highlighted in blue. Note that *comunas* are numbered between 1 and 22. The *corregimientos* are indicated by their proper names. There are no wetlands in zones that are shown in white.

2.3.3. Robustness

Based on findings in the literature, which show a negative relationship between wetland value and wetland area (Chaikumbung et al., 2016; Woodward & Wui, 2001), an additional filter is applied to the data selected. In this way, the wetland area of the source studies is restricted by selecting those smaller than 6,000 ha, a dimension that includes two valuations in Latin America (Ibarra et al., 2013; Sención, 2002). Twenty-seven value estimates were obtained, in seven ES, for wetlands located in eight developing countries. We proceeded to carry out benefit transfer as shown in Tables 5 and 6 and obtained a value of 76,827 USD/ha/year and 30,354 USD/ha/year for urban and peri-urban wetlands, respectively. The results coincide with Chaikumbung et al. (2016) and Woodward and Wui (2001), where having

smaller wetland areas has an increase in valuation. Additionally, the values obtained are similar to the benefit transfer of this research presented in Table 5 and Table 6.

Table 5. Total value of urban wetlands in Cali with area constraint.

ES*	N**	Minimum USD/ha/yr °	Maximum USD/ha/yr	St. Deviation USD/ha/yr	Mean USD/ha/yr	Total ° Urban (33 ha)
Provisioning						
Food	8	6	5218	2101	2071	67,932
Water	3	79	78,842	45,459	26,351	864,422
Raw material	8	10	40,692	14,115	5806	190,451
Regulation and maintenance						
Climate regulation	2	1066	3854	1971	2460	80,709
Water flow regulation	1	449	449	NA***	449	14,713
Waste treatment	4	37	24,509	12,133	6311	207,022
Habitat						
Maintenance of life cycle of migratory species	1	33,379	33,379	NA***	33,379	1,094,962
	27	35,026	186,943		76,827	2,520,211

Note: *Ecosystem services; **number of value estimates; ***does not apply; °international dollars. Year 2020.

Table 6. Total value of peri-urban wetlands in Cali with area constraint.

ES*	N**	Minimum USD/ha/yr °	Maximum USD/ha/yr	St. Deviation USD/ha/yr	Mean USD/ha/yr	Total ° Peri-urban (217 ha)
Provisioning						
Food	8	2	2062	830	818	177,856
Water	3	31	31,151	17,961	10,411	2,263,199
Raw material	8	4	16,077	5577	2294	498,633
Regulation and maintenance						
Climate regulation	2	421	1523	779	972	211,309
Water flow regulation	1	177	177	NA***	177	38,521
Waste treatment	4	15	9684	4794	2493	542,018
Habitat						
Maintenance of life cycle of migratory species	1	13,188	13,188	NA***	13,188	2,866,789
	27	13,839	73,861		30,354	6,598,324

Note: *Ecosystem services; **number of value estimates; ***does not apply; °international dollars. Year 2020.

2.3.4. Legal framework

There are guidelines that contain the regulations that address the management of wetlands in Cali. First, there is the Convention on Wetlands of International Importance (Ramsar Convention). Colombia committed to the Ramsar Convention through Law 357 in 1997. Nationally, the Political Constitution of Colombia protects natural resources, regulates their exploitation, and creates control agencies. There are policies related to the integrated management of water resources such as the 2002 National Policy for Inland Wetlands. There is also the 2012 National Policy for the Integrated Management of Biodiversity and its Ecosystem Services (PNGIBSE). Regionally, the 2007 Agreement No. 038 of the Regional Autonomous Corporation of Valle del Cauca (CVC) declares the natural wetlands of the Valle del Cauca as a renewable natural resource reserve. Locally, the land use plan of Cali (POT, 2014), defines the conservation and environmental protection areas of the city that include water sources, surface streams, and wetlands.

This legal and regulatory framework provides the formal rules governing the management of urban and peri-urban wetlands in a centralized manner. This situation poses challenges to the collective actions that could contribute to wetland management, as well as enhancing the capacity of cities to promote environmental culture, which is the case studied by Nagendra and Ostrom (2014) in peri-urban wetlands in Bangalore, India.

2.3.5. Governance

By reviewing the environmental management plans of wetlands available in Cali, an exploratory review of principles of institutional design proposed by Anderies et al. (2004) was undertaken. The analysis shows that governance is weak in Cali; for example, there are issues to be solved in property-rights, proportional equivalence in costs and benefits, efficient collective choice agreements, integrated monitoring indicators, and institutions adapted to the

needs of users. The existence of regulations covering graduated sanctions, conflict resolution mechanisms, and recognition of organizational rights is highlighted.

Clearly defined boundaries: Twenty-two percent of the city's urban wetlands are located on private land and 78% on public land. This means that there are users who do not have the right to enjoy the benefits of some wetland ES located on private properties. We are faced here with an unresolved problem of property-rights and social justice.

Proportional equivalence between benefits and costs: Thirty-one percent of the urban wetland area is located in *Comuna* 22 where the socioeconomic level corresponds to the highest in the city. The wetlands in other areas are in poor condition and have a higher incidence of hostile actors such as gangs or criminality (CVC, 2006, 2010, 2017). Despite that the wetlands of the city are protected, 27 are located in the urban expansion zone where housing activity is permitted. That is, these wetlands are in danger of being lost.

Collective choice agreements: There is representation of the population for wetland management. This is the case of the community action boards, local action boards, and committees that represent the community and environmental organizations. On the other hand, a lack of organization among communities occurs in wetland areas where there is limited supply of institutional services, as well as irregular settlements, and marginalization of these ecosystems in urban planning, among others (CVC, 2010, 2017).

Monitoring: The legal framework corresponds to political-administrative limits that go against the areas of environmental influence (Tabares-Mosquera et al., 2020). This encompasses areas that go beyond the boundaries of the department of Valle del Cauca. Connections and shared ecological monitoring with other local authorities are needed to carry out actions in regions that share ecological structures.

Gradual sanctions*:* The legal framework defines the uses of wetlands and water bodies, as well as the consequences of noncompliance (The Nature Conservancy et al., 2016).

Conflict resolution mechanisms: The legal framework includes instruments for conflict resolution (The Nature Conservancy et al., 2016).

Minimum recognition of organizational rights*:* Users have access to existing community action boards, local action boards, and on local and civic organizations. In *Comuna* 22, an outstanding case is that of water-user associations recognized as social stakeholders of the wetlands (DAGMA, 2012a, 2012b).

Nested enterprises: The institutions are perceived as rigid and often slow to respond, leading to inappropriate policy decisions (CVC, 2010).

In line with this, because of the weak governance that has been found, policy and decision makers in Cali are not well-informed. Insufficient attention is given to the economic valuation of wetlands in Cali as an input in project assessment. Therefore, if the benefits of wetlands are unknown, the cost-benefit analysis would not sufficiently take into account the benefits of biodiversity. For instance, a decision maker who is unaware of the economic value of maintenance of the life cycle of migratory species will not realize that birds will be impacted if a housing project is approved where a wetland exists. Consequently, the economic cost of damage could be higher than the benefits of the construction project.

2.4. Discussion

2.4.1. Comparison with other research

Table 7 shows the average value per ES of wetlands: i) developing countries, 236–6620 USD/ha/year/ES; ii) developed countries, 2942–7403 USD/ha/year/ES; and iii) global 2279 USD/ha/year/ES. On one hand, the meta-regressions by He et al. (2015) and Chaikumbung et al. (2016) show that the value of wetlands in developing countries is lower than in developed countries. This can reflect findings that explain that the value of wetlands is influenced by the level of development of the country, showing a higher value in those countries with higher

GDP (Chaikumbung et al., 2016). On the other hand, in developing countries, the valuation of peri-urban wetlands in Cali presents values lower than those obtained by Ibarra et al. (2013) in Mexico City for the urban wetland of Xochimilco. This can be explained by the fact that evidence has been found where urban wetlands have a higher value than rural wetlands. This is due to urban residents having higher incomes than rural inhabitants, in addition to having different preferences. Citizens with higher incomes are also more willing to pay to protect wetlands (Hassan et al., 2019; Mombo et al., 2014). Furthermore, the valuation of urban wetlands in Cali presents values that are higher than Ibarra et al. (2013). This can be understood by the findings in the literature that show a negative relationship between wetland value per hectare and wetland area (Chaikumbung et al., 2016; Woodward & Wui, 2001). Notice that the wetland of Xochimilco in Mexico is larger than the urban wetlands of Cali. At the same time, the value of urban wetlands obtained by Liu et al. (2010) is lower than our value of urban wetlands. This can be due to urban wetlands in New Jersey being larger than urban wetlands in Cali.

Table 7. Valuation compared to other research.

Authors	Country	Wetland	ha*	Method **	Year +	USD/ha/yr ++	ES°	USD/ha/yr/ ES ++
Costanza et al. (1997)	Global	Generic	330,000,000	BT	1997	22,790	10	2279
Liu et al. (2010)	New Jersey, NJ, USA	Urban	329,608	BT, GIS	2004	11,769	4	2942
He et al. (2015)	Quebec, Canada: Africa, North America Asia, Europe Australia	Rural and urban: Man-made, isolated, complex	NA ***	MRA, GIS	2014	22,208 °°	3	7403
Chaikumbung et al. (2016)	Developing countries: Asia, Africa, Latin America, Pacific Islands	Rural and urban: Estuarine, riverine, marine, artificial, lacustrine, marshy among others	NA***	MRA	2002	2829 °°	12	236
Ibarra et al. (2013)	Mexico	Urban	2614	RC, MP	2020	13,796	3	4599
This study	Cali, Colombia	Urban	33	BT, GIS	2020	72,825	11	6620
This study	Cali Colombia	Peri-Urban	217	BT, GIS	2020	28,773	11	2616

Note: *Hectares; **BT: benefit transfer, GIS: geographical information system, MRA: meta-regression analysis, RC: replacement cost, MP: market prices; ***does not apply; +year of reported value; ++ international dollars. Year 2020; °assessed ecosystem services; °°average per hectare value calculated from the meta-analysis database.

However, the average value per ES in Cali is higher than Costanza et al. (1997). This can be attributed to the fact that this study performed worldwide valuations that do not report urban wetlands. Finally, the mean value of the studies analyzed by Chaikumbung et al. (2016) includes rural and urban wetlands that mostly reflect valuations performed in Southeast Asian countries. They provide values that are very different from those obtained by Ibarra et al. (2013) and the benefit transfer performed in Cali.

Regarding our methodological approach, one of the applications of the GIS-supported benefit transfer method in scientific literature consists of the combination of a land cover layer with another that represents the geography, which can be connected with ES facilitating their assessment (Liu et al., 2010). In the context of our economic valuation, this methodology permits the analysis of physical and sociodemographic variables, such as the wetlands area and inhabitants around wetlands. As a result, we obtained the value of wetlands by zone, as well as

per inhabitant. The first encourages policy makers to achieve policies for peri-urban wetlands (e.g., ecotourism), urban wetlands (e.g., appropriation of knowledge), and *comunas* of Cali (e.g., improvement of environmental culture). The second can be used as a starting point for payments of ecosystem services in the protection and conservation programs of wetlands.

2.4.2. Convergent validity and transfer error

The concept of convergent validity has been discussed in the literature in the context of the benefit transfer applied to ES assessment. Thus, validity refers to the degree to which a construct is adequately measured. In this case, the construct refers to the estimate derived from the original study site, which is a proxy for the true value (Liu et al., 2010). There are two ways to determine whether the measurements are valid: compare the value transferred with the value of an original study site conducted in the study area and compare two transferred values to determine the variability of the valuations (Rosenberger & Loomis, 2000). Since there is no primary valuation study for wetlands in Cali, the second alternative is chosen to identify the convergence between the valuation performed and the benefit transfer calculated from another study with similar characteristics to the research area.

Validity is linked to the error generated during the process of benefit transfer in ES valuations. Plummer (2009) identifies generalization error as the main source of errors in this methodology; there are uniformity error, sampling error, and regionalization error. The first occurs when it is assumed that the value of an ES is constant regardless of the land cover being analyzed. The second occurs with the bias in the selection of source studies (since the availability of these studies is sometimes very limited and there are few measurements). The third occurs when small study areas are taken as a reference, which may not be representative for extrapolation to a wider region (Eigenbrod et al., 2010). Additionally, error measurement involves errors associated with the estimation of values of the source studies, which is linked

to the methodology and quality of the study, and those inherent in the transfer process (Brouwer et al., 1999; Liu et al., 2010).

It is therefore necessary to ensure that the information is accurate and valid. Equation (4), proposed by Champ et al. (2003), shows one way of measuring the accuracy of benefit transfer in which the error associated with benefit transfer is:

$$V_{Ti} = V_{Pj} + \sigma_{ij} \qquad (4)$$

where V_{Ti} corresponds to the transferred value from study site i, V_{Pj} is the required value for policy site j, and σ_{ij} is the transfer error. The error is calculated as the difference between the known value and the transferred value, measured in absolute percentage. In Equation (5), established by the same authors, the absolute error is:

$$\%\sigma_{ij} = \left|\left(\left(V_{Ti} - V_{Pj}\right)/V_{Pj}\right)\right| \times 100 \qquad (5)$$

As mentioned above, to identify the convergent validity of the benefit transfer of this research, two transferred values are compared to determine the variability of the valuations and the equations described are used to measure the transfer error. First, we selected the study by Ibarra et al. (2013) conducted in Mexico City. They performed a monetary valuation of the Xochimilco urban wetland for three ES: waste treatment, climate regulation, and maintenance of the life cycles of migratory species. Second, we proceeded to perform benefit transfer based on the value of 13,796 USD/ha/year from Ibarra et al. (2013). Third, benefit transfer was carried out based on the estimates of ES values selected from our database for the three ES mentioned. Fourth, the variation between the two valuations was identified, finding an absolute error of 34% for peri-urban wetlands and 66% for urban wetlands. This is within the range of 4% to 191% found for wetlands by Morrison and Bennett (2000).

Finally, it should be clarified that the uniformity error for this study is limited by taking value estimates from studies originating only from wetlands, so that ES values from other land

cover are not involved. With regard to the sampling error, study selection bias has been declared because benefit transfer methodology requires obtaining studies with context characteristics similar to those in the policy site, which in this study are wetlands located in tropical zones in developing countries and continental areas. The regionalization error is dealt with by taking into account that the source studies include inland wetlands at a local level, but with a larger extension than the Cali wetlands. Therefore, it is expected that characteristics of small contexts will not be reflected in the value of the wetlands of the city. On the other hand, the error of the source studies is reduced because we worked with an ESVD database that has a peer-review process, as well as published papers.

2.4.3. Economic valuation and governance

The economic valuation and governance system in Cali can be interpreted through the frameworks for integrated assessment and valuation of ecosystem services (De Groot et al., 2002) and social-ecological systems (McGinnis & Ostrom, 2014). The first framework takes into account ES that provide benefits to society (e.g., wetlands offer ES to Cali), as well as actors who assign economic, sociocultural, and ecological values to the ES. The second considers unit resources (e.g., a wetland), system resources (e.g., urban wetlands), governance systems, and actors. All of these interact with action situations that produce social and ecological outcomes (e.g., sustainable development and conservation policies of wetlands).

The above indicates that in the case of Cali, economic valuation is an input that interacts with actors and the governance system. As a result of these interactions, decision making is carried out to produce outcomes such as policies. To illustrate, because of the highest valuation of existence and legacy values and maintenance of the life cycles of migratory species, decision makers could enhance conservation policies, ecotourism, and the environmental culture in the city. Tabares-Mosquera et al. (2020) confirms that these ES are relevant to the city. Therefore, there is a need for policies that are focused on these issues.

Kabil et al. (2022) propose policies to enhance ecotourism and environmental education in protected areas through economic valuation, as a policy to support local, regional, and national economies. The wetlands of Cali are also considered as areas of conservation and environmental protection. These policies could thus stimulate economic activities in the city.

Addressing the subject of weak governance in Cali, the centralized government has to move toward governance that is more inclusive and well-informed. On one hand, decision makers must encourage collective actions where inhabitants' points of view are taken in wetland management policies. On the other hand, policy makers should pay special attention to the provisions of the land use planning, since approving changes in land use with misinformation could be detrimental to wetlands.

For the abovementioned reasons, findings of this research can be applied to urban wetlands from developing countries (e.g., Latin America). By encouraging wetland protection and restoration programs, local authorities could develop green infrastructure projects to compensate for areas where wetlands are absent or scarce. Likewise, by promoting greater community participation, social appropriation of the benefits of wetlands could be encouraged. As a result, these policies would foster environmental culture among city residents.

2.5. Conclusions

Using benefit transfer and supported by data provided by GIS, this study carried out a total valuation of 61 urban wetlands and 175 peri-urban wetlands in Cali, covering an area of 250 ha. The wetlands are part of the environmental influence area that provides ES to the city, benefiting the population, businesses, and institutions. The total annual value of wetlands in Cali is estimated as USD 8,643,583. Seventy-six percent of the total value of the wetlands is provided by the ES for existence and legacy values, maintenance of the life cycles of migratory species, and water supply. The per capita value of wetlands depends on the distribution of the

population in the *comunas* and *corregimientos* of the city. The economic valuation is an approximate estimate that provides information on the benefits of wetlands, thus being a better alternative to not recognizing any value of these ecosystems. An exploratory analysis of governance suggests the need for a regulatory framework that aims at wetland protection, and which includes noncompliance with regulations, dispute settlement, and legal recognition of users.

The results of this research have theoretical, methodological, and public policy implications. The theoretical implications have to do with the identification and valuation of positive externalities provided by wetlands, which benefit society without users paying for them. The methodological implications refer to the constructive replication of the GIS-supported benefit transfer method to perform an economic valuation of wetlands. This is not an end in itself, since it requires developing and applying integral valuation methodologies that make it possible to understand their monetary and non-monetary dimensions. The implications in terms of public policies are directed at the need to design dynamic institutions that allow for better coordination between environmental regulations, the land use plan, and the social-ecological system of the city. This requires governance built on an understanding of the benefits provided by wetlands that places the needs of all users before particular short-run interests. For example, despite the national and regional legal framework that has guidelines related to the sustainable management of wetlands in the urban expansion zone, 27 wetlands are being pressured by housing projects. That is because the land use plan has allowed construction projects in this area.

Regarding the limitations of this work, the economic valuation should be interpreted with caution, owing to the small number of studies found with similar characteristics to those of Cali (of which there are only two in Latin America). Selection bias is declared because the sample of source studies is not chosen randomly. Additionally, the assessment of the wetland area does

not include the hydrological complex of rivers and streams that feed them, which is due to data limitations. Last, it should be clarified that governance analysis is exploratory, and it requires confirmatory empirical studies that could emerge as lines of research derived from this work.

This research is positioned as a starting point for urban wetland valuation studies in Colombia, as well as in Latin America. Research into valuations of the loss of ES is needed. An empirical analysis of the differences between urban and rural wetlands, in terms of user preferences and benefits is also necessary. Finally, it is necessary to continue research on the valuations of urban wetlands in developing countries to generate contributions to the development of their governance systems.

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CHAPTER 3: The Social-ecological System Framework of Urban Wetlands: The Role of Collective Management at Local Level

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The Social-ecological System Framework of Urban Wetlands: The Role of Collective Management at Local Level

Abstract

Wetlands play a key role in facing biodiversity loss. Despite this, in developing countries, these resources suffer from a mismatch between public institutions and ecological systems, as well as different preferences and governance systems in urban and rural areas. This work aims to apply Ostrom´s framework to identify ecosystem services in urban and peri-urban wetlands and their connections with factors that encourage collective actions and sustainable outcomes. This is a case study located in the city of Cali (Colombia), and the methodology includes 33 semi-structured interviews and the analysis of documents. Our research links provisioning and cultural ecosystem services with rural and urban perceptions, environmental conflicts, property-rights systems, and self-organizing activities. Leadership, networking, and social capital positively influence collective actions and encourage sustainable outcomes, while the existence of excluded socioeconomic groups, larger size of the resource, low wetland dependence, and pollution patterns negatively affect both collective actions and outcomes. Community and public agency collaboration is crucial, enhancing local governance efficiency and fostering a culture of environmental protection.

Keywords: collective actions, governance, social-ecological system, urban wetlands, urban ecosystem services

3.1 Introduction

Urban growth exerts pressure on ecosystems such as wetlands, which are essential for human livelihood and sustainable development (Ramsar, 2018). In developing countries, growth rates for population and land occupation are higher than in developed countries (Angel, 2017); furthermore, by 2050 Latin America will account for 88%[7] of the population living in urban areas, higher than the European Union with 84%[8].These facts imply a higher consumption of natural resources, generating significant impacts on ecosystems. Despite the fact that Latin America has almost 60% of the world´s terrestrial life (UNEP-WCMC, 2016), this is a region in which their natural ecosystems are threatened, due to change of land use and agricultural expansion (IPBES, 2019). Moreover, ecosystems located in peri-urban areas are subject to greater pressures, different forms of governance, and conflicting preferences between rural and urban inhabitants (see Bangalore, India in Nagendra & Ostrom, 2014; in Spain, Doñana in Méndez et al., 2012). This is the case of the city of Cali (Colombia), which has 250 hectares of urban and peri-urban wetlands affected by the sprawl of the city, and the monoculture of sugar-cane (DAGMA, 2018). This situation has resulted in several problems, such as loss of biodiversity and connectivity of wetlands, pollution, the exclusion of rural and urban groups from management decisions, and property-rights system issues (CVC, 2006, 2010).

This study considers the social-ecological system (SES) framework (McGinnis & Ostrom, 2014), which has been applied to analyze cooperative governances and community-based systems as a successful alternative in the sustainable management of

[7] See https://statistics.cepal.org (accessed on 11 May 2023) for more information.
[8] See https://population.un.org/wup/Download/ (accessed on 11 May 2023) for more information.

common-pool resources (Ostrom, 2009). Wetlands are commons that share the attributes of the rivalry of private goods, and the difficulty of exclusion of public goods, therefore, markets or conventional state management do not guarantee efficiency (Ostrom, 2010).

The SES approach has been mainly used to investigate forestry, grasslands, wildlife, fisheries, and irrigation systems (Frey, 2017). However, limited research has been carried out on urban wetlands considering ecosystem services (ES) (e.g., Nagendra & Ostrom, 2014; Ban et al., 2015), which are subject to rights arrangements, analyzable via the SES framework. Also, there are few published studies regarding ES and economic valuation of wetlands in Colombia (Díaz-Pinzón et al., 2022; Sierra et al., 2021), nevertheless, they do not link these with the SES. In addition, there is a need for studies on cooperative governance in cities experiencing rapid growth (Herrera, 2024; Mukhija, 2005), as well as in connecting ES and the SES framework with emphasis on sustainability (Partelow & Winkler, 2016).

The SES framework is used to establish which actions in governance have been successful in the wetlands of Cali with the aim of: i) identifying ES and their connections with collective actions and variables of the SES and sustainable outcomes, and ii) evaluating factors that potentially affect collective actions and sustainable outcomes. To achieve this, a case study is carried out through 33 semi-structured face-to-face interviews with users, social leaders and key informants, as well as the analysis of documents.

This study applies the SES framework, which provides variables that influence collective actions, which are understood hereafter as the process of chanelling efforts towards the common interest as well as obtaining benefits resulting from these efforts (Brady & Ratajczyk, 2015; Marshall & Scott, 1998). Also, this research includes ES, which are understood hereafter as the direct and indirect benefits that ecosystems provide to society (Costanza et al., 1997). Thus, we consider both collective actions and ES

because they are key in the understanding of sustainable outcomes. Finally, the SES framework allows us to understand property-right system issues in the wetlands of Cali, which currently experience conflicts[9] in the access to, and the use of the resource. Empirical data from both urban and rural wetlands and watersheds indicates that the resource size, pollution, and low social capital act as constraints to collective actions, consequently yielding suboptimal ecological outcomes (Amblard, 2021; Nagendra & Ostrom, 2014). Furthermore, the exclusion of socioeconomic groups such as fishermen, gatherers, and migrants, affects the self-organization of social-ecological systems (D'Souza & Nagendra, 2011). In line with this, in our research we discuss whether these assertions are evident.

The significance of this study lies in the recognition of the usefulness of joint community-public systems as an important form of governance in urban common-pool resources. This represents an opportunity to enhance the relationship between humans and nature in cities, by involving more people in the management of their ecosystems, where local governments play a key role in this regard (Colding, 2011).

The questions that guided this research are: firstly, what have the successful actions in wetlands governance been between the community and public bodies in Cali? and secondly, in what way and how are the ES of wetlands of Cali perceived, and what is their relationship with self-organization activities? To tackle these questions, we have updated the insights and techniques developed by Elinor Ostrom and her co-authors regarding the study of successful actions in wetland governance. As with Nagendra & Ostrom (2014), in the following sections we apply the SES framework to analyze variables of self-organization activities and discuss ES supplied by 8 wetlands of Cali. Subsequently, we

[9] This term refers to conflicts among stakeholders, including environmental, excluding armed conflicts.

categorize these as barriers to, or facilitators of collective actions that generate sustainable outcomes. Finally, we identify attributes of participative governance in wetland management that can be useful in similar cities in developing countries.

3.2. Theoretical background

The SES framework is a variable-oriented structure for understanding common-pool resources (see Figure 7). The framework considers resource units, resource systems, governance systems and interacting actors generating outcomes and feedback to the system. Resource units refer to elements from a resource system, which is the grouping of resources in a delimited entity. The governance system includes rules, policies and activities, influencing actors who have certain property-rights over the resource. Outcomes are translated into measures of social, ecological and other externalities. In addition, exogenous variables, i.e., social, economical and political settings as well as those related to the ecosystems exert effects on the system (McGinnis & Ostrom, 2014; Ostrom, 2009, 2011).

From an anthropocentric view, the SES framework enables us to understand how the governance system influences actors and vice versa, where actors withdraw resources impacting the ecological system, causing externalities, and affecting its sustainability (Binder et al., 2013). Moreover, by means of the SES framework, research can be applied to determine the success or failure of SES, as well as how the social system can avoid the destruction of natural resources. Hence, sustainability is understood through long-term institutions for governing common-pool resources and avoiding a shift in the ecological system to a state that is unable to sustain human life (Anderies et al., 2004).

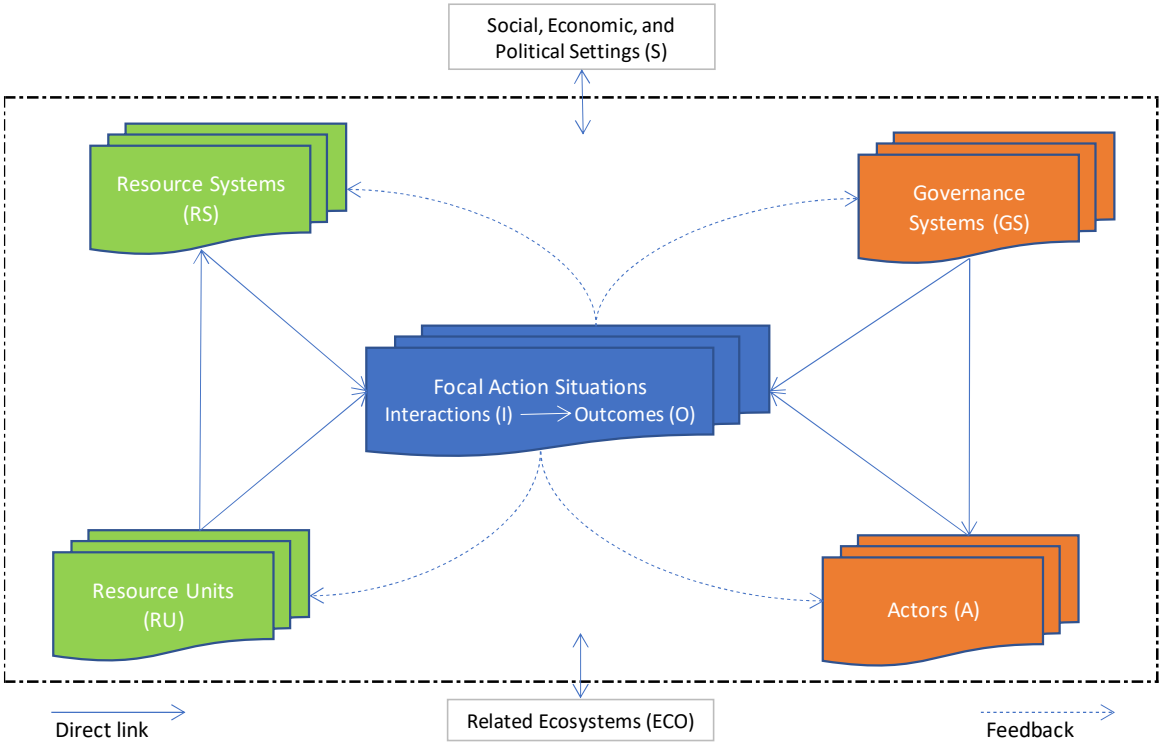

Figure 7. Structure of the social-ecological systems (SES) framework.

Note: Adapted from McGinnis & Ostrom (2014).

Our initial focus was on 9 variables associated with collective actions on the successful management of common-pool resources, as well as 2 variables related to outcomes (Ostrom, 2009). The variables are consistent with the methodological proposal of Delgado-Serrano & Ramos (2015), who analyze 3 case studies in Latin America (one of these in Colombia). Furthermore, it was found that all of these variables have affected collective action and ecological performance in urban and peri-urban wetlands in Bangalore, India (Nagendra & Ostrom, 2014); thus, we consider them to be crucial to this study. One additional variable related to ecosystems was considered because the presence

of pollution patterns in some wetlands of Cali is relevant (CVC, 2006, 2010). The initially selected variables[10] are shown in Table 8.

Table 8. Initially selected variables for social-ecological system (SES) of wetlands in Cali.

First-tier variables[1]	Second-tier variables[1]	Third-tier variables[1]
Resource systems (RS)	RS3 – Size of resource system	
Governance systems (GS)	GS5 – Operational-choice rules	
Actors (A)	A1 – Number of relevant actors	
	A2 – Socioeconomic attributes	A2(a) Socioeconomic groups excluded
	A5 – Leadership/entrepreneurship	
	A6 – Norms (trust-reciprocity)/social capital	
	A8 – Importance of resource (dependence)	
Interactions (I)	I8 – Networking activities	I8(a) Networking with government
	I9 – Monitoring activities	
Outcomes (O)	O1 – Social performance measures (e.g., efficiency, equity, accountability, sustainability)	O2(a)[2] Quality of the units
	O2 – Ecological performance measures (e.g., overharvested, resilience, biodiversity, sustainability)	O2(b)[2] Maintenance of the resource
		O2(c)[2] Condition of the resource due to the use
Related ecosystems (ECO)	ECO2 – Pollution patterns	

Note: Adapted from McGinnis & Ostrom (2014) and Nagendra & Ostrom (2014); [1]According to the classification of the SES framework; [2]Based on coding questions by Brady & Ratajczyk (2015).

Furthermore, the Integrated Valuation and Assessment of Ecosystem Services framework (De Groot et al., 2002) considers ES as the link between the ecological and social systems. The ecological system includes natural processes where biotic and abiotic components interact to generate functions that benefit society, and the social system is manifested through actors who act as value instruments of ES (De Groot et al., 2002). From an anthropocentric view, in this framework the ecological system provides benefits

[10] The potential relevance of initially selected variables is explained in Appendix A Table A.1.

to society, therefore the use of ES should be limited to sustainable levels (Binder et al., 2013).

Addressing the benefits of wetlands to society, these range from freshwater renewal for human consumption, fishing as a subsistence activity, waste treatment, tourism destinations, to non-commercial benefits that may exceed those of a commercial nature (MEA, 2005). Based on The Economics of Ecosystems and Biodiversity (TEEB) ES classification, we worked on provisioning, regulating, habitat and cultural ecosystems services[11] (TEEB, 2010).

3.3. Study area

This research is conducted in the city of Cali (Colombia), which is located in the Valle del Cauca region, in the south-west of the country. Its wealth of water is visible across 47 watersheds and in its network of wetlands, forests and mangroves. The region has 50% of all bird species found in the country, which amounts to about 10% of all birds found in the world, more than in Europe and the United States[12]. In the Global Big Day 2022, the Valle del Cauca was the principal tourist destination for bird watching in Colombia[13].

In 2023 Cali has a projected population of 2,297,230 inhabitants, and of these, 98% live in the municipality, and the remainder in surrounding rural communities. In 2021, its GDP per capita in current prices was USD 6,317 (a proxy in the absence of municipal accounts) (DAP, 2022). In 2021, the percentage of people living in poverty in Cali was 29.3% (DAP, 2022). This figure is higher than the poverty headcount ratio at national

[11] The initially selected variables are shown in Appendix A Table A.2.
[12] See https://visitvalle.travel/eventos.html (accessed on 11 May 2023) for more information.
[13] See https://ebird.org/globalbigday (accessed on 11 May 2023) for more information.

poverty lines for Spain or Germany, which in 2020 registered 21.7% and 16% respectively[14].

The Valle del Cauca region is a place where environmental conflicts flourish. For instance, intensive exploitation of sugar-cane monoculture has brought social and ecological impacts, such as increased corruption, unemployment, land expropriation, atmospheric pollution, loss of biodiversity, deforestation, water pollution, and reduction of ecological/hydrological connectivity, among others[15].

In this context, the wetlands of Cali extend into 250 hectares, of which 13% are urban and 87% peri-urban (DAGMA, 2018). The research area is shown in Figure 8 where built-up and crop zones surround wetlands. We focus on 4 urban wetlands, i.e., Charco Azul, La Babilla-Zanjón del Burro, Javeriana and Acequia Grande, as well as 4 peri-urban wetlands, i.e., Las Garzas, Pacheco, Hormiguero complex and Club Farallones. Socioeconomic features of these are shown in Table 9.

Table 9. Grid for the selection of wetlands.

Wetland	Low-income level[1]	High-income level[1]
Urban on public land	(1)	(2)
Urban on private land		(3)(4)
Peri-urban on public land		(7)
Peri-urban on private or public land	(5)(6)	(8)
Total	3	5

Note: (1) Charco Azul, (2) La Babilla-Zanjón del Burro, (3) Javeriana, (4) Acequia Grande, (5) Pacheco, (6) Hormiguero complex (Cascajal, El Diablo, Cauca Viejo), (7) Las Garzas, (8) Club Farallones; [1]Zone of the city in which the wetland is located.

[14] See https://data.worldbank.org (accessed on 11 May 2023) for more information.
[15]See https://ejatlas.org/print/sugar-cane-cauca-valley-colombia?translate=es (accessed on 11 May 2023) for more information.

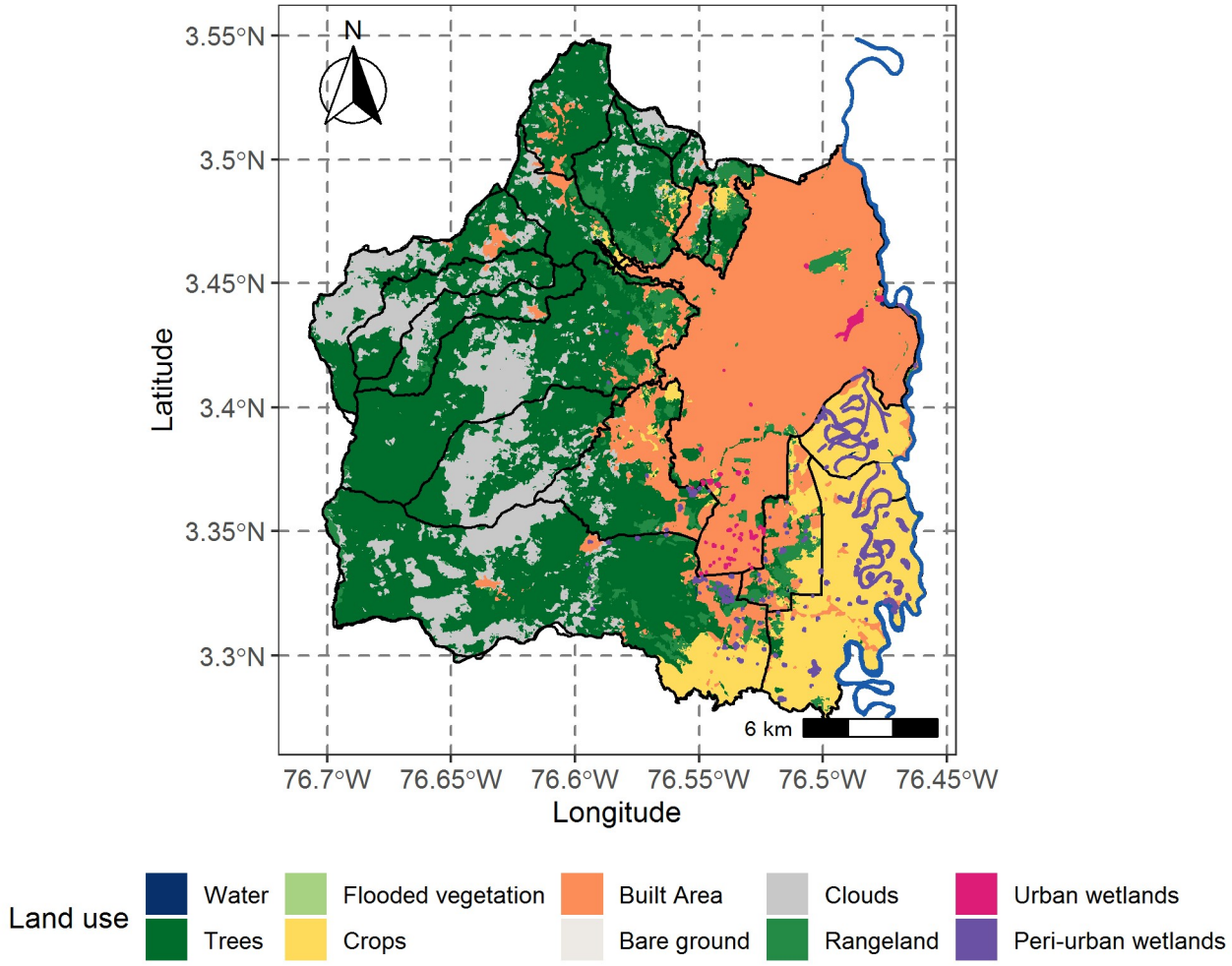

Figure 8. Study area located in Cali (Colombia).

Note: The geographical coordinates were taken by the European Monitoring Centre of 2018 and the Spatial Data Infrastructure of Cali and resolution 055 of 2018 by the Administrative Department of Environmental Management of Cali. The built-up area of Cali is shown in orange. Urban wetlands are shown in purple. Peri-urban wetlands are shown in violet. Cauca river is shown in blue. Note that most of the wetlands are small in their extension. The inventory of urban and peri-urban wetlands is available upon request.

3.4. Methodology

This study adopts a robust qualitative approach to achieve the research objectives and understand the mechanisms that shape ES, collective actions and sustainable outcomes in the selected wetlands. We conduct a case study to thoroughly analyze situations in which self-organization activities occur, as well as moments in which ES of wetlands are perceived and related with these situations. The empirical evidence obtained with this approach yields great depth and richness. Face-to-face semi-structured interviews together with analysis of documents provide data collection relating to the previously listed variables in Table 8. These data are analyzed following a qualitative content analysis procedure (Mayring, 2014). This procedure was performed using the ATLAS.ti software. The coding process considered the CPR Coding Manual, the Design Principles Coding Manual, and the TEEB ES classification (Brady & Ratajczyk, 2015; Ostrom et al., 1989; TEEB, 2010).

3.4.1. Scope of analysis

The theoretical framework from pre-existing literature enables us to identify the criteria for selection and pre-screening of the potential units of information as well as the variables of interest (Verd & Lozares, 2016). We employ the maximum variation criterion (Patton, 2015) for selecting the wetlands in this research, that is to say that the wetlands selected are different in their conditions of urban and rural governance systems, in their property-right systems issues and have a heterogeneity of actors involved. The list of urban and peri-urban wetlands of Cali chosen is shown in Table 9 and Table 10.

Table 10. Wetlands chosen for the analysis.

Wetland	Description
Urban	Charco Azul and La Babilla-Zanjón del Burro are located in lower and higher socioeconomic levels. They are included in Resolution[16] 1350 from 2018 and Agreement[17] 521 from 2021 for the adoption of environmental management plans for prioritized wetlands and protected areas.
	Javeriana and Acequia Grande represent the academic and residential sector. They are subject to property-rights that restrict their use by users.
Peri-urban	Pacheco and Hormiguero complex are included in the 2014 Land Management Plan Article 273 as management of areas threatened by flooding from the Cauca River.
	Las Garzas is also included in Resolution 1350 from 2018.
	Club Farallones represents the private club sector and is subject to property-rights that restrict their use by users.

3.4.2. Units of information

We focus our research on men and women (>18 years of age), who are users, social leaders, other leaders, and key informants involved in a certain way with the chosen wetlands. The purposive sampling of users, leaders and social leaders uses socioeconomic profile as control variables, and gender to obtain equity-related perceptions. A total of 29 individuals were selected (55 % men and 45% women) in wetlands located in high or low-income levels[18] as well as urban and peri-urban areas (see Table 11).

[16] Administrative act of a public body deciding on situations of specific interest.
[17] Decisions by city council that perform a certain act or comply with an institutional norm.
[18] Areas of the city according to the economic stratification of public services regulated by the national constitution. Strata 1-2 (low-income level), strata 3-4 (medium-income level), strata 5-6 (high-income level).

Table 11. Selection grid of units of information.

Wetland	Subtotal	Low-income level		High-income level	
		Men	Women	Men	Women
Urban public					
Charco Azul	8	2	2		
La Babilla-Zanjón del Burro				2	2
Urban private					
Javeriana	6			2	2
Acequia grande				2	0[1]
Peri-urban					
Pacheco		2	2		
Hormiguero complex	15	2	2		
Las Garzas				2	2
Club Farallones				2	1[1]
Subtotal by type		6	6	10	7
Subtotal by income levels			12		17
Total				29	

Note: [1]Women not available or willing to take part in the study.

The purposive sampling of key informants corresponds to the functional areas of Administrative Department of Environmental Management of Cali (DAGMA). We selected 4 key informants, making a grand total of 33 units of information[19].

3.4.3. Fieldwork, data analysis and trustworthiness

Fieldwork was undertaken between March and September of 2022. Interviews were carried out with selected individuals from Monday to Friday or at weekends, at the time arranged with interviewees. Thus, data collection was obtained from 33 face-to-face semi-structured interviews, the interviews were recorded, and notes were also taken. The interviews had two different guidelines[20], the first for the interviews with users, leaders or social leaders who interact with wetlands, and the second for the interviews with key informants from the environmental authority. The guidelines were focused on the ES and

[19] See the profile of individuals in Appendix B.
[20] See the guidelines in Appendix C.

disservices associated with wetlands as well as the initially selected variables. The guidelines also focused on perceptions regarding resource management and the governance system of wetlands.

The content analysis began with the identification of recordings from interviewees, followed by encoding. As the process progressed, further and relevant variables were emerging to generate new categories, and subsequently identify relationships among variables. These new categories were added to the initial list of categories stemming from the literature review. At the same time as the interviews were carried out, an analysis of documents was performed out using sources from environmental authorities, the local municipality and legal norms. The information obtained allows us to understand the temporal and special context between interviews and selected wetlands.

The following strategies were used to enhance the trustworthiness as well as ethical principles of the study. First, all interviewees gave their authorization to perform the semi-structured interviews. Second, data collections were made by only one researcher. Third, the coding process, analysis and interpretation of data were carried out under supervision of the same researcher. Finally, validation of information provided by interviews was accomplished with study of documents, web pages and field visits [21].

3.5. Analysis and results

3.5.1. Context

The wetlands of Cali have a set of direct and indirect actors involved in different ways (CVC, 2006, 2010). First, direct actors include users, private sector and community

[21]See the information validation sources in Appendix D.

organizations with different roles in monitoring access to, and the use of, the resource. In peri-urban zones, diverse actors create power imbalances that adversely affect users. Rural inhabitants that have lost access to wetlands and suffer pollution resulting from sugar-cane production exemplify unequal power distribution. Second, indirect actors include social actors (e.g., universities, non-governmental organizations, government and international organizations), all of which are related to direct actors and/or wetlands. In addition, different governance systems define and set environmental rules for actors and their relationship with these ecosystems (CVC, 2006, 2010). These include the environmental authority DAGMA, Municipal Companies of Cali, the Regional Autonomous Corporation of Valle del Cauca and National Parks of Colombia (DAGMA, 2018). However, overlaps among them must be taken carefully because the effectiveness of a governance lies in the alignment with local ecology, evolution of rules, and whether users perceive it as legitimate and fair (Ostrom, 2010).

The wetlands of Cali have had periods influenced by social, institutional, economic, and serendipitous events over time, which have had negative or positive effects on the environmental condition of the resource and their relationship with users:

- Between 1938 and 1951 political violence displaced many families from rural areas to the city (CVC, 2006, 2010).
- In 1958 the draining of lands at risk of flooding for industrial agricultural use and expansion of the city, and the construction of the main drainage system of Cali (CVC, 2006, 2010).
- During the 60s and 70s, the creation of the Navarro landfill (today closed) (CVC, 2006, 2010).

- The environmental conflict generated by the construction of La Salvajina[22] dam in 1985.
- The new illegal settlement in Navarro, near the Pacheco wetland at the moment of this study (stated by some interviewees).
- In 1995 the American Airlines disaster[23] defined self-organization activities in Las Garzas
- In 2012 restoration activities started in Charco Azul (CVC, 2010).

Considering design principles of institutions (Anderies et al., 2004), the governance system of Cali is weak with regard to property-rights systems, rules-in-use, collective-choice agreements, systematic monitoring, and networking within and between public agencies (Díaz-Pinzón et al., 2022; Herrera, 2024). For instance, the environmental authority seems unlikely to deal with the wetlands located in private properties due to conflicting property-rights, or contradictory rules-in-use between land use and protection of wetlands (POT, 2014).

3.5.2. Relevant variables

Interviews provide findings regarding the initially selected variables of Table 8, as well as others related to governance systems, actors and interactions including property-rights systems, knowledge of the SES, conflicts, and self-organization activities[24] (see Table 12). The most important aspects are related to how property-rights systems and governance systems shape the relationships between community and institutions. First,

[22] See https://ejatlas.org/conflict/represa-la-salvajina-colombia (accessed on 11 May 2023) for more information.
[23] A Boeing 757-223 crashed in the mountains of Buga, Colombia. As a result, 4 out 155 passengers survived from the 965 flight. See https://www.elpais.com.co/especiales/accidente-vuelo-965/ (accessed on 11 May 2023).
[24] See the intensity of variables among interviewees within each wetland in Appendix E.

urban wetlands located in public lands show involvement on the part of the community, while urban wetlands located in private lands do not achieve participative governance. Second, wetlands located in high-income levels as well as private lands have more favourable ecological outcomes than those located in low-income levels. Lastly, peri-urban wetlands with fuzzy property-rights systems and contradictory governance systems negatively affect participative governance as well as ecological and social outcomes.

Table 12. Main variables identified in social-ecological system (SES) of wetlands in Cali and descriptive analysis.

First-tier variables	Second-tier Variables	Third-tier Variables	(U) Public		(U) Private		(P)Public	(P) Public or private	(P)Public	(P)Private
			Low-income level	High-income level	High-income level		Low-income level		High-income level	
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Resource system (RS)	RS3 – Size of resource system[1]		Large(-) 7.5	Moderate 0.9	Small 0.4	Small 0.2	Large(-) 7.0	Large(-) 138.4	Moderate 0.8	Large 6.7
Governance systems (GS)	GS4 – Property-rights system		Define relations	Define relations	Limit access	Limit access	Limit access	Limit access	Define relations	Limit Access
	GS5 – Operational-choice rules		Public/ community/ irregular settlements	Public/ community	Private /public	Private /public	Irregular settlements /private/ public	Private/ public	Public/ community	Private/ Public
	GS8 – Monitoring and sanctioning rules		Existence of norms	Existence of norms	Existence of norms	Existence of norms	Existence of norms	Existence of norms	Existence of norms	Existence of norms
Actors (A)	A1 – Number of relevant actors[2]		Large 306.0		Moderate 24.3		Small 3.7	Small 1.1	Small 0.5	
	A2 – Socioeconomic attributes	A2(a) – Socioeconomic groups excluded	Yes	Latent	Not reported	Latent	Yes	Yes	Not reported	Latent

First-tier variables	Second-tier Variables	Third-tier Variables	(U) Public		(U) Private		(P)Public	(P) Public or private	(P)Public	(P)Private
			Low-income level	High-income level	High-income level		Low-income level		High-income level	
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	A3 – History or past experiences		Present	Present	Present	Present	Present	Present	Present	Present
	A5 – Leadership/entrepreneurship		Present	Present	Present	Present	Present	Present	Present	Present
	A6 – Norms (trust-reciprocity)/social capital	A6(a) – formal	Low	High	High	High	Low	Low	High	High
		A6(b) – informal	High	High	Low	High	High	High	High	Low
	A7 – Knowledge of SES/mental models		Present	Present	Present	Present	Present	Present	Present	Present
	A8 – Importance of resource (dependence)	A8(a) – Economic dependence	Moderate	Low	Low	Low	Disrupted	Disrupted	Low	Low
		A8(b) – Personal benefit (well-being)	High	High	High	High	Disrupted	Disrupted	High	High
Interactions (I)	I2 – Information sharing		Present	Present	Present	Present	Present	Present	Present	Present
	I3 – Deliberation processes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	I4 – Conflicts		High	Moderate	Low	Low	High	High	Low	Low
	I5 – Investment activities[3]	I5(a) – Public investment activities	Moderate		Moderate		Low	Low	High	
			4,303.2		2,971.6		572.4	561.4	20,060.7	

First-tier variables	Second-tier Variables	Third-tier Variables	(U) Public		(U) Private		(P)Public	(P) Public or private	(P)Public	(P)Private
			Low-income level	High-income level	High-income level		Low-income level		High-income level	
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		I5(b) – Own investment activities	Not reported	Yes	Yes	Yes	Not reported	Not reported	Yes	Yes
	I7 – Self-organizing activities		Yes	Yes	Not reported	Yes	Yes	Yes	Yes	Yes
	I8 – Networking activities	I8(a) With government	High	High	Moderate	Low	High	High	High	Low
		I8(b) With non-government organizations	Moderate	Low	Not reported	Not reported	Moderate	Not reported	Low	High
		I8(c) With social networks	High	High	Low	Low	Low	Low	High	High
		I8(d) With neighbours	High	High	Moderate	Moderate	High	High	Moderate	Moderate
	I9 – Monitoring activities	I9(a) – Informal monitoring activities	Present	Present	Present	Present	Present	Present	Present	Present
Outcomes (O)	O1 – Social performance measures		Low(+)	High	Not reported	Not reported	Low	Low	Moderate	Not reported
	O2 – Ecological performance measures	O2(a) Quality of the units	Moderate(-)	Moderate (-)	High	High	Moderate (-)	Low	Moderate (-)	High

First-tier variables	Second-tier Variables	Third-tier Variables	(U) Public		(U) Private		(P)Public	(P) Public or private	(P)Public	(P)Private
			Low-income level	High-income level	High-income level		Low-income level		High-income level	
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		O2(b) Maintenance of the resource	Moderate	Moderate	High	High	Moderate (-)	Low	High	High
		O2(c) Condition of the resource due to the use	Improved	Improved	Improved	Improved	Worsen	Worsen	Improved	Improved
Related ecosystems (ECO)	ECO2 – Pollution patterns		High(-)	Low	Low	Low	High	High	Low	Low

Note: (U) Urban, (P) Peri-urban; (1) Charco Azul, (2) La Babilla Zanjón del Burro, (3) Javeriana, (4) Acequia Grande, (5) Pacheco, (6) Hormiguero complex, (7) Las Garzas, (8) Club Farallones; [1]Hectares; [2]Inhabitants/hectare for *comuna*[25] or *corregimiento*[26] in which the wetland is located; [3]Total public budget in COP million (1USD =3,743.09COP) for *comuna* or *corremiento* (DAGMA, 2018; DAP, 2022); (-) and (+) indicated negative or positive changes through the years; blue color indicates descriptive analysis for initially selected variables.

[25] A group of neighborhoods within a city.
[26] A territorial area, the jurisdiction of which depends on the municipality.

3.5.3. Barriers and facilitators affecting collective actions and ecosystem services

According to the interviews the size of the resource, dependence on the resource, excluded socioeconomic groups, social capital, networking with government, and leadership are the main barriers to, or facilitators of collective actions. In addition, property-rights systems, pollution patterns and self-organizing activities are the main factors with effects on ES.

In line with Nagendra & Ostrom (2014), barriers or facilitators belong to the physical-ecological, social, and institutional categories, therefore we categorize the variables highlighted by interviewees in these fields (see Figure 9). Social barriers include the number of relevant actors (A1), excluded socioeconomic groups (A2a), and conflicts (I4). Institutional barriers include property-rights systems (GS4). Physical-ecological barriers include the size of resource system (RS3), and pollution patterns (ECO2).

Social facilitators include history or past experiences (A3), leadership/entrepreneurship (A5), norms (trust-reciprocity)/social capital (A6), knowledge of SES/mental models (A7), information sharing (I2), deliberation processes (I3), investment activities (I5), self-organizing activities (I7), and monitoring activities (I9). Institutional facilitators include monitoring and sanctioning rules (GS8) and networking activities (I8). Lastly, there are factors that could be facilitators or barriers depending on the situation such as operational-choice rules (GS5), and the importance of the resource (dependence) (A8).

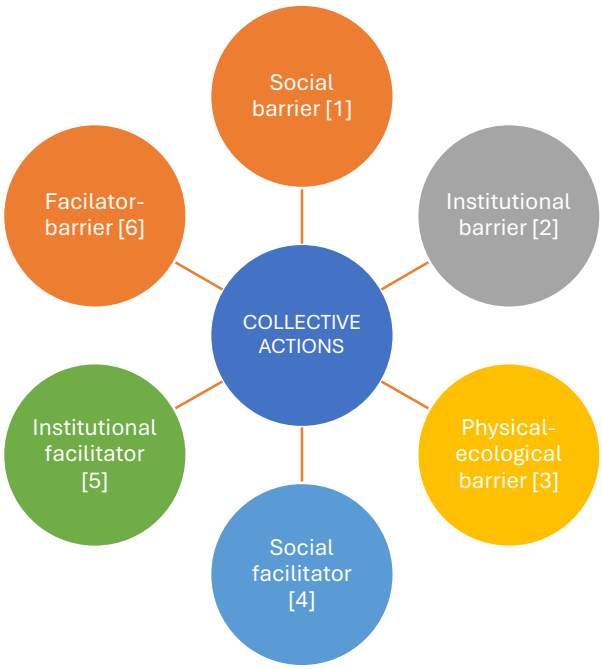

Figure 9. Barriers to and facilitators of collective actions in selected wetlands.

Note: Barriers
[1] (A1), (A2a), (I4)
[2] (GS4)
[3] (RS3), (ECO2)
Facilitators
[4] (A3), (A5), (A6), (A7), (I2), (I3), (I5), (I7), (I9)
[5] (GS8), (I8)
Barrier-facilitator
[6] (A8), (GS5)

Furthermore, we found relationships between barriers, facilitators and ES. Barriers to collective actions such as lower dependence on the resource, conflicts, fuzzy property-rights systems, excluded socioeconomic groups, pollution patterns and conflicting operational-choice rules affect ES. For instance, pollution patterns (ECO2) degrade ecosystems, generating loss of ES (e.g., loss of biodiversity). This variable, and social conflicts (I4) (e.g., territorial control disputes between groups) generate disservices reflected in negative social outcomes (e.g., bad odor produces the rejection of an ecosystem, or violence around wetlands).

Facilitators of collective actions such as higher social capital, higher dependence on the resource, self-organizing activities, networking activities and community operational-choice rules enhance ES. An instance of self-organization activities are communal orchards, which are present in public wetlands in Cali. These are informal initiatives with little intervention from public agencies, which can be key elements in urban social inclusion.

Collective actions are affected by a set of combinations of barriers. For instance, findings in urban wetlands located in public land and low-income levels show that the size of the resource (RS3), number of relevant actors (A1), with the existence of excluded socioeconomic groups (A2a), conflicts (I4), and polluted patterns (ECO2), affect collective actions and decrease the common goal in wetlands. Therefore, both negative social and ecological outcomes are generated (O1, O2), which was the situation before 2012 in Charco Azul. In contrast, when social and institutional facilitators are present in the arena, networking with government (I8) and leadership/entrepreneurship (A5) are keys to increasing the common goal in wetlands (see Figure 10). That was after 2012 when the environmental authority and social leaders showed willingness to work together and maintenance activities began. As a consequence, facilitators such as public-community operational-choice rules (GS5) (e.g., management committees that considers the opinion of the community), the importance of the resource (dependence) (A8), information sharing (I2), deliberation processes (I3), public investment activities (I5), self-organizing activities (I7), and informal monitoring activities (I8) were enabled. Hence, positive ecological outcomes were generated (O2a, O2b, O2c)[27].

[27] See further examples in Appendix F subsection 1.

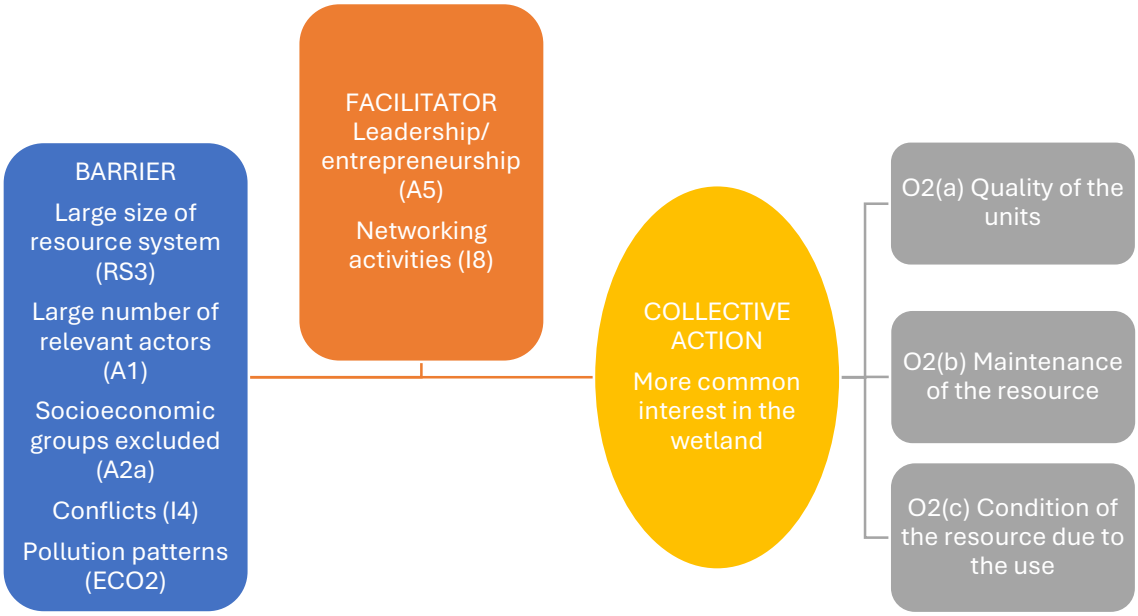

Figure 10. Barriers and facilitators improving collective actions and outcomes in Charco Azul wetland after 2012.

3.5.4. Leadership and networking

There is important evidence regarding networking with government (I8a) and leadership/entrepreneurship (A5). Leaders are a pivotal point in many interactions in urban and peri-urban wetlands of Cali (see Figure 11); they are representatives of community action boards, local action boards, or environmental and *comanejo* (joint management) committees. Not only is their role crucial on environmental issues, but also because it includes social work in wetlands located in low-income levels (e.g., stopping violence and promoting social work in Charco Azul). In addition, leaders of urban and peri-urban wetlands of high-income levels focus mainly on environmental actions (e.g., networking to ensure that no more constructions are permitted around La Babilla-Zanjón del Burro).

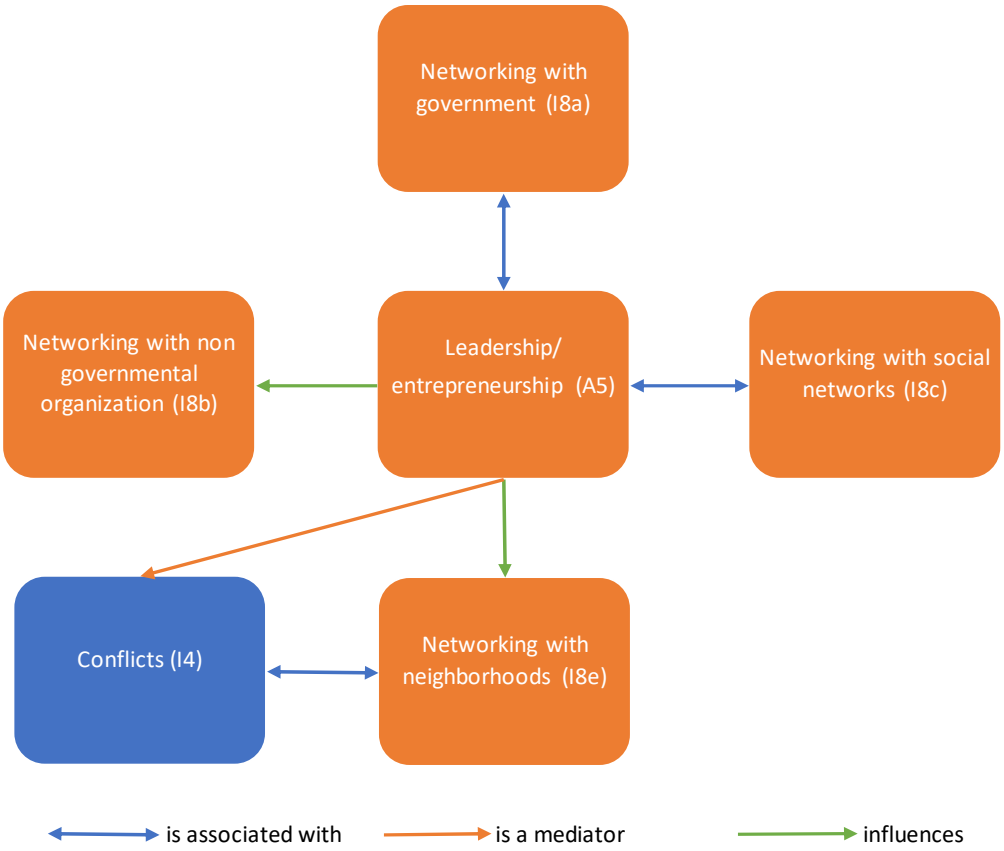

Figure 11. Relationships among leadership and networking in Charco Azul, La Babilla and Las Garzas.

Note: is associated with: co-occurrence of two variables; is a mediator: one variable exerts an effect on the other; influences: one variable enhances the other.

Furthermore, norms (trust-reciprocity)/social capital (A6), and operational-choice rules (GS5) are influenced by leaders in different ways. One the one hand, in urban and peri-urban wetlands located in low-income levels, leaders play a role in environments where members of the community trust informal rules, that is, inhabitants feel heard more by their leaders than by public agencies, consequently leaders can shape their perceptions (e.g., in Charco Azul and Hormiguero complex). On the other hand, in urban and peri-urban wetlands located in high-income levels, many leaders have a higher level of education, that is, an opportunity to share knowledge and to build rules of use together with public agencies at different levels[28].

[28] See further examples in Appendix F subsection 2.

3.5.5. Excluded socioeconomic groups, conflicts and outcomes

Excluded socioeconomic groups (A2a) are identified as a barrier for collective actions and environmental outcomes, given the influence of conflicts (I4). Consequently, the relationship between users as well as with the wetland is affected.

Environmental conflicts impact on urban and peri-urban wetlands. For instance, in urban wetlands located in low-income levels, conflicts give rise to excluded socioeconomic groups, who are mainly Afro-descendants that came from Colombian Pacific zones and arrived in Cali during the 1950s and 1960s (CVC, 2010). These groups settled around wetlands, forming land invasions, where they have undergone structural oblivion by public agencies and previous inhabitants of the city. Moreover, in peri-urban wetlands located in low-income levels, conflicts are evident because the sugar-cane monoculture has broken the connection between rural inhabitants and wetlands. Therefore, these inhabitants, who also formed informal settlements, have lost their livelihoods that wetlands had given them, and most of them have fallen into poverty. As a result, they have changed their perceptions, needs and interests about wetlands, which means that conflicts influence rules-in-use which in turn affect excluded socioeconomic groups' perceptions. Furthermore, not only has the population in these areas grown, but also weak governance systems exert pressure on wetlands, generating barriers such as pollution patterns (ECO2) over the resource (e.g. the Navarro landfill). In addition, we find that maintenance activities decrease or increase resource sustainability (O2), where leaders and networking are essential (see Figure 12). If a leader captures the attention of an environmental authority, he/she initiates an interaction that can lead to maintenance projects being accepted by the community (e.g., Charco Azul)[29].

[29] See further examples in Appendix F subsection 3.

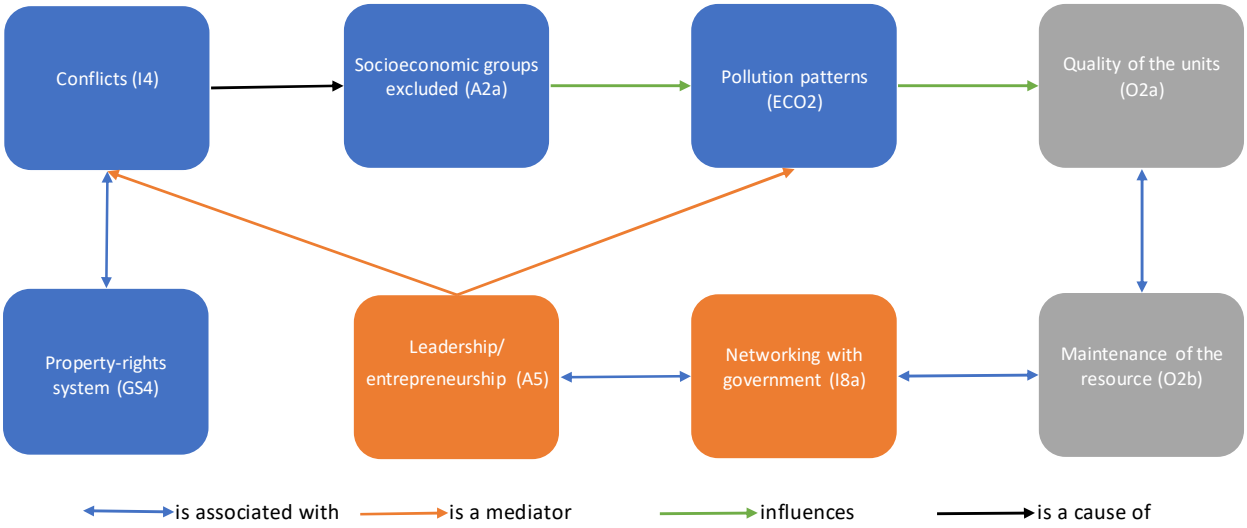

Figure 12. Relationships among excluded socioeconomic groups in Charco Azul, Pacheco and Hormiguero complex.

Note: is associated with: co-occurrence of two variables; is a mediator: one variable exerts an effect on the other; influences: one variable enhances the other; is a cause of: one variable is the origin of the other.

3.5.6. Ecosystem services, disservices and outcomes

We describe the ES and disservices perceived by interviewees regarding the selected wetlands and their connections with social and ecological outcomes. The interviews permitted the identification of 22 ES from the wetlands of Cali, which are within the provisioning, regulating, habitat and cultural services groups. The first includes ES of food (ES1), water (ES2), raw materials (ES3), genetic resources (ES4) and ornamental resources (ES6), for instance fish and community orchards, water for agricultural use, fibers, endemic flora and orchids respectively.

Regulating services encompasses air quality regulation (ES7), climate regulation (ES8), moderation of extreme events (ES9), regulation of water flows (ES10), waste treatment (ES11), erosion prevention (ES12), maintenance of soil fertility (ES13), pollination (ES14), and

biological control (ES15) all of which generate reduction of heat islands, decrease in flood risk, biomass formation, and fruit and seed production, thanks to pollinators.

Habitat services cover maintenance of life cycles (ES16) and maintenance of genetic diversity (ES17), such as migratory and endemic species. Cultural services present aesthetic information (ES18), opportunities for recreation and tourism (ES19), inspiration for culture, art and design (ES20), spiritual experience (ES21), (ES22) and existence and bequest values (ES23). These are evident in contemplation activities, passive or active recreation, bird watching, memorials, activities of religious groups, environmental education, as well as myths and legacy of the city.

ES perceptions at personal level primarily focus on livelihoods or cultural services. An example of the former would be that of fish as a food many years ago, or today for those in extreme poverty living near wetlands, as well as community orchards providing food and the latter such as recreational purposes or memories of deceased relatives from the American Airlines disaster in 1995. The families who lost their loved ones in the disaster, generated activities of self-organization and originated the project Las Garzas, while at the same time, regulating, habitat and cultural services are linked at neighborhood, community and city levels, e.g., Charco Azul as one of the main water regulators of the city, and bird watching.

Moreover, there are important findings that enable links to be established between food and cultural services. First, rural inhabitants who have left their places of origin due to armed conflicts or in search of new opportunities became migrants in irregular settlements in the wetlands of Cali. These people make connections with the body of water because their memories of past experiences, such as fish allow them to have a kind of sense of belonging in their new location. Second, some urban inhabitants fish in wetlands as a livelihood (e.g., Charco Azul), and others for recreational purposes (e.g., wetlands located in private land). In

fact, fishing is a source of conflict (I4) in urban wetlands of Cali. We found that some people wish to ban the activity, while others want to preserve it, and the environmental governance system finds itself in the middle of this dispute (e.g., a 'popular action' that was brought before DAGMA by one city's overseers in the Panamericano wetland).

On the subject of disservices, there is evidence of pollution patterns (ECO2) around wetlands that affect social outcomes. These could be termed 'social disservices' because the source is the action of human beings (e.g., illegal settlements, insecurity, corruption). In addition, maintenance of the resource (O2b) is important to regulating ES, which generate disservices when they are negative (e.g., a lack of wetland maintenance increases flooding risk or mosquito proliferation). However, most perceptions of interviewees show that the problem is human action around wetlands, not the wetland itself, and as a consequence, social performance measures (O1) are affected.

3.6. Discussion and conclusions

We applied the SES framework to analyze urban and peri-urban wetlands, examining 12 variables impacting collective actions and sustainability outcomes. Drawing upon the methodology and insights of Nagendra & Ostrom (2014), we explored the relationship between these variables and ES provided by the wetlands of Cali. Through this framework, we identified additional variables acting as either barriers to, or facilitators of, collective actions.

Our analysis reveals that 6 out of 8 wetlands have achieved different degrees of success in fostering collective actions. Particularly noteworthy is the restoration of Charco Azul, which occurred despite challenges such as socioeconomic exclusion, conflicts, pollution, and the complexity of the resource system and stakeholder involvement. Here, the pivotal role of institutional facilitators from public to community initiatives was influential in driving wetland

recovery. In contrast, wetlands within the Hormiguero complex and Pacheco have struggled to recover due to institutional, social, and physical-ecological barriers that have disrupted user-wetland relationships and altered resource dependencies. Conversely, the successful management of wetlands in La Babilla-Zanjón del Burro and Las Garzas have benefited significantly from social facilitators pursuing from community to public agency involvement. This process was influenced by the creation of collective rules, high levels of education, mutual trust, and networking. Meanwhile, successful wetland management on private lands often originated from initiatives by landowners or their representatives, indicating a lack of collaborative efforts between communities and public agencies in such endeavors.

Within similar contexts, we find barriers that affect collective actions and result in negative sustainable outcomes. These barriers include the large size of the resource, involvement of numerous actors, exclusion of socioeconomic groups, pollution, conflicts, issues with property-rights systems, and diminished resource dependence. Conversely, facilitators in wetland governance promote positive outcomes through effective leadership, understanding of social-ecological system dynamics, history of past experiences, engagement with government entities, high social capital, and community-operational choice rules.

These findings align with the research of Nagendra & Ostrom (2014) on urban and peri-urban wetlands in Bangalore, exhibiting similar patterns to those observed in the case of Cali. These findings also align with the study of Amblard (2020), who explores water pollution from agricultural and hybrid governance models, and D'Souza & Nagendra (2011), who analyze shifting perceptions of residents due to urban expansion and varying governance approaches. Our study delves into different forms of leadership and networking, along with both formal and informal types of social capital, echoing the work of Delgado-Serrano & Ramos (2015), who propose adaptations to enhance Ostrom's framework in Colombia, Mexico, and Argentina. In addition, our findings are consistent with Herrera (2024), who demonstrates successful

collaboration in wetland management in Bogotá (Colombia), ensuring legal protection, institutional policy, and citizen engagement. Furthermore, we identify a correlation between conflicts, property-right systems, and adverse social outcomes, similar to Villamayor-Tomas et al., (2020), who examine fisheries, forest and water sectors highlighting how private appropriation rules, immigration, and conflicts impact on property-rights systems, thereby reducing livelihood opportunities and wealth distribution. Moreover, conflicts related to water resource allocation in Cali affect access to provisioning, regulating, habitat, and cultural services, as discussed by Jorda-Capdevila & Rodríguez-Labajos (2015) and Rodríguez-Labajos & Martínez-Alier (2015) when they analyze environmental conflicts.

In conclusion, the application of the SES framework in our study provides insights into the social-ecological systems of urban and peri-urban wetlands and their associated ES, which have been relatively understudied. Leadership and networking, both with government and communities, and social capital emerge as crucial factors in achieving sustainable outcomes for urban wetlands. Institutions play a pivotal role in addressing pollution threats to common-pool resources, activating restoration efforts that, when supported by the community, ensure their continuity. Communities possess valuable contextual knowledge, serving as sources of information and focal points for addressing environmental challenges. This indicates that public agencies should collaborate with local leaders to establish synergies, thereby stimulating greater community engagement in environmental restoration.

Effective environmental education plays a crucial role in fostering social capital, requiring that governments create conducive environments and allocate resources to ensure accessibility for all. This strategy fosters cohesion among groups with shared experiences and goals, encouraging collaborative efforts. Alignment between public bodies, communities, and universities is imperative in this endeavor. Moreover, government agencies should draw

lessons from community self-organizational activities, encouraging resilience and social inclusion in urban settings.

Moving beyond the conventional public-private sector dichotomy, it is essential to recognize alternative governance models for common-pool resources, emphasizing collaboration between communities and public entities. This study underscores the value of community-public systems as a viable governance approach for urban common-pool resources. Public institutions bring economic, administrative, technical, and legal resources, while communities possess valuable knowledge of the social-ecological system, making them complementary and offering opportunities for mutual learning.

The findings of this research have direct implications for the management of the wetlands analyzed and similar urban areas in developing countries with social-ecological systems such as the wetlands of Cali. Finally, this study suggests lines of research such as assessing the comparison of perceptions between urban and rural residents in regional economies, both in developing and developed countries; also, assessing the contribution of community-based organizations to restoration projects, and quantitative assessment relating to the impact of leadership and networking with government on these ecosystems.

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CHAPTER 4: The Socio-cultural Value of Urban Wetlands: Insights into Local Sustainable Management

Winning research project at the RUPIV tender: Alliance for the Promotion of Science, Technology and Innovation in Valle del Cauca 2021. Funding: Pontificia Universidad Javeriana Cali and Universidad Icesi. External allies: DAGMA from productive sector and ASOMEVID from community.

Author: Lida Díaz-Pinzón

Status: Manuscript

The Socio-cultural Value of Urban Wetlands: Insights into Local Sustainable Management

Abstract

Wetlands play a key role in facing climate change, biodiversity loss, and extreme events by means of providing water, supporting biodiversity, flooding protection, and enhancing the mental health and well-being of inhabitants in cities. This study aims to evaluate perceptions of value and willingness to pay for cultural ecosystem services, to identify similarities and differences between monetary and non-monetary valuation, as well as to assess the incidence of factors influencing collective actions and their effects on ecological sustainability. This empirical research collected data through a personal survey of 276 participants about urban and peri-urban wetlands in Cali (Colombia). Responses were analyzed using bivariate and multivariate methods. Results show that wetland location influences non-monetary valuation, monetary valuation, collective actions, and ecological outcomes. Non-monetary valuation has a positive and significant effect on ecological outcomes, and is higher compared to the effect of monetary valuation. Factors that enhance collective actions do not impact the relationship between non-monetary valuation and ecological outcomes; however, there is an influence on ecological outcomes when these attributes are present or absent. This integral approach defines relationships among different dimensions of value, emphasizing that perceptions of value of cultural ecosystem services go beyond monetary valuation, while observing that public institutions are required to make decisions towards equity in the access to and use of these ecosystems.

Keywords: collective actions, socio-cultural valuation, urban ecosystem services, urban wetlands

4.1. Introduction

The greatest socioeconomic risks facing society today are focused on biodiversity loss, climate change and extreme events (WEF, 2022). Rising sea levels, coral bleaching and altered hydrology affect wetlands, and added to this, the growth of cities impacts these ecosystems due to the increased demand for resources and territorial occupation (Ramsar, 2021). As a consequence, the flow of provisioning, regulating, habitat, and cultural ecosystem services (ES) has been affected. Cities in the Global North depend on worldwide supply chains diminishing the focus on local management, and leading to greater emphasis on cultural and regulatory services (Nazmul Haque & Sharifi, 2024). Moreover, in the Global South, institutional barriers hinder effective planning and the availability of ES due to weak institutions, and stakeholders to make way for economic activities and environmental regulations that are often disregarded or inadequately implemented (Herrera, 2024; Nazmul Haque & Sharifi, 2024; Díaz-Pinzón et al., 2024[30]). This environment makes urban settlements more vulnerable to climate change (UN, 2018). Evidence of this can be clearly seen in the city of Cali (Colombia), where urban wetlands come within the scope of weakly centralized governance, as well as peri-urban wetlands which are under pressure from the growth of the city, agricultural development, and are subject to heterogeneous actors that have brought a change in the relationship between inhabitants and these ecosystems (CVC, 2006, 2010; Díaz-Pinzón et al., 2024).

It is essential to incorporate wetlands into the solution of these issues, as they provide benefits related to climate change mitigation and adaptation, biodiversity protection, and sustainable development (Ramsar, 2021). Urban green-blue infrastructure, including wetlands, provides regulating and cultural ES to cities i.e., supporting biodiversity, carbon sequestration, purifying air, stormwater protection, aesthetic experiences, and recreational activities

[30] Hereafter Díaz-Pinzón et al. (2024) corresponds in this dissertation to the article in first review by the International Journal of Commons. See Chapter 3.

(Langemeyer et al., 2015; Nazmul Haque & Sharifi, 2024). Moreover, cultural ES contribute to better physical and mental health of inhabitants, fostering the well-being of society (Gómez-Baggethun & Barton, 2013; Langemeyer et al., 2015; MEA, 2005).

Understanding benefits of urban ES by means of valuation has been the object of research especially in the Global North, however studies in the Global South, excluding China, are underrepresented in scientific literature (Brander et al., 2024; Haase et al., 2014; Nazmul Haque & Sharifi, 2024). Research activity has focused mainly on two perspectives regarding ES assessment. On the one hand there has been an economic approach, which emphasizes natural capital and monetary valuations that can be used in decision-making processes (Brander et al., 2024; Costanza et al., 1997, 2014, 2017; Díaz-Pinzón et al., 2022; Hernández-Blanco et al., 2020), and on the other, a holistic approach, which emphasizes the ecological structure of human settlements, incorporating socio-cultural valuations, and applying economic valuations to achieve diverse perspectives based on pluralism of values (Arias-Arévalo et al., 2017; Díaz et al., 2015; Gómez-Baggethun & Barton, 2013; IPBES, 2019; Langemeyer & Connolly, 2020; Rincón-Ruiz et al., 2019) . Furthermore, research has been evolved with an integral approach including economic and socio-cultural dimensions, with actors and governance involved (Arias-Arévalo et al., 2017; CSIRO, 2012; Langemeyer et al., 2015; Lliso et al., 2020; Martín-López et al., 2014; Pandeya et al., 2016; Zafra-Calvo et al., 2020), nevertheless, none of these have included variables of the social-ecological system (SES) framework developed by Ostrom and her colleagues (Ostrom, 2009, 2011) to understand urban commons management.

This study considers economic and socio-cultural dimensions of cultural ES of urban and peri-urban wetlands, taking into account the Integrated Valuation and Assessment of Ecosystem Services framework (De Groot et al., 2002), along with the SES framework (McGinnis & Ostrom, 2014). The first highlights connection between ES, that is to say, the benefits that natural ecosystems provide to society (Costanza et al., 1997), and different valuation methods

that contribute to better-informed decision-making processes. The latter provides important variables that enhance collective actions, or the efforts made, and the benefits obtained when achieving a common interest (Brady & Ratajczyk, 2015; Marshall & Scott, 1998), which are key to the understanding of sustainable common-pool resources management.

With the aim of establishing the socio-cultural values of urban wetlands in Cali, and how these relate to sustainable outcomes, this research has the following objectives: i) to evaluate perceptions of value or importance of cultural ES of wetlands located in urban and peri-urban areas; ii) to assess the economic valuation of cultural ES by means of evaluating the willingness to pay to visit the wetland; iii) to identify factors that enhance collective actions and ecological outcomes in wetlands located in urban and peri-urban areas; and iv) to assess how the importance of cultural ecosystem services, willingness to pay and collective actions influence ecological outcomes.

To tackle these objectives, this study updates the insights and methodology proposed by Langemeyer et al. (2015), who compare monetary and non-monetary valuation of cultural ES and connect these with the management of urban gardens in Barcelona, Spain. Data of the present research was further collected through sessions with community, applying a survey of 276 participants in which the perceptions of people, willingness to pay (WTP) to visit the wetland, collective actions and ecological outcomes were measured. Subsequently, bivariate and multivariate methods were applied to better understand relationships among these constructs. The main contribution indicates that perceptions of value and WTP are influenced by the socioeconomic characteristics of wetlands. This represents a challenge for local policymakers, as it is necessary to guide management, taking into consideration the needs of the population by different areas of the city.

The next sections present the theoretical framework and literature review, followed by methodological steps to obtain the first data base in the city of Cali with measurement of non-monetary and monetary values, where collective actions and sustainable outcomes are involved. Subsequently, valuation and the analysis of the integral approach were carried out, based on defining relationships between different dimensions of value and its connection with literature. Finally, conclusions and lessons for community and institutional action are presented for application in the city.

4.2. Theoretical background and literature review

The SES framework is a structure for understanding common-pool resources, including resource units, resource systems, governance, actors, and outcomes. Resource units are elements within a resource system, and governance involves rules influencing actors with property-rights over the resources. Lastly, outcomes include social and ecological measures, influenced by exogenous variables such as social, economic, and political factors (McGinnis & Ostrom, 2014; Ostrom, 2009, 2011).

Within the resource system, the economic value assigned to the resource establishes an input in the arena where variables of the SES framework interact, subsequently yielding ecological and social outcomes (Ostrom, 2011). In addition, regarding the value of the resources and their ES encompassing values unrecognized by markets, it has been postulated that these are related with both resources and actors, functioning as inputs to the action situations that influence outcomes (Delgado-Serrano & Ramos, 2015; Partelow & Winkler, 2016). Moreover, economic conditions, including living standards and well-being are exogenous variables that influence the SES framework, since these provide an insight into the social context and the risks derived from human pressures (Delgado-Serrano & Ramos, 2015). Hence, outcomes are the result of interactions of the SES framework variables, and are reflected

in social and ecological performance measures, as well as positive or negative externalities (McGinnis & Ostrom, 2014). In line with this, ecological outcomes relate to the environmental state of resources such as biodiversity or sustainability (Ostrom, 2009), and at local level can involve environmental sustainability, resource pressure, habitat condition, SES management effects, environmental quality, resilience, and vulnerability (Delgado-Serrano & Ramos, 2015).

The value or importance of ecosystems is generally categorized into three types: ecological, socio-cultural, and economic. The socio-cultural values and perceptions, including equity, are pivotal in determining the importance of natural ecosystems, contributing to non-material well-being for sustainable societies (De Groot et al., 2002). Thus, social motivation encourages individuals to function as value instruments during the valuation process of cultural ES (De Groot et al., 2002). Therefore, natural environments offer diverse socio-cultural values that are linked with people's welfare: aesthetic enjoyment influences real estate housing prices, recreation fosters eco-tourism, nature inspires cultural expression and existence and bequest values, and ecosystems serve scientific and educational purposes, fostering awareness and understanding (Costanza et al., 1997; De Groot et al., 2002).

4.2.1. Urban ecosystem services and urban commons

Urban ES, particularly those of a cultural nature, benefit urban well-being and are subject to policy challenges such as environmental awareness and social integration, as in Camps-Calvet et al. (2016). Through the assessment of the perceived importance of socio-cultural ES (non-monetary valuation), these authors highlight the necessity of understanding the valuation of cultural ES provided by urban gardens in Barcelona (Spain), and how this information can inform local policies, particularly in promoting sustainable urban development and enhancing the quality of life for city residents. In addition, it has been found that both monetary and non-monetary valuations provide complementary insights, revealing variations in the values of cultural ES across green infrastructure and management approaches, as in Langemeyer et al.

(2015). This research evaluates cultural ES in Park Montjuïc, Barcelona (Spain), finding contrasting results for certain services, for example tourism, place values, aesthetical information, and environmental education, which showed opposites in non-monetary and monetary valuation. While monetary valuation focuses on motivations of users, non-monetary valuation concerns the importance of ecosystem services, thus, authors call for a holistic approach in assessment and management.

The success of urban commons depends on its inclusivity towards diverse actors within the resource system, according to Unnikrishnan et al. (2023). This study states that to achieve sustainable outcomes, individuals must not only possess access, appropriation, management, and/or property-rights over the resource, but their collective actions must also be systematic. These authors analyzed urban wetlands in Bangalore within groups concerned with cultural ES, and similar findings are present in the case of the River Piedra in Spain by Felipe-Lucia et al. (2015). Thus, cultural ES serve as a key component in shaping power dynamics, influencing collective actions, and determining the sustainability and inclusivity of resource governance in the social-ecological system around urban wetlands.

4.2.2. Socioeconomic implications

The perceived value in urban parks can be influenced by socioeconomic factors, as in Gobster (1998). For an understanding of the complex dynamics involved in the perception and experience of urban parks in socioeconomically diverse contexts, the author suggests how lower-income neighborhoods may perceive less value in parks if they lack environmental quality and essential amenities, compared to higher-income areas. Similarly, when studying perceptions and values in urban nature in Chile, Germany, and Spain, Priego et al. (2008) found that socioeconomic status influences the use of and preferences to green spaces. Furthermore, findings when examining urban trees in Bogotá (Colombia) show that wealthier areas had larger and more diverse trees and higher carbon stocks than poorer areas, as in Escobedo et al.

(2015). These authors demonstrate disparities in tree attributes and ES provision based on socioeconomic status. Regarding socio-cultural valuation, there are rural-urban differences in ES perception, shaped by diverse lifestyles and socio-economic factors, as in Martín-López et al. (2012). Through the assessment of ES in the Iberian Peninsula, the authors find that variables such as age, education, gender, and income influence perceptions. Finally, focusing on the monetary valuation of ES, socioeconomic status significantly relates to perception and WTP in urban green spaces in China, as in Tian et al. (2020). This research shows that higher socioeconomic status correlates with both increasing WTP and perceived ecosystem services. Hence, individuals with a higher socioeconomic status have access to better physical and ecological green infrastructure, thus influencing the value they assign to the benefits received.

4.2.3. Collective actions and sustainable outcomes

Urban areas prioritize cultural ES such as tourism and aesthetics, while intensively managed rural areas primarily perceive provisioning services related to food production, as in Martín-López et al. (2012). This empirical evidence shows that actors attribute different values and perceptions to ES, as well as developing different land management strategies that influence these perceptions. Therefore, socio-cultural valuation shaped by management strategies influences sustainable outcomes (e.g., environmental quality, management effects, and habitat condition). Furthermore, in the context of forests and the SES framework, Rodríguez-Robayo et al. (2020) found in San Antonio (Mexico), that the relationship between local context variables and the payment for ES outcomes reflects community recognition of the preservation of benefits. The authors provide evidence that variables such as opportunity costs, attitudes, and traditional practices, affect environmental, economic, and social perceptions of payments for ES outcomes. Thus, in the presence of local context variables, monetary valuation influences sustainable outcomes.

Furthermore, the qualitative study by Díaz-Pinzón et al. (2024) collected data from 33 semi-structured interviews and applied the SES framework in urban and peri-urban wetlands in Cali. The authors highlighted the fact that leadership, networking with government, high social capital, community operational choice-rules and monitoring activities, serve as a facilitator for collective actions, fostering more sustainable outcomes. Conversely, barriers include factors such as the non-inclusion of socioeconomic groups, and lower dependence on the resource, which negatively affect such outcomes. Thus, the presence of social inclusion, leadership, networking, clear operational norms, community monitoring, and connection with the resource shapes collective actions in the governance of wetlands. Consequently, collective actions are likely to impact valuation and outcomes, particularly when compared to situations where such actions do not exist.

4.3. Methodology

4.3.1. Study area

This study is centered in Cali (Colombia), which is situated in the Valle del Cauca region in the southwestern part of the country. In 2023, Cali was projected to have a population of 2,297,230, with 98% residing in the municipality and the remainder in surrounding rural areas, its GDP per capita in current prices was USD 6,317 (a proxy in the absence of municipal accounts) (DAP, 2022). The region faces environmental conflicts, notably from sugar-cane monoculture, resulting in various social and ecological issues such as corruption, unemployment, deforestation, and water pollution (Díaz-Pinzón et al., 2024). The urban wetlands of Cali cover 33 hectares, while the peri-urban wetlands 217 hectares (DAGMA, 2018), all of which are located in different socioeconomic levels[31]. High-income zones have

[31] Areas of the city according to the economic stratification of public services regulated by the national constitution. Strata 1-2 (low-income level), strata 3-4 (medium-income level), strata 5-6 (high-income level).

urban and peri-urban wetlands located in public and private lands mostly in parks, housing, recreational clubs, and universities. Medium-income areas have wetlands in public recreational parks, housing, and the army battalion. Low-income zones have public wetlands that are hydrological regulators of the city, in which local inhabitants have different concerns, such as an interest in recovering from pollution patterns, fishing, environmental education, bird watching and orchards among others. Peri-urban low-income areas have wetlands with unclear property-rights systems where the relationship with the wetland was disrupted due to the monoculture of sugar-cane (Díaz-Pinzón et al., 2024). Urban and peri-urban wetlands on which this study focusses are shown in Figure 13.

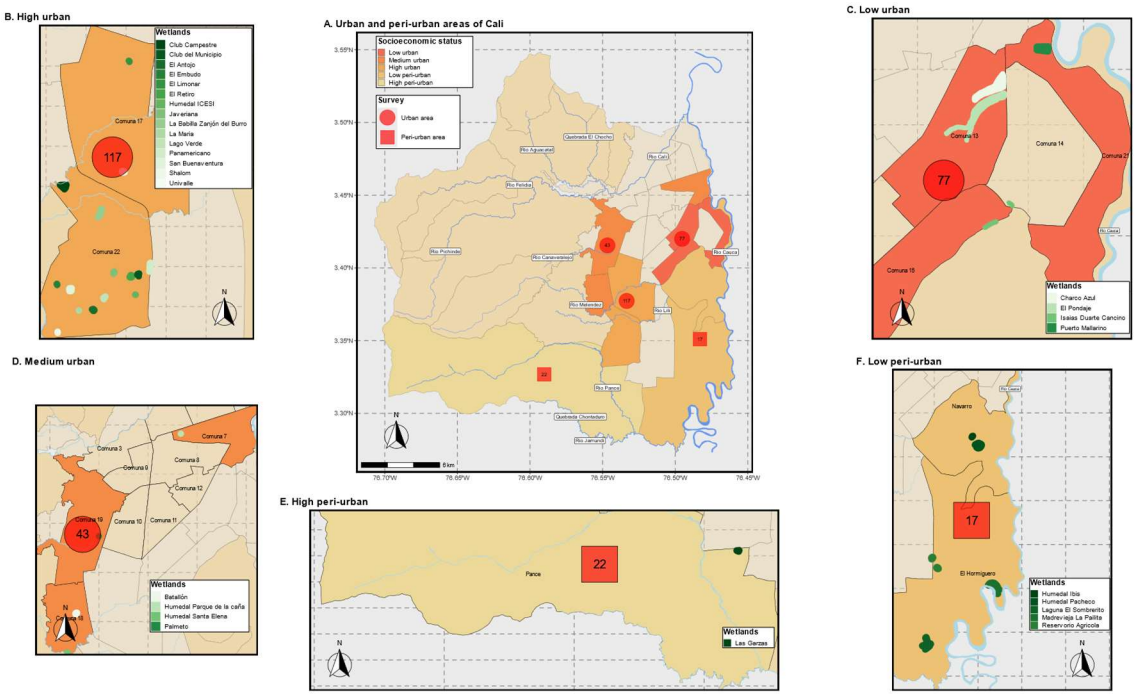

Figure 13. Study area located in Cali (Colombia).

Note: **Figure 13A.** Study area and sampling zones. The red circles correspond to surveys collected in each urban zone. The red squares correspond to surveys collected in each peri-urban zone. The geographical coordinates were taken by the Spatial Data Infrastructure of Cali and resolution 055 of 2018 by the Administrative Department of Environmental Management of Cali. **Figure 13B.** Urban zone located in high-income levels. **Figure 13C.** Urban zone located in low-income levels. **Figure 13D.** Urban zone located in medium-income levels. **Figure 13E.** Peri-urban zone located in high-income levels. **Figure 13F.** Peri-urban zone located in low-income levels.

4.3.2. Data and procedures

In order to assess the cultural benefits offered by wetlands of Cali, this research conducted fieldwork that included planning and implementing workshop sessions with the community. 276 valid surveys were completed to collect data for the study (see Figure 13). The target audience were men or women over 18 years who have visited a wetland, and have passed by, or know that it exists. It applies to urban wetlands located in low, medium, and high-income levels as well as peri-urban wetlands. Each session consisted of an opening and awareness-raising activity, a survey for data collection and a closing activity overall from 1 to 2.5 hours, depending on the group. 17 sessions were held in October, November, and December 2022 with 3 additional sessions in January and February 2023. The list of sources included community members convened by environmental committee leaders, and/or students from universities with wetlands on or near campus, and/or environmental authority officials and/or housing construction workers, since the growth of the city exerts pressure on wetlands. The questionnaire underwent multiple rounds of review by university students, professors, and professionals, as well as a pilot survey with students to evaluate the viability, structure, and efficacy of the instrument. The survey consisted of six blocks. The first part consisted of general questions, and responses regarding the selected wetland with the frequency and time of visits. The second included questions related to the benefits of ES and the importance of cultural services (non-monetary valuation). The third contained questions regarding travel time and cost, as well as income level (monetary valuation). The fourth involved questions related to collective actions and outcomes. The fifth comprised socioeconomic profile information. Finally, the sixth part included questions related to the motivation for visiting the wetland[32]. Methodological steps and approach with research objectives are shown in Chart 2.

[32] See the guideline of the survey in Appendix G.

Objectives	Focus	Methods and Analysis
Evaluate perceptions of value or importance of cultural ecosystem services of wetlands located in urban and peri-urban areas	A.Non-monetary valuation	Measuring through Likert Scale Reliability of importance of categories of ecosystem services and cultural services through factor analysis Bivariate analysis by socioeconomic features through Krustal-Wallis test
Assess the economic valuation of cultural ecosystem services through evaluating willingness to pay to visit the wetland	B.Monetary valuation	Measuring through stated cost of the trip, time of the trip and income Calculate visit to the wetland expressed on individual travel cost Bivariate analysis by socioeconomic features through Krustal-Wallis test
Identify factors that enhance collective actions and ecological outcomes in wetlands located in urban and peri-urban zones	C.Collective actions and outcomes	Binary analysis regarding factors than enhance collective actions through Krustal-Wallis test Multiple correspondence analysis to summarize the categorical variables, and analysis of dimensions of collective actions Measuring of perceptions of ecological outcomes through Likert Scale Bivariate analysis by socioeconomic features through Krustal-Wallis test
Assess how the importance of cultural services, willingness to pay and collective actions influence ecological outcomes	Integration A+B+C	Mapping monetary and non-monetary valuation across the city Pebble Distribution Method to identify willingness to pay for each cultural service through the motivation to visit the wetland Normalize monetary and non-monetary valuation to compare and evaluate differences and similarities Structural equation modelling to evidence relationships between non-monetary valuation, monetary valuation, collective actions and ecological outcomes

Chart 2. Methodological steps of the socio-cultural valuation of wetlands in Cali.

Phase A. Non-monetary valuation

Based on The Economics of Ecosystems and Biodiversity (TEEB) ES classification, this research takes into account provisioning, regulating, habitat and cultural ecosystems services (TEEB, 2010). Cultural services include: aesthetic information (ES18), opportunities for recreation and tourism (ES19), inspiration for culture, art and design (ES20), spiritual experience (ES21), information for cognitive development (ES22), existence and bequest values (ES23). This study used a Likert scale ranging from 1, strongly disagree, to 10, strongly agree, to measure categories of ecosystem services and cultural ES. Next, an analysis was carried out regarding reliability of the importance of categories of ES and cultural services through factor analysis. Then a bivariate analysis was applied to better understand the socioeconomic features of wetlands by means of a Krustal-Wallis test, a non-parametric test used to determine whether there are statistically significant differences between two or more population groups.

Phase B. Monetary valuation

This research employs the Travel Cost Method to conduct monetary valuation, which resembles conventional demand curves. In this method, the quantity demanded corresponds to the number of trips to the site, while the price encompasses total trip expenses, including travel costs and time. Prices differ by distance; lower for closer individuals and higher for those further away (Champ et al., 2003).

Following Langemeyer et al. (2015), the present research analyzed the collected survey data. Specifically, it examined the individual travel cost, which was calculated based on the stated cost and time of the trip, as well as household income of respondents. This evaluation included the time spent traveling to and from the wetland, as well as the costs incurred in reaching the destination and the opportunity cost for travel time. Cesario (1976) and McConnell

& Strand (1981) proposed valuing time in recreation and measuring the opportunity cost to be used in travel cost analyzes, within a range from 0.3 to 0.9 times the hourly wage. According to Langemeyer et al. (2015), this study used a 0.5 factor, and hourly wage was determined by computing the mean household income within the sample by an estimated number of 208 working hours per family per month, based on the assumption of one full-time working person per household in Colombia. See Equation (6):

$$TC_i = TC_{si} + 0.5\frac{lmean}{tW}tT_i \qquad (6)$$

where, TC_i is the individual travel cost, TC_{si} is the individual stated transport (cost), $lmean$ is the mean household income within the sample, tW corresponds to 208 working hours per family per month, and tT_i is the individual travel time to and from the wetland. Then, individual travel cost was calculated considering wetland location in concordance with Hein et al. (2006). Lastly, a bivariate analysis was applied to better understand socioeconomic features of wetlands using a Krustal-Wallis test.

Phase C. Collective actions

Important factors that enhance collective actions and sustainable outcomes are key issues in the understanding of successful management of common-pool resources (Nagendra & Ostrom, 2014). Therefore, this research considers the existence or otherwise of excluded socioeconomic groups (A2a), leadership (A5), operation-choice rules (GS5), dependence on the resource (A8), networking (I8) and monitoring of the resource (I9), which are relevant in wetlands of Cali as in Díaz-Pinzón et al. (2024). These factors were measured with ‘yes’, ‘no’ and ‘do not know’ responses, then translated to a binary variable (1=visited, 0= not visited and do not know). A multiple correspondence analysis was then applied to summarize these categorical variables. Next, an analysis of the dimensions was carried out. In addition, a Likert Scale ranging from 1 (very low quality/very little maintenance/very bad condition), to 10 (very

high quality/a lot of maintenance/very good condition) was applied to measure ecological outcomes. These outcomes include assessing the quality of the body of water (Oa), maintenance (Ob) and condition of the resource due to its use (Oc). Lastly, a bivariate analysis was applied to better understand the socioeconomic features of wetlands using a Krustal-Wallis test.

Phase A+B+C Integration of different dimensions of value

This research carried out the integration of values through spatial, graphical, and statistical analysis with the aim of assessing similarities, differences, and relationships. First, both monetary and non-monetary valuation were mapped across the city, considering *comunas* (group of neighborhoods within Cali) and *corregimientos* (peri-urban areas which depends on the municipality). Second, building upon the work of Langemeyer et al. (2015), this study utilized the Pebble Distribution Method to assess WTP for each cultural ES based on respondents' motivation to visit the wetland. Participants were instructed to allocate 10 coins among 6 ES (ES18 to ES23). Next, the obtained weights were allocated to the individual travel costs to obtain monetary valuation for each cultural ES. Then, both the monetary and non-monetary valuation variables were normalized to facilitate comparison. Third, an analysis considering structural equation modelling (SEM) was applied to identify relationships among non-monetary valuation, monetary valuation, collective actions, and ecological outcomes.

Multivariate analysis involves the application of statistical techniques that concurrently assess multiple variables. A prominent method within this domain is structural equation modeling, which allows for the incorporation of latent variables measured indirectly through observable indicators. There are two primary types of SEM: covariance-based SEM (CB-SEM) and partial least squares SEM (PLS-SEM). CB-SEM is employed to validate or disconfirm theoretical propositions, while PLS-SEM is predominantly utilized in exploratory research to

formulate theories, with a focus on explaining the dependent variable within the model (Hair Jr et al., 2017). This study applied PLS-SEM[33] which is evolving as a statistical modeling technique that has found applications in the fields of business administration, marketing, and strategic management (Hair Jr et al., 2017). The structural equation modeling technique has also been applied in the context of the SES framework and urban commons (Tuominen et al., 2022), as well as the assessment of ES and their effects on human well-being (Aldana-Domínguez et al., 2022; Fu et al., 2022). However, few analyzes have been conducted on relationships among actors (e.g., Felipe-Lucia et al., 2015) or different perceptions between rural and urban inhabitants with regard to tourism development (e.g., Rasoolimanesh et al., 2017).

4.4. Results

4.4.1. Descriptive statistics

This research conducted 276 valid surveys; 237 (86%) were carried out in wetlands located in urban areas and 39 (14%) in peri-urban areas. Out of 29 wetlands selected by respondents, 23 (32 ha) and 6 (65 ha) are located in urban and peri-urban wetlands respectively. Table 13 shows that, on average, the sample included responses made by 45% women, 54% men, and 1% who preferred not to say. The age of those surveyed ranged from 18 to 44 years (72%) and from 45 to over 75 years (28%). The monthly household income (Colombian current monthly minimum wage SMMLV) ranked from 0 to 3 SMMLV (74%), followed by >3 to > 10 SMMLV (24%) (1 SMMLV=USD 206.02). Moreover, the average educational level of respondents was high school and professional (77%), followed by postgraduate and others (23%). Among those surveyed, the average occupation was full-time employment and undergraduate students (77%), followed by part-time employment, unemployed, and others (23%). Respondents

[33] SmartPLS GmbH, http://www.smartpls.com (accessed on 15 January 2024).

reported that they had visited the wetland (67%), had passed by (25%), or knew that it existed (8%).

Table 13. Sample profile of respondents.

Variable	Description	Urban		Peri-urban		Total	
		N	%	N	%	N	%
Gender	Women	102	43%	21	54%	123	45%
	Men	131	56%	18	46%	149	54%
	Preferred not to say	3	1%			3	1%
Total		236	100%	39	100%	275	100%
Age (years)	18-24	87	37%	4	10%	91	33%
	25-34	54	23%	14	36%	68	25%
	35-44	33	14%	6	15%	39	14%
	45-54	27	11%	3	8%	30	11%
	55-64	26	11%	7	18%	33	12%
	65-74	6	3%	1	3%	7	3%
	Over 75	2	1%	4	10%	6	2%
Total		235	100%	39	100%	274	100%
Income	0 SMMLV[1]	5	3%	3	8%	8	4%
	>0-1 SMMLV	53	31%	7	19%	60	29%
	>1-2 SMMLV	52	31%	6	17%	58	28%
	>2-3 SMMLV	20	12%	6	17%	26	13%
	>3-4 SMMLV	9	5%	2	6%	11	5%
	>4-5 SMMLV	11	7%	3	8%	14	7%
	>5-10 SMMLV	12	7%	4	11%	16	8%
	>10 SMMLV	7	4%	5	14%	12	6%
Total		169	100%	36	100%	205	100%

Note: [1] SMMLV=USD 206.02, TRM= 4,853.9

4.4.2. Non-monetary valuation of cultural ecosystem services

Table 14 shows that community and personal benefits as well as ES variables were considered in non-monetary valuation. Moreover, Table 15 shows that community benefits of cultural services means were higher in urban and peri-urban wetlands located in high-income levels (7.97 and 9.38 Likert Scale points, standard error SE=0.20 and 0.20) than those located in low-income levels. Meanwhile, community benefits of provisioning services mean were higher in urban and peri-urban wetlands located in low-income levels (7.03 and 7.65 Likert

Scale points, SE=0.32 and 0.60) than those located in high-income levels. Descriptive statistics show that personal benefits were ranked higher than community benefits. In addition, there exists a trade-off between cultural and provisioning services, depending on the socioeconomic status of wetland location. For example, higher scores in cultural ES correspond to lower provisioning services in wetlands located in high-income areas, and vice versa in wetlands located in low-income areas.

Table 14. Descriptive statistics of ecosystem services.

	Variable	Description[1]	N	Mean	SD[2]	Min	Max
Community Benefits		Indicate to what extent the wetland you have selected provides benefit to the community because...					
	Provisioning	it provides resources and raw materials produced by nature	274	6.41	2.96	1	10
	Regulating	it supports the care of human health and the functioning of the environment	275	7.67	2.38	1	10
	Habitat	it provides habitat for the life cycle of migratory species, as well as genetic diversity of great importance for sustaining life on earth	275	8.39	2.02	1	10
	Cultural	it provides spaces for spiritual enrichment, environmental education, recreational and aesthetic experiences	275	7.75	2.52	1	10
Personal Benefits		The wetland you have selected is important for you because…					
	ES18 - Aesthetic information	its nature, colors, smells, sounds enrich the human mind	276	8.05	2.33	1	10
	ES19 - Opportunities for recreation and tourism	it serves as an area for recreation as well as sports among other activities. Its spaces and green areas are attractive to tourists	276	7.21	2.82	1	10
	ES20 - Inspiration for culture, art and design	its nature and components inspire the human mind in different creations	275	7.29	2.50	1	10
	ES21 - Spiritual experience	its landscapes and locations create a sense of place that stimulates spiritual experiences	275	6.90	2.72	1	10
	ES22 - Information for cognitive development	its natural environment provides an opportunity for environmental education of the population	275	7.63	2.63	1	10

	Variable	Description[1]	N	Mean	SD[2]	Min	Max
	ES23 - Existence and bequest values	it generates environments that are conducive to beliefs, stories and / or it is the legacy of future generations	275	7.36	2.60	1	10

Note: [1] Questions asked to respondents; [2] Standard deviation.

Table 15. Mean analysis of community benefits through zones in which wetlands are located.

	Provisioning		Regulating		Habitat		Cultural	
Zone[1]	Mean	SE[2]	Mean	SE	Mean	SE	Mean	SE
Urban								
(1)	5.91	0.27	7.86	0.18	8.63	0.15	7.97	0.20
(2)	6.53	0.48	7.53	0.37	8.28	0.34	8.53	0.28
(3)	7.03	0.32	7.24	0.31	7.75	0.27	6.79	0.34
Peri-urban								
(4)	7.65	0.60	7.24	0.74	8.29	0.65	6.47	0.79
(5)	5.71	0.64	9.14	0.29	9.57	0.16	9.38	0.20

Note: [1]Zone of the city in which wetlands are located N=275; (1) Urban high-income level; (2) Urban medium-income level; (3) Urban low-income level; (4) Peri-urban low-income level; (5) Peri-urban high-income level; [2]Standard error.

The reliability of categories of ES as well as the importance of cultural services was analyzed through factor analysis, in addition a bivariate analysis was carried out to identify significant differences between non-monetary valuation and socioeconomic features. First, a factor analysis was applied to better understand the relationship among provisioning, regulating, habitat and cultural categories of ES. Their validity was checked trough the Bartlett test and the Kaiser-Meyer-Olkin (KMO=0.763), finding that the variables are sufficiently correlated. The 4 categories of ES were grouped in one factor (community benefits) that explains 60.43% of the variability of all the model. The correlation among provisioning, regulating, habitat and cultural services and the factor were 0.5854, 0.858, 0.8215 and 0.8145 respectively. The variable most explained by the factor was that of regulating services (73.62%), followed by habitat (67.49 %), cultural (66.34%), and the least explained was that of provisioning (34.27%). These findings show that all services contribute to the benefits that

wetlands provide to the community of Cali, and when people consider community benefits, they value regulating and habitat services more than cultural and provisioning services.

Second, a factor analysis was applied to better understand the relationship among the following cultural ES: aesthetic information (ES18), opportunities for recreation and tourism (ES19), inspiration for culture, art and design (ES20), spiritual experience (ES21), information for cognitive development (ES22), existence and bequest values (ES23). Their validity was checked through the Bartlett test and the Kaiser-Meyer-Olkin (KMO=0.892), finding that the variables were sufficiently correlated. The 6 ES were grouped in one factor (importance of cultural services or non-monetary valuation), which explains 64.01% of the variability of all the model. The correlations among ES18, ES19, ES20, ES21, ES22 and ES23 and the factor were 0.8312, 0.795, 0.8429, 0.8004, 0.8046 and 0.7206 respectively. The variable most explained by the factor was that of inspiration for culture, art and design (71.05%), followed by aesthetic information (69.08%), information for cognitive development (64.74%), spiritual experience (64.06%), opportunities for recreation and tourism (63.21%) and the least explained was that of existence and bequest values (51.93%). These findings demonstrate that all cultural services contribute to the importance at personal level, and when people consider their well-being, they value having a place to inspire different creations or enjoy aesthetic information more than believing in legends or leaving a legacy for future generations.

Third, a Krustal-Wallis test was applied to better understand the effect of wetland location, educational level (as a proxy of socioeconomic status) and visiting the wetland on non-monetary valuation. Firstly, findings showed significant differences in non-monetary valuation (p=0.0001) among at least one of the groups of wetland location (urban in high, medium, low-income levels, and peri-urban in low and high-income levels). For instance, non-monetary valuation showed significant differences among urban wetlands located in high-income levels and wetlands located in peri-urban areas (p=0.0010 and p=0.0001) (see Table 16 for significant

differences between groups). These findings demonstrate that wetland location affects non-monetary valuation, or that the importance of cultural services is perceived differently regarding wetland location.

Table 16. Effect of wetland location on non-monetary valuation.

Zone[1]	(1)-(2)	(1)-(3)	(1)-(4)	(1)-(5)	(2)-(3)	(2)-(4)	(2)-(5)	(3)-(4)	(3)-(5)	(4)-(5)
P-value[2]	0.6678	0.1200	0.0010*	0.0001*	0.1551	0.0036*	0.0001*	0.0557	0.0001*	0.0001*

Note: [1]Zone of the city in which wetlands are located; (1) Urban high-income level, N=117; (2) Urban medium-income level, N=43; (3) Urban low-income level, N=76; (4) Peri-urban low-income level, N=17; (5) Peri-urban high-income level, N=22; [2]Krustal-Wallis probability; **p*-value<0.05: there are significant differences between groups (α=0.05).

Secondly, findings do not show significant differences in non-monetary valuation with respect to educational level. Nevertheless, findings showed significant differences in non-monetary valuation (p=0.0390) between those who have visited the wetland (walking or stayed there for a short time) and those who did not visit.

4.4.3. Monetary valuation of cultural ecosystems services

Individual travel costs as well as visiting time variables are shown in Table 17. The mean of the individual travel cost of those who have visited the wetland was 2.26 USD (standard deviation SD=2.52). The mean of individual travel time was 0.65 hours (SD=0.52). The mean of time spent per visit ranked from 1.02 hours on weekend to 1.07 hours on weekdays (SD=1.19 and 1.10). When visiting on weekdays, respondents reported once per week, once per month or every day (28%, 17% and 18% respectively), while visits per quarter, semester, year, or no visits (37%). When visiting on weekends, respondents reported once per week, once per month or everyday (14%, 14% and 15% respectively), while others reported different frequencies (57%). Descriptive statistics indicate variability on individual travel cost, individual trip cost (transport) as well as travel time because selected wetlands by respondents are located in

different zones of the city, thus analyzes were carried out in this regard in the following paragraphs.

Table 17. Descriptive statistics of visiting the selected wetland.

Variable	Description	N	Mean	SD[7]	Min	Max
TCi[1]	Individual travel cost	173	2.26	2.52	0	12.83
TCsi[2]	How much money do you spend on a trip (from leaving your home to returning home) when you visit the place?[6]	175	1.47	2.22	0	10.30
tTi[3]	How long does a trip take (leaving your home and returning home) when you make your visit?). Think only about the time of the trip[6]	197	0.65	0.52	0	2.00
Weekdays[4]	On average, how much time do you spend at the wetland?[6]	184	1.07	1.10	0	3.50
Weekend[5]		183	1.02	1.19	0	5.00

Note: [1]Individual travel cost (USD); [2]Individual travel trip (USD); [3]Individual travel time (hours); [4]Hours spent on the visit if this was on weekdays; [5]Hours spent on the visit if this was on weekend; [6]Questions asked to respondents; [7]Standard deviation.

Table 18 shows that the individual travel cost was higher both in urban and peri-urban wetlands located in high-income zones (mean= 2.81 and 3.94 USD, standard error SE= 0.33 and 0.65) than medium- and low-income areas. Similarly, the individual travel trip cost was higher in high-income zones (mean= 1.77 and 2.89 USD, SE=0.30 and 0.58) than medium- and low-income areas. Also, individual travel times were higher both in urban and peri-urban wetlands located in high-income zones (mean= 0.82 and 0.83 USD, SE= 0.07 and 0.14) than medium- and low-income areas. When visiting the wetland, hours spent during weekends were higher in peri-urban wetlands located in high-income levels (mean 2.14 hours, SE=0.33) than in other cases. In contrast, hours spent on weekdays were higher in urban and peri-urban wetlands located in low-income levels (mean 1.26 and 1.54 hours, SE=0.16 and 0.42) than in other cases. Descriptive statistics indicate that preferences for visiting the wetland vary according to the environment in which they are located. For instance, La Babilla-Zanjón del

Burro and Parque de las Garzas are public wetlands located in urban and peri-urban areas with high-income levels. These locations serve as recreational and touristic destinations of the city, and the results suggest that these activities occur mainly on weekends. Meanwhile, in urban low-income areas, Charco Azul wetland serves as a hydrological regulator for the city. Additionally, it is predominantly visited by neighbouring residents for provisioning purposes (fishing) and cultural services (environmental education or existence and bequest values), as reported by Díaz-Pinzón et al. (2024). The results suggest that these activities primarily occur on weekdays.

Table 18. Mean analysis of visiting through zones in which wetlands are located.

	TCi[2]		TCsi[3]		Tti[4]		Weekdays[5]		Weekend[6]	
Zone[1]	Mean	SE[7]	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Urban										
(1)	2.81	0.33	1.77	0.30	0.82	0.07	0.88	0.11	0.84	0.13
(2)	2.31	0.64	1.76	0.58	0.44	0.11	0.82	0.09	0.86	0.15
(3)	1.04	0.19	0.52	0.15	0.41	0.06	1.26	0.16	0.95	0.14
Peri-urban										
(4)	0.95	0.26	0.33	0.17	0.49	0.09	1.54	0.42	0.75	0.40
(5)	3.94	0.65	2.89	0.58	0.83	0.14	1.00	0.34	2.14	0.33

Note: [1]Zone of the city in which wetlands are located N=169; (1) Urban high-income level; (2) Urban medium-income level; (3) Urban low-income level; (4) Peri-urban low-income level; (5) Peri-urban high-income level; [2]Individual travel cost (USD); [3]Individual travel trip (USD); [4] Individual travel time (hours); [5]Hours spent on the visit if this was on weekdays; [6]Hours spent on the visit if this was on weekends; [7]Standard error.

The Krustal-Wallis test was applied to more completely understand the effect of wetland location or educational level (as a proxy of socioeconomic status) on individual travel costs (monetary valuation); as well as the effect of wetland location on time visiting on weekdays or weekends[34]. Findings showed significant differences in monetary valuation (p=0.0001) with at least one of the groups of wetland locations (urban in high, medium, and low-income levels, and peri-urban in low, and high-income levels). For instance, individual travel cost showed

[34]See detailed results in Appendix H, subsection 1.

significant differences among urban wetlands located in high-income levels and low-income levels (p=0.0001) (see Table 19 for significant differences between groups). These findings demonstrate that wetland location affects monetary valuation, or values vary with distance from site: low for nearby inhabitants, high for those more distant. While public wetlands located in high-income levels are visited by many citizens and tourists, public wetlands in low-income levels are visited mainly by those living around the wetland.

Table 19. Effect of wetland location on monetary valuation.

Zone	(1)-(2)	(1)-(3)	(1)-(4)	(1)-(5)	(2)-(3)	(2)-(4)	(2)-(5)	(3)-(4)	(3)-(5)	(4)-(5)
P value	0.0807	0.0001*	0.0010*	0.0228*	0.4431	0.8456	0.0180*	0.4064	0.0001*	0.0001*

Note: [1]Zone of the city in which wetlands are located; (1) Urban high-income level, N=73; (2) Urban medium-income level, N=22; (3) Urban low-income level, N=46; (4) Peri-urban low-income level, N=14; (5) Peri-urban high-income level, N=18; [2]Krustal-Wallis probability; *p-value<0.05: there are significant differences between groups (α=0.05).

An additional analysis was carried out to determine the incidence of possible bias in monetary valuation when there are trips with multiple destinations. This is the case for those surveyed whose work involves supervision or maintenance of wetlands, as well as university students who go to study, and as part of their recreational activities visit wetlands within their university activity. The results showed that by not taking these observations into account, there is an increase in the value of the trip for urban and peri-urban wetlands located in high-income levels (mean= 3.05 and 4.01 USD, SE= 0.51 and 0.73) and a decrease for those in urban low-income levels (mean= 0.90, SE= 0.17). Although there is a decrease in travel time, this is probably due to individuals living closer to the wetland. Despite the decrease observed in travel time, the increase in value among high-income zones and the decrease among those of low-income is influenced by transportation costs incurred by respondents. For example, in the case of results without bias analysis, students who selected wetlands in high-income levels and live far from the wetland have a longer travel time, but the transportation cost is lower compared to a person with a higher income level who lives near the wetland. By not taking these students

into account, travel time decreases and transportation costs increase. However, the Kruskal-Wallis test showed the same results as the initial modeling, with significant differences between the aforementioned groups. In addition, the effect of wetland location on hours spent on weekdays for the groups was found to be significant (p=0.0125) with at least one of the groups. Therefore, the bias effect does not change the analysis of this monetary valuation.

4.4.4. Collective actions and outcomes

With regard to variables related to actors (A2a, A5, A8a, A8b), Table 20 shows that respondents recognized the selected wetland as a source of human well-being (58 %), knew local leaders dealing with wetland issues (37 %), recognized that their wetland needs are considered (37%), and earned income from wetland work (13%). Addressing governance systems (GS5), those surveyed indicated that they knew rules-in-use of the wetland (58%). Lastly, regarding variables related to interactions (I8a, I8b, I9), respondents indicated that they carried out networking activities (54%), knew about networking with government (45%), and knew about informal monitoring activities (36%). Descriptive statistics reveal that the importance of the wetland is mainly due to personal well-being rather than an economic dependence. Leadership and inclusion of groups is represented, however there are respondents (63%) that did not recognize these, nor felt included, thus there are users unrepresented in their wetland-related needs. In addition, operational-choice rules results suggest knowledge about wetland-related uses. Finally, there are important results regarding networking and monitoring, reflecting the involvement of community in wetland management.

Table 20. Descriptive statistics of factors that enhance collective actions.

Variable[1]	Description[2]	Yes	%	No	%	Total	%
Actors (A)							
A2(a) - Socioeconomic groups excluded	Do you consider that your needs are taken into account by those who make decisions in relation with the wetland?	102	37%	174	63%	276	100%
A5 - Leaderhip/ Entrepreneurship	Do you know local leaders who represent community interests on wetland-related issues?	101	37%	174	63%	275	100%

Variable[1]	Description[2]	Yes	%	No	%	Total	%
A8(a) - Importance of the resource (economic dependence)	Do you receive income from working in wetland activities?	35	13%	239	87%	274	100%
A8(b) - Importance of the resource (human well-being)	Is the wetland a source of benefits for your personal well-being?	160	58%	116	42%	276	100%
Governance systems (GS)							
GS5 – Operational-choice rules	Do you know or have you seen any rules, regulations or provisions of wetland use? Examples: signs, established uses, sanctions for non-compliance with rules	160	58%	116	42%	276	100%
Interactions (I)							
I8(a) - Networking with government	Do you know if there are wetland-related relationships or workspaces between the community and public bodies?	124	45%	151	55%	275	100%
I8(b) - Other networking activities	To deal with wetland-related issues, in which of the following initiatives of community or public offices have you participated? Examples: training activities, meetings, public demonstrations, social networks, contribution of money or time	150	54%	126	46%	276	100%
I9 - Monitoring activities	Apart from state organizations, do community members monitor the wetland? Example: records of extraction or status of resources?	98	36%	175	64%	273	100%

Note: [1]Adapted from McGinnis & Ostrom (2014) and Nagendra & Ostrom (2014); [2]Questions asked to respondents.

Multiple Correspondence Analysis was carried out to summarize categorical variables by representing their interdependence or association. Thus, there were 2 groups of respondents, those who had attributes of collective actions and those who did not[35]. Furthermore, the Krustal-Wallis test was applied to more fully understand the effect of collective actions between non-monetary valuation and monetary valuation. Firstly, the findings showed significant differences in non-monetary valuation (p=0.0024) between those who have attributes that enhance collective actions (N=128) and those who do not (N=147). Secondly, findings showed significant differences in monetary valuation (p=0.0177) between those who have attributes of

[35]See detailed results in Appendix H, subsection 2.

collective actions (N=99) and those who do not (N=74). Moreover, the Krustal-Wallis test was applied to understand the effect of wetland location on collective actions. Findings showed significant differences in collective actions (p=0.0009) between at least one of the groups of wetland location (N=276). These results evidence that there is an effect of factors that enhance collective actions on both monetary and non-monetary valuation, in the same way that wetland location has an effect on collective actions.

Addressing the outcomes, Table 21 shows perceptions of respondents regarding sustainable ecological outcomes. The quality of the body of water, maintenance of the wetland, and its condition due to human activities that have been carried out there are quite similar (mean= 5.95, 5.99 and 6.34 Likert Scale points, standard deviation SD= 2.58, 2.72 and 2.70). Therefore, to more completely understand these descriptive results, an analysis considering wetland location was performed. Table 22 shows that ecological outcomes were more highly perceived by respondents in urban and peri-urban wetlands located in high-income areas than those in medium-income and low-income areas. For instance, the condition of the resource was perceived as the highest in high-income zones (mean= 7.43 for urban Likert Scale points and 8.40 for peri-urban, standard error SE= 0.20 and 0.24) in comparison with the others. Conversely, ecological outcomes were perceived in low-income areas with less intensity than the others. For example, quality, maintenance, and condition of the resource were the least favorably perceived (under neutral 5 points) in peri-urban wetlands located in low-income areas (mean= 4.38, 2.63 and 2.63 Likert scale points, SE= 0.62, 0.44 and 0.54). These results are consistent with the context of wetland location, and those with environmental conflicts, less public investment, and a disrupted relationship between users and the resource. For instance, Pacheco wetland has less sustainable outcomes than those with wealthy public or private investment, such as Las Garzas wetland, as reported by Díaz-Pinzón et al. (2024).

Table 21. Descriptive statistics of ecological outcomes.

Variable	Description[1]	N	Mean	SD[2]	Min	Max
O2(a) Quality of the units	What is your perception of the degree of water pollution provided by the wetland at the moment?	205	5.95	2.58	1	10
O2(b) Maintenance of the resource	What is your perception of the current maintenance of the wetland?	205	5.99	2.72	1	10
O2(c) Condition of the resource due to its use	What is your perception of the condition of the wetland as a consequence of its use?	204	6.34	2.70	1	10

Note: [1]Questions asked to respondents; [2]Standard deviation.

Table 22. Mean analysis of outcomes through zones in which wetlands are located.

	Oa[2]		Ob[3]		Oc[4]	
Zone[1]	Mean	SE[5]	Mean	SE	Mean	SE
Urban						
(1)	6.37	0.23	6.70	0.24	7.43	0.20
(2)	5.38	0.55	5.92	0.53	6.00	0.48
(3)	5.55	0.38	5.32	0.37	5.34	0.37
Peri-urban						
(4)	4.38	0.62	2.63	0.44	2.63	0.54
(5)	7.20	0.43	7.70	0.39	8.40	0.24

Note: [1]Zone of the city in which wetlands are located N=204; (1) Urban high-income level; (2) Urban medium-income level; (3) Urban low-income level; (4) Peri-urban low-income level; (5) Peri-urban high-income level; [2]Quality of the units; [3]Maintenance of the resource; [4] Condition of the resource due to the use; [5]Standard error.

The Krustal-Wallis test was applied to more fully understand the relationship between ecological outcomes and wetland location. The findings showed significant differences in the quality of the body of water, maintenance, and condition of the resource due to its use (p=0.0094, 0.0001 and 0.0001) with at least one of the groups of wetland location. For instance, maintenance and condition of the resource showed significant differences among wetlands located in high-income and low-income levels (p=0.0063 and 0.0001 for urban and p=0.0001 and 0.0001 for peri-urban) (See Table 23 for significant differences between groups). These results confirm that sustainable outcomes vary depending on the wetland location.

Table 23. Effect of wetland location on ecological outcomes.

Zone[1]	(1)-(2)	(1)-(3)	(1)-(4)	(1)-(5)	(2)-(3)	(2)-(4)	(2)-(5)	(3)-(4)	(3)-(5)	(4)-(5)
Oa[2] *P* value[5]	0.1112	0.1914	0.0056*	0.091	0.7324	0.2462	0.0237*	0.1518	0.0384*	0.0011*
Ob[3] *P* value	0.1695	0.0063*	0.0001*	0.068	0.4474	0.0002*	0.0157*	0.0008*	0.0021*	0.0001*
Oc[4] *P* value	0.0066*	0.0001*	0.0001*	0.0541	0.3629	0.0002*	0.0006*	0.0008*	0.0001*	0.0001*

Note: [1]Zone of the city in which wetlands are located; (1) Urban high-income level, N=82; (2) Urban medium-income level, N=24; (3) Urban low-income level, N=63; (4) Peri-urban low-income level, N=16; (5) Peri-urban high-income level, N=20; [2]Quality of the units; [3]Maintenance of the resource; [4]Condition of the resource due to the use; [5]Krustal-Wallis probability; **p*-value<0.05: there are significant differences between groups (α=0.05).

Finally, the Krustal-Wallis test was applied to achieve greater understanding of the relationship among ecological outcomes and collective actions. Nevertheless, results showed that among those who reported attributes of collective actions and those who do not, there are no significant differences in their effect on ecological outcomes.

4.4.5. Integration among valuation, collective actions, and outcomes

Both monetary and non-monetary dimensions were analyzed spatially and graphically. First, the average valuations of these dimensions were distributed across different *comunas* and *corregimientos* of Cali. Second, the Pebble Distribution Method was employed to determine WTP for each cultural ES[36]. In addition, this section systematically applied PLS-SEM based on the theoretical background encompassing valuation, collective actions, and ecological outcomes considering respondents who reported that they had visited the selected wetland.

A possible causal relationship of non-monetary valuation on ecological outcomes was validated (See Figure 14). Firstly, outer model quality criteria were checked. Construct reliability and validity showed that measured variables describe the same concept for non-monetary valuation and ecological outcomes (Cronbach´s alpha=0.901 and 0.842, composite reliability CR=0.921 and 0.880, average variance extracted AVE=0.668 and 0.760, outer

[36]See detailed results in Appendix H, subsection 3.

loadings ≥0.7 and significant). Discriminant validity showed differentiation between latent variables (Heterotrait-Monotrait Ratio of correlations HTMT=0.588). Lastly, inner model predictive power was validated. The explanatory power of the model for ecological outcomes was 29.7% (R^2=0.297). The path coefficient of non-monetary valuation on outcomes was positive and statistically significant (coeff=0.545, p=0.000). The effect of inspiration for culture, art and design on non-monetary valuation was the highest (loading=0.880, p=0.000)) among cultural ES. The effect of condition of the resource on outcomes was the highest (loading=0.927, p=0.000) among ecologically measured variables. These results show that there is a positive effect of non-monetary valuation on outcomes; thus the higher value of cultural ES, the higher sustainable ecological outcomes.

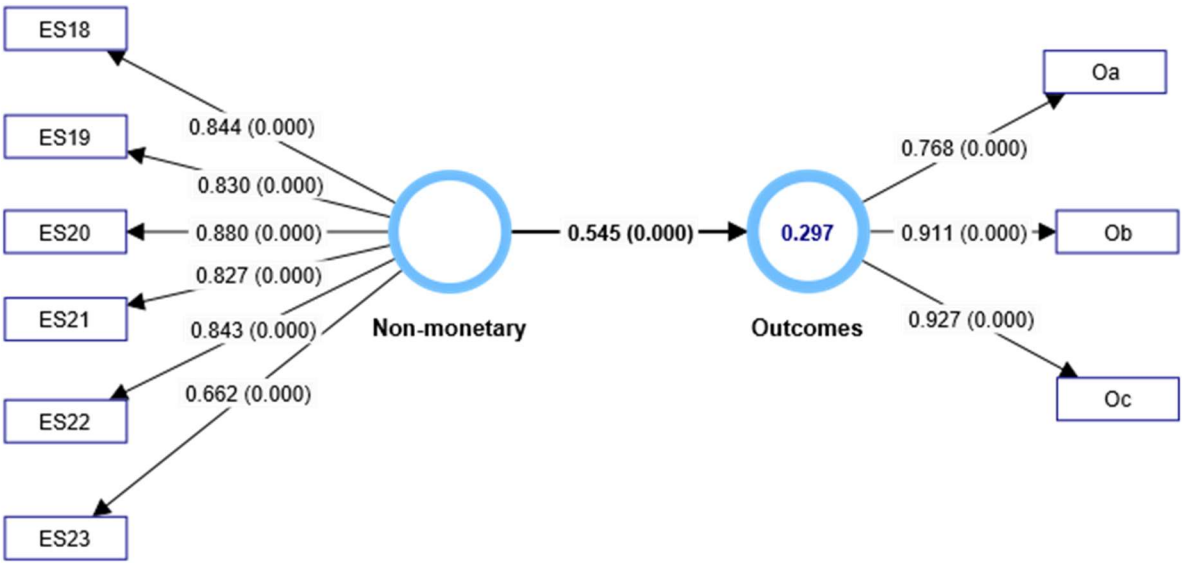

Figure 14. Inner and outer structural equation modeling (SEM) model.

Note: The SEM model indicates the causal relationship between non-monetary valuation and ecological outcomes, as well as the relationships between latent and measured variables. Circles represent latent variables and rectangles represent measured variables; aesthetic information (ES18); opportunities for recreation and tourism (ES19); inspiration for culture art and design (ES20); spiritual experience (ES21); information for cognitive development (ES22); existence and bequest values (ES23); quality of the units (Oa); maintenance of the resource (Ob); condition of the resource due to the use (Oc); p-value are shown in brackets (α=0.05).

A possible causal relationship of monetary valuation on ecological outcomes was introduced in the model, considering WTP to visit the wetland as a formative latent variable measured through household income and time of the trip. The measurement model accomplished quality criteria; nevertheless the explanatory power of the model for ecological outcomes showed little contribution (R^2=0.313 including non-monetary and monetary vs R^2=0.297, with only non-monetary valuation).

Additionally, a multigroup analysis was applied in the SEM model to identify whether collective actions have an impact on the relationship between non-monetary valuation and outcomes, however there were no significant differences between groups who have, or do not have collective actions. Moreover, a multigroup analysis was applied to determine whether educational level (as a proxy of socioeconomic status) has an impact on the relationship between non-monetary valuation and outcomes, nonetheless there were no significant differences between groups (≤ high school or > high school).

Finally, the possible effect of collective actions on ecological outcomes was calculated adding the former as a control variable. Table 24 demonstrates a significant effect, indicating that the presence or absence of these attributes influences ecological outcomes (p=0.043). Specifically, an increase in collective actions leads to a corresponding increase in ecological outcomes. Furthermore, the possible effect of wetland location on ecological outcomes was calculated adding the former as a control variable. Results showed a positive significant effect of urban and peri-urban wetlands located in high-income areas, and a significant negative effect of peri-urban in low-income areas, meaning that wetlands located in different income levels influence ecological outcomes (p=0.000, 0.015 and 0.000). For instance, for urban wetlands located in high-income areas there is an increase of ecological outcomes. Conversely, for peri-urban wetlands located in low-income areas there is a decrease of ecological outcomes.

Table 24. Effect of control variables on ecological outcomes.

Descripcion	Coefficient	*P* values	R^2
Without control			
Non-monetary -> Outcomes	0.545	0.000*	0.297
With control by collective actions			
Non-monetary -> Outcomes	0.553	0.000*	0.313
collective -> Outcomes	0.249	0.043*	
With control by wetland location			
Non-monetary -> Outcomes	0.522	0.000*	0.342
(1) -> Outcomes	0.423	0.000*	
Non-monetary -> Outcomes	0.550	0.000*	0.306
(2) -> Outcomes	-0.295	0.111	
Non-monetary -> Outcomes	0.531	0.000*	0.309
(3) -> Outcomes	-0.241	0.094	
Non-monetary -> Outcomes	0.460	0.000*	0.350
(4) -> Outcomes	-0.912	0.000*	
Non-monetary -> Outcomes	0.516	0.000*	0.308
(5) -> Outcomes	0.348	0.015*	

Note: (1) Urban high-income level; (2) Urban medium-income level; (3) Urban low-income level; (4) Peri-urban low-income level; (5) Peri-urban high-income level; **p*-value (α=0.05).

4.5. Discussion

This research attempted to compare non-monetary and monetary valuation of socio-cultural values within the ES framework proposed by De Groot et al. (2002), and following the methodology proposed by Langemeyer et al. (2015). Additionally, the SES framework proposed by McGinnis & Ostrom (2014) is involved to analyze, from a quantitative perspective, important factors that influence collective actions in the sustainable management of wetlands. Results show nuanced findings that are discussed below**.**

4.5.1. Socioeconomic features in wetlands valuation

The most significant finding of this research is the empirical evidence of the effect of wetland location on perceptions of the importance of cultural ES (non-monetary valuation), revealed preferences (monetary valuation), collective actions and sustainable ecological outcomes. This pattern is repeated across the complete analyzed results, findings showed that there are significant differences among responses for urban or peri-urban wetlands placed in

high, medium and low-income levels. For instance, there is an effect of wetland location on non-monetary valuation between urban wetlands in low-income areas and peri-urban wetland in high-income areas, in addition there is an effect on monetary valuation in the same groups. The same evidence was found for collective actions, for example there are significant differences in the effect of wetland location on collective actions in urban wetlands in high and low-income zones. Furthermore, this tendency proved to be consistent across ecological outcomes. For instance, the effect of peri-urban wetlands located in areas with low and high-income levels significantly differs in terms of resource quality, maintenance, and condition of the resource. Therefore, this research extends the work of Camps-Calvet et al. (2016) and Langemeyer et al. (2015) by incorporating social and ecological factors into the analysis of urban cultural ES, as well as delving deeper into the effect of socioeconomic features on the valuation process.

Empirical evidence of wetland location in Cali is consistent with Escobedo et al. (2015) in Colombia; Gobster (1998) in United States; and Priego et al. (2008) in Chile, Germany and Spain, who found socioeconomic issues in perceptions, preferences and allocation of green spaces in cities. In addition, findings of the present research complement ES theory in which socioeconomic drivers influence non-monetary and monetary valuations, as identified by Arias-Arévalo et al. (2017) in Colombia; Martín-López et al. (2012) in Spain; and Tian et al. (2020) in China. Moreover, research by Nazmul Haque & Sharifi (2024) found injustice in the access to urban ES, affecting the well-being and quality of life of inhabitants and increasing socioeconomic inequalities. In line with this, authors found that property-right system issues and WTP for urban ES are scenarios of injustice in the Global South. Consequently, it is a priority to design wetland policies in this regard to ensure equitable access to and the use of these resources by the inhabitants of Cali. This situation represents an additional challenge for local management, which, added to feeble governance, also experiences difficulty in the area

of social inclusion and norms that prioritize economic activity over the conservation of these ecosystems (Díaz-Pinzón et al., 2024).

4.5.2. Complementary values in cultural ecosystems services

The SES of urban and peri-urban wetlands provides ES that engage users in a dynamic interplay, leading to trade-offs influenced by diverse interests in these resources. Findings of this research showed that people's perceptions in Cali recognized regulating over cultural ES, and socio-cultural values were perceived differently between peri-urban and urban wetlands. These results are consistent with Escobedo et al. (2020) and Martín-López et al. (2012), who found that urban inhabitants more frequently acknowledge regulating over cultural ES due to the knowledge of the resource related with human well-being, and rural residents tend to recognize cultural ES less often when compared to their urban equivalents. Moreover, results of this research are also aligned with D'Souza & Nagendra (2011) and Garnett (2012) , who found different perceptions between rural and urban residents which shift from being regarded as local livelihoods and cultural heritage to aesthetic and recreational activities in urban areas.

Results of this research complement the mapping of cultural ES carried out by Burgos-Ayala et al. (2024); Escobedo et al. (2020) and Zapata-Caldas et al. (2022) in Colombia, who identify aesthetic values and environmental education in urban and regional areas. The present study adds inspiration for culture, art and design as relevant in Cali. An explanation of this result is that public wetlands are quite used to taking pictures in special events such as birthdays, celebrations or modelling. Moreover, this research found evidence of existence and bequest values, but these are the least valued, unlike Zapata-Caldas et al. (2022) who analyzed crowdsourced imagery featured in social media, finding urban green spaces in Cali as large generators of this service. This result can be explained considering that the authors categorized pictures of plants or animals as a proxy to existence and bequest values that can also relate to

environmental education, or inspiration for culture, art and design, which were highly valued in the present study.

Addressing valuation, this research found greater relevance of non-monetary over monetary valuation in coincidence with Langemeyer et al. (2015) and Martín-López et al. (2014), nevertheless each dimension of value has its own drivers and outputs that complement each other. Perceptions of importance, based on understanding socio-cultural preferences towards ES, encompass a wide range of nuances that influence people in their human values, attitudes, and beliefs reflecting well-being and quality of life (Aldana-Domínguez et al., 2022; Martín-López et al., 2012; MEA, 2005). On the one hand, in this study respondents were asked about the importance of wetlands considering different socio-cultural experiences that they have found relevant with regard to these ecosystems. The results of non-monetary valuation showed that complete cultural ES were scored highly, and 58% of respondents reported well-being. Moreover, connections with the SES were identified by Díaz-Pinzón et al. (2024), in which material and non-material dependence on the wetland have shaped the relationship between users and these resources. On the other hand, when the same individuals were asked about specific variables that were translated into the individual travel cost, their preferences revealed that they were willing to pay to visit the wetland instead of foregoing this experience. Considering that the travel cost method includes expenses related to traveling to the location and the opportunity cost of choosing to be there instead of being elsewhere (Champ et al., 2003), the monetary valuation results yield valuable insights into differences in such valuation attributable to wetland location, thus reflecting socioeconomic issues in Cali. However, this cost does not necessarily reflect the emotional or significant value that the experience holds for the individual. Hence, monetary valuation provides information of the behaviors of users, taking into account the nearness or remoteness from wetlands, as well as associated routines in weekdays and weekends, while non-monetary valuation, better captures feelings of connection

with nature or well-being derived from the environment that are also influenced by wetland location.

4.5.3. Issues with collective actions and outcomes

Ostrom's research on the successful management of common-pool resources in community-based systems demonstrated that communities are able to create their own rules in use, since their livelihoods depend on these resources (Ostrom, 2010). This fact demonstrates the relevance of the connection between users and the natural resources to achieve sustainable outcomes. This research confirms such a connection in different degrees in Cali, not only for the well-being that wetlands provide to people, but also and to a lesser extent for the economic incentives that some receive. Furthermore, findings revealed two groups of people concerning factors that enhance collective actions: those with the closest relationship mainly among networking, the inclusion of groups, and informal monitoring in the presence of leadership, operational-choice rules, and dependence on the resource, and those who do not have such attributes. These results align with findings of Díaz-Pinzón et al. (2024) and Nagendra & Ostrom (2014) who demonstrated that the stronger the facilitators of collective actions, the better the success in wetland management. Consistent with this, bivariate analysis revealed that collective actions influence valuation. However, SEM multigroup analysis indicated no significant differences between groups with and without collective action attributes regarding the impact of valuation on outcomes. Nonetheless, when collective actions were treated as a control variable, an effect on ecological outcomes was observed. These findings resemble those of Rasoolimanesh et al. (2017), who showed significant differences in community involvement regarding negative perceptions toward tourism development between urban and rural inhabitants. Additionally, they found that economic gain significantly influences positive perceptions of such activities.

Contrasting results of the present research in which collective actions both influence non-monetary valuation and outcomes, and not the relationship between valuation and such outcomes, indicate that people value benefits of wetlands due to the connection they have with them, but not because they are involved in their management. However, individuals who participate in management might hold different perceptions due to their understanding of the SES. As a result of their participatory efforts, they may derive material or non-material benefits, leading to a subsequent higher perception of value. Hence, further research is necessary in this regard.

Addressing common-pool resources, conventional laws of supply and demand do not function in the same way as they do for goods and services in the market. For example, if the number of people visiting wetlands increases, meaning that demand exceeds supply, the travel cost does not necessarily increase. Conversely, if wetlands are seldom visited, meaning that supply exceeds demand, the travel cost does not necessarily decrease. This is due to the fact that in the case of these resources; the relationship between resource availability is more complex and does not follow the same rules as traditional private market goods (Ostrom, 2010). Thus, collaborative work between community and public agencies is essential in the sustainable management of such resources as reported by Díaz-Pinzón et al. (2024).

Lastly, multivariate analysis demonstrated that there is a positive and significant relationship between non-monetary valuation and ecological outcomes. For instance, inspiration for art, design and arts and condition of the resource showed the highest coefficients among other indicators in the SEM model. This means that the better the benefit obtained from wetlands such as taking pictures for special moments, the better their ecological sustainability. In contrast, when introducing monetary valuation to the model, there is a limited impact of such valuation in explaining ecological outcomes, arguably because the decision to visit the wetland lacks economic incentives that translate into its sustainability.

4.5.4. Managerial implications

Managing green-blue infrastructure such as wetlands poses diverse challenges. Case studies in the Global North reveal hurdles in creating green spaces in dense areas, leading to unexpected consequences from ignoring complexities among the needs of people, institutions, and public infrastructure (Kronenberg et al., 2021). Similarly, the Global South encounters additional obstacles, especially institutional barriers, which impede fair planning and allocation of urban ES due to institutions failing in inclusiveness or ensuring equitable outcomes for communities, irrespective of their space and temporal conditions (Nazmul Haque & Sharifi, 2024; Unnikrishnan et al., 2023).

Results of this research concerning significant differences in urban wetlands located in high, medium, and low-income areas, as well as peri-urban wetlands in high and low-income areas, pose a challenge for local policymakers. Regional environmental governance systems in Colombia prioritize cultural ES, mainly through education and training initiatives (Burgos-Ayala et al., 2024). Therefore, in the case of Cali, further long-term policies must be implemented in which legal, administrative, technical, and economic resources of public institutions should be directed towards the most marginalized areas of the city, where wetlands are located. Not only is conservation, restoration, and protection of wetlands required, but also the need for regulations to be consistent, and for people to participate in wetland policy formulation, which are achievable goals, as demonstrated by community initiatives in La Conejera Wetland in Bogotá (Herrera, 2024).

It is imperative to guide management, considering the varying needs of population across each wetland location in the city. The presence or absence of collective actions influencing sustainable ecological outcomes and not affecting the relationship between valuation and outcomes requires complementary actions. These underscore the need for decision-makers to spearhead initiatives to engage the community in wetland management as well as to provide

the necessary investment and infrastructure for equitable access to cultural ES. Public institutions bear the responsibility of ensuring that urban and peri-urban wetlands are preserved and accessible to current and future generations, irrespective of their location or the economic status of inhabitants.

This research confirms the interdependency of networking, the inclusion of groups, and informal monitoring, all of which require reinforced leadership. Hence, wetland policies should incentivize the emergence of leaders, and foster collaboration between communities and institutions to facilitate sustainable resource management. There should be increased awareness among citizens about the benefits of wetlands and the importance of their involvement in management. Adaptative governance is needed to enable communities to actively participate in formulating policies and projects related to these resources.

Furthermore, public bodies should promote the connection between users and wetlands. For instance, organizing school visits to identify positive aspects and areas for improvement can encourage reflection among children and strengthen the wetland culture in inhabitants. In addition to environmental education and training, public agencies can also create scenic spots for photography, art or design in wetlands, attracting more visitors. Thus, fostering the importance of these resources, social inclusion, and participative management can contribute to long-term sustainable outcomes.

4.5.5 Limitations and future research

Measurements for non-monetary and monetary valuation in this research involve limitations to the value assigned by survey respondents. From an anthropocentric view, non-monetary valuation is framed in a Likert Scale, aimed at identifying the importance of cultural ES for those surveyed, without considering other values such as the intrinsic value of wetlands, disservices or measures that connect with human well-being. Furthermore, monetary valuation

does not allow assessing non-use values or what people would be willing to pay for experiences they have not yet had. Moreover, motivation to visit the wetland was framed to specific cultural ES, not including other incentives to visiting such as provisioning services (e.g., orchards in wetlands located in low-income areas). Multiple motivation in visiting was taken into consideration in the calculation of individual travel cost as mentioned in the results section.

Data collection to both non-monetary valuation and collective actions considered not only people who visit the wetland, but also those who do not. For individual travel cost and perceptions of sustainable ecological outcomes, participants were required to have visited the wetland, which was taken into account in the SEM model. Thus, valuation of the model only reflects perceptions and preferences of those who have visited the wetland, so that additional studies are needed to analyze preferences of those who have not visited, and what is needed to involve them in its management.

Fieldwork of this study required significant effort in coordinating logistical, administrative, and economic resources, which made data collection challenging, resulting in non-random sampling. For this reason, data collection was focused on areas close to wetlands, where the target population was given the freedom to choose the wetland from which they wished to provide their responses. Scarcity of local-level data is a challenge; thus, the collected database of this research deserves to be highlighted as the first of its kind at local and national level in Colombia.

Contrasting results with regard to collective actions requires further quantitative research into their magnitude and positive or negative effects on valuation and sustainable outcomes. Moreover, research in developing countries is needed to identify accurate drivers of socio-cultural valuation of ES in wetlands.

Finally, it is essential to replicate this study among children, who will become the adults of the future, as they will be those most profoundly affected by environmental degradation and the excessive consumption of natural resources. Their opinions should also be taken into account in policies and decision-making regarding wetland management.

4.6. Conclusions

Through the integration of different dimensions of value of cultural ES, collective actions, and sustainable outcomes, this research reveals several key findings. Firstly, wetland location significantly influences the results, affecting perceptions of value and WTP, collective actions and outcomes due to varying socioeconomic features at microlevel in the city. Secondly, non-monetary valuation plays a crucial role in shaping outcomes, having a greater positive effect on sustainable outcomes compared to monetary valuation. Thirdly, while collective actions are important for enhancing successful community-based systems, the study shows contrasting results: the presence or absence of collective actions influences ecological outcomes, but it does not affect the relationship between valuation and outcomes. Finally, these findings have significant policy implications. Local policymakers face the challenge of guiding wetland management while considering the diverse needs of different areas within the city. Collaborative efforts between the community and public agencies are essential for sustainable wetland management. Decision-makers must prioritize community involvement in wetland management and allocate investment and infrastructure to ensure equitable access to cultural ES. These insights are particularly relevant for growing cities in developing countries with urban and peri-urban wetlands, highlighting the need for further research to identify common patterns in similar contexts.

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CHAPTER 5: General conclusions

5.1. Research questions and main contributions

The integration of the three research papers of this dissertation shows key contributions. Chart 3 provides a concise comparison of research questions across Chapters 2, 3, and 4. Furthermore, it outlines the methodology used to achieve research objectives and summarizes the main findings related to those questions, and main contributions of the doctoral project.

Chapter 2 underscores the economic importance of wetlands for urban areas and their inhabitants. Additionally, it applies the GIS-supported benefit transfer method for economic valuation, offering a replicable methodology for other growing cities in Colombia and Latin America. It also suggests the necessity of long-term institutions to enhance coordination among environmental regulations, land-use planning, and the SES of the city.

Chapter 3 emphasizes the role of community-public systems in effectively managing urban common-pool resources. Additionally, it categorizes barriers and facilitators of collective actions influencing wetland management in Cali. It also highlights the role of institutional facilitators and community initiatives in wetland recovery, while identifying barriers posed by institutional, social, and physical-ecological factors. Furthermore, it applies the SES framework along with ES analysis as a methodology to study urban common-pool resources in growing cities.

Chapter 4 reveals substantial disparities between urban and peri-urban wetlands across various income levels, emphasizing the impact of socioeconomic factors on both non-monetary and monetary valuation. Additionally, it demonstrates that non-monetary valuation significantly impacts outcomes, positively influencing their sustainability, and has a greater impact compared to monetary valuation. It also confirms the connection between collective actions and sustainable outcomes in wetland management; however, their impact on valuation and outcomes yields contrasting results, demanding further research.

Chapter 2	Chapter 3	Chapter 4
Research question: What are the benefits of wetlands in Cali and what is their economic value?	**Research questions:** What have the successful actions in wetlands governance been between the community and public bodies in Cali? In what way and how are the ecosystem services of wetlands in Cali perceived, and what is their relationship with self-organization activities?	**Research questions:** What are the socio-cultural values of wetlands in Cali and how are these related to sustainable outcomes?
Objectives: Determine and value the ecosystem services of the urban and peri-urban wetlands in Cali Explore governance characteristics for the management of the wetlands	**Objectives:** Identify ecosystem services and their connections with collective actions and variables of the social-ecological system and sustainable outcomes. Evaluate factors that potentially affect collective actions and sustainable outcomes	**Objectives:** Evaluate perceptions of value or importance of cultural ecosystem services of wetlands located in urban and peri-urban areas in Cali Assess the economic valuation of cultural ecosystem services through evaluating willingness to pay to visit the wetland Identify factors that enhance collective actions and ecological outcomes in wetlands Assess how the importance of cultural ecosystem services, willingness to pay and collective actions influences ecological outcomes
Methodology: Quantitative Data collection through Ecosystem Services Valutation Data Base (ESVD) Benefit transfer method with a geographical information system (GIS) and an analysis of documents to exploratory review of the governance system of Cali	**Methodology:** Qualitative Data collection through 33 semi-structured interviews and the analysis of documents Case study	**Methodology:** Quantitative Data collection through 276 surveys Bivariate and multivariate methods
Main response to the research question: The total value for 11 ecosystem services of urban wetlands is USD 2,388,942 (72,825 USD/ha/year), while the value for peri-urban wetlands is USD 6,254,641 (28,773 USD/ha/year)	**Main response to the research questions:** Succesful actions in governance in wetlands include effective leadership, understanding of social-ecological system dynamics, importance of past experiences, engagement with government entities, high social capital, and community-operational choice rules 22 ecosystem services were identified. Provisioning and cultural ecosystem services are linked with rural and urban perceptions, environmental conflicts, property-rights systems, and self-organizing activities, thus affecting sustainable outcomes	**Main response to the research questions:** Wetland location exerts an effect on socio-cultural values with regard to non-monetary and monetary valuation as well as variables and outcomes of the social-ecological system framework People's perceptions recognized regulating over cultural ecosystem services and socio-cultural values were perceived differently between peri-urban and urban wetlands. People's perceptions recognized inspiration for culture, art and design over existence and bequest values People's perceptions recognized condition of the resource due to its use as the most relevant within ecological outcomes There is a positive and significant relationship between non-monetary valuation and ecological outcomes
Main contribution: By assigning monetary values to ecosystem services of urban and peri-urban wetlands, the study highlights the economic significance of such resources to the city and its inhabitants	**Main contribution:** Highlighting the need of community-public systems to achieve success in the management of urban common-pool resources	**Main contribution:** Providing empirical evidence of how wetland location affects perceptions of cultural ecosystem services, willingness to pay, collective actions, and ecological outcomes. It reveals significant differences in responses between urban and peri-urban wetlands across different income levels, highlighting the influence of socioeconomic factors on non-monetary and monetary valuations

Chart 3. Overview of the Chapter 2, Chapter 3, and Chapter 4.

The integral approach of this dissertation encompasses not only different dimensions of value and social and ecological factors involved in wetland management, but also a comprehensive analysis through primary and secondary sources of information. Chapter 2, from a quantitative perspective, utilizes secondary sources such as the ESVD to the benefit transfer for the economic valuation of ES. Then Chapter 3, from a qualitative perspective, is based on 33 interviews to conduct content analysis of the SES and associated ES. Lastly, Chapter 4, from a quantitative perspective, is based on 276 surveys to apply bivariate and multivariate methods, analyzing non-monetary and monetary valuation and factors influencing the management of wetlands.

Finally, the development of the research objectives contains findings related to monetary valuation, non-monetary valuation, and factors associated with the SES of urban and peri-urban wetlands in Cali as follows:

Chapter 2 presents the valuation of urban and peri-urban wetlands, with total values of USD 2,388,942 and USD 6,254,641 respectively. 76% of the total value is attributed to existence and bequest values, maintenance of the life cycle of migratory species, and water supply. The research also identifies areas with higher user benefits and highlights weak governance issues, including challenges related to property-rights, monitoring, and regulations.

Chapter 3 identifies 22 ES from the wetlands of Cali, primarily focusing on livelihoods and cultural ES at personal level. ES perceptions are linked at neighborhood, community, and city levels. There are barriers affecting collective actions and resulting in negative outcomes. These barriers include resource size, involvement of diverse actors, socioeconomic exclusion, pollution, conflicts, property-rights issues, and diminished resource dependence. Facilitators include effective leadership, understanding of SES dynamics, history of past experiences, engagement with government entities, social capital, and community-operational choice rules.

Lastly, provisioning and cultural ES are linked with rural and urban perceptions, environmental conflicts, property-rights, and self-organizing activities, impacting sustainable outcomes.

Chapter 4 demonstrates that wetland location consistently influences non-monetary and monetary valuation, collective actions, and sustainable outcomes. Perceptions of ES vary between peri-urban and urban wetlands, with socio-cultural values and inspiration for culture, art, and design being notable. Sustainable outcomes are primarily influenced by the condition of the resource. Individual travel cost serves as a proxy for the WTP to visit the wetland ranging from USD 0.95 to USD 3.94 and varies by wetland location. Collective actions impact valuation but not the relationship between valuation and outcomes. There is a positive relationship between non-monetary valuation and ecological outcomes.

5.2. Managerial implications

Elinor Ostrom's legacy emphasizes community-based management of common-pool resources through collective action and self-governance. Management involves establishing rules and institutions for the equitable and sustainable use of the resource. Her work challenges centralized governance, advocating for policies that empower local communities to develop adapted management systems. This approach fosters resilience and sustainability, addressing complex resource governance. Consequently, managerial implications of this dissertation are related to sustainable collective management, access to and use of the resource and importance of the urban and peri-urban wetlands of Cali.

Chapter 2 highlights the economic perspective and the contribution of wetlands to society of Cali, Chapter 4 confirms the complementarity between the economic and socio-cultural dimensions, and Chapter 3 holds the key to sustainable management, which is based on collaborative efforts between the community and public bodies, especially in the context of

Latin America's cities. Notably, when public institutions fail to respond adequately, the community assumes leadership. The policy implications of these findings aim to genuinely empower the community in terms of their involvement in wetland policy development and sustainable resource management.

Findings from Chapter 4 indicate that non-monetary dimension and sustainable outcomes of wetlands are positively related. Additionally, Chapter 3 reveals that specific factors interact either positively or negatively in wetland management. For this reason, the challenge for decision-makers lies not only in strengthening the relationship between users and wetlands and providing the infrastructure necessary for citizens to enjoy ES equitably, but also in actively engaging people in wetland management.

Achieving equitable access to ES, Chapters 2, 3 and 4 showed trials with socioeconomic features and property-right issues, which, in the context of common-pool resources, also relate to the degree of withdrawal, management, exclusion, and alienation of such resources. Therefore, public institutions have a duty to ensure that these resources are not depleted and are freely accessible to present and future generations, regardless of the location of these ecosystems or the economic condition of the inhabitants. However, the city of Cali faces a challenge incorporating socioeconomic and environmental issues. For instance, developing public areas involving wetlands entails restoring those that are more degraded or contaminated, and working with stakeholders to control pollution patterns, as in the case of deprived zones of the city (e.g., Pondaje wetland). Additionally, there is the need to collaborate with universities that have wetlands on their campuses to provide open access to the resource (e.g., in *Comuna* 22), and apart from this, to clarify access to and use of wetlands with fuzzy property-rights (e.g., Hormiguero Complex).

Additionally, findings presented in Chapters 2, 3, and 4 contribute to the mapping of socio-cultural values and ES in Cali. These ES are interconnected, and their assigned values are influenced by socioeconomic features. Additionally, the relationship between users and wetlands is shaped by social, institutional, and physical-ecological factors. For instance, existence and bequest values exhibit distinct nuances. Economic valuation through benefit transfer in Chapter 2, presents the highest valuation for such ES. Then Chapter 3 delves deeply into the connection between existence and bequest values, considering the history of past experiences, sense of belonging, and livelihoods of Afro-descendants who migrate to Cali. Next Chapter 4 reveals that these ES are more relevant in peri-urban than urban areas. Consequently, wetland policies should directly focus on management efforts that consider the needs of people, depending on the specific zone where the wetlands are located.

Finally, in Chapter 2, regulating ES exhibited the lowest economic value, but in the qualitative analysis of Chapter 3, these were highlighted as a benefit to the community. Next, in the non-monetary valuation of Chapter 4, they were demonstrated to be more relevant than cultural ES, therefore, decision-makers must consider that wetland management should be carried out holistically and appropriately on each scale of the city.

5.3. Future research

Further research is needed regarding gain and loss of ES in growing cities in developing countries involving regional economies, together with extending research by evaluating drivers of socio-cultural values in wetlands. This should occur particularly in local urban economies, for instance, by quantifying the monetary and non-monetary value of ES due to wetland degradation. This could involve assessing the impact on regulating and cultural ES, as well as the quality of life of the population, in addition to evaluating how differences between urban

and rural inhabitants influence management decisions and resource allocation in urban-blue infrastructure.

Additional research is needed considering community-based systems, for example, by investigating their impact on urban wetland restoration projects. Analysis is required in Latin America regarding community-public systems contributions, challenges, and effectiveness in achieving sustainable outcomes, for instance by quantitatively assessing how leadership and collaboration with government agencies influence sustainable outcomes and the implications on different dimensions of value.

The comprehensive assessment of urban wetlands presented in this dissertation goes beyond merely considering the economic dimension based on the perspective of natural capital and the socio-cultural dimension highlighted through the pluralism of values. It also delves into a deep analysis of the SES system using a robust methodology, such as that proposed by Elinor Ostrom. This approach allows for an integrated understanding of the resource, the actors involved, governance and sustainable management. Consequently, this dissertation calls for an expansion of the assessment of ES or nature's contributions for people, including the SES framework in the valuation process of urban common-pool resources.

Finally, replicating this study and expanding the sample size to include a diverse group of people and children would allow us to consider their perspectives on wetlands.

5.4. Dissemination of science

Diffusion of knowledge related to this dissertation has been carried out as described below:

Presenting at local, national, and international conferences and seminars

Díaz-Pinzón, L. (2021). *El valor económico de los humedales en zonas urbanas: Una aplicación del método de transferencia de beneficios.* XVI Congreso La Investigación en la Pontificia Universidad Javeriana. 15th-16th September 2021. Bogotá hybrid conference, Colombia.

Díaz-Pinzón, L., Sierra, P. & Trillas, F., (2022). The Economic Value of Wetlands in Urban Areas: The Benefits in a Developing Country. Seminario de Investigación Departamento de Economía en la Pontificia Universidad Javeriana Cali. 19th-20th October 2022. Cali, Colombia.

Díaz-Pinzón, L., Sierra, P. & Trillas, F., (2022). *El valor económico de humedales urbanos: Los beneficios en un país en desarrollo.* IV Congreso Latinoamericano sobre Conflictos Ambientales y III Congreso de la Sociedad Andina de Economía Ecológica en la Universidad del Valle. 24th-28th October 2022. Cali, Colombia.

Díaz-Pinzón, L., Sierra, P. & Trillas, F., (2022). The Economic Value of Wetlands in Urban Areas: The Benefits in a Developing Country. XV Congreso de Economía y Ciencias Regionales y Urbanas en la Universidad Tecnológica de Bolívar. 12th-13th October 2023. Cartagena, Colombia.

Díaz-Pinzón, L. *El valor de los humedales urbanos: Un enfoque integral*. Seminario de Investigación Departamento de Economía en la Pontificia Universidad Javeriana Cali. 28th September 2023. Cali, Colombia.

Díaz-Pinzón, L., Sierra, P., Trillas, F. & Verd, JM., (2023). The social-ecological system of urban wetlands: Sustainable collective management. 4th ESP LAC 2023. 6th-10th November 2023. La Serena hybrid conference, Chile.

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Díaz-Pinzón, L., Sierra, L., & Trillas, F. (2022). The Economic Value of Wetlands in Urban Areas: The Benefits in a Developing Country. *Sustainability* (Switzerland), 14(14). https://doi.org/10.3390/su14148302

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Díaz-Pinzón, L., Sierra, L., & Trillas, F., & Verd, JM. The social-ecological system framework of urban wetlands: The role of collective management at local level. *International Journal of the Commons.* In first review.

Research project

PUJC, Icesi (2022-2023). *Valoración Sociocultural e Integral de Servicios Ecosistémicos de Humedales Urbanos y Peri-urbanos, caso de estudio Cali*. Winning research project at the RUPIV tender: Alliance for the Promotion of Science, Technology and Innovation in Valle del Cauca 2021. Funding: Pontificia Universidad Javeriana Cali and Universidad Icesi. External allies: DAGMA from productive sector and ASOMEVID from community. 24th June 2022. Cali, Colombia.

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Appendices

Appendix A. Variables

Table A.1. Variables of the social-ecological system (SES) framework.

First-tier variables	Second-tier variables	Third-tier variables
Social, economic, and political settings (S)	S1 – Economic development S2 – Demographic trends S3 – Political stability S4 – Other governance systems S5 – Markets S6 – Media organizations S7 – Technology	
Resource systems (RS)	RS1 – Sector (e.g., water, forests, pasture, fish) RS2 – Clarity of system boundaries RS3 – Size of resource system[1] RS4 – Human-constructed facilities RS5 – Productivity of system RS6 – Equilibrium properties RS7 – Predictability of system dynamics RS8 – Storage characteristics RS9 – Location	
Governance systems (GS)	GS1 – Government organizations GS2 – Nongovernment organizations GS3 – Network structure GS4 – Property-rights systems GS5 – Operational-choice rules[1] GS6 – Collective-choice rules GS7 – Constitutional-choice rules GS8 – Monitoring and sanctioning rules	
Resource systems (RS)	RU1 – Resource unit mobility RU2 – Growth or replacement rate RU3 – Interaction among resource units RU4 – Economic value RU5 – Number of units RU6 – Distinctive characteristics RU7 – Spatial and temporal distribution	
Actors (A)	A1 – Number of relevant actors[1] A2 – Socioeconomic attributes[1] A3 – History or past experiences A4 – Location A5 – Leadership/entrepreneurship[1] A6 – Norms (trust-reciprocity)/social capital[1] A7 – Knowledge of SES/mental models A8 – Importance of resource (dependence)[1] A9 – Technologies available	A2(a) Socioeconomic groups excluded[1]

First-tier variables	Second-tier variables	Third-tier variables
Interactions (I)	I1 – Harvesting I2 – Information sharing I3 – Deliberation processes I4 – Conflicts I5 – Investment activities I6 – Lobbying activities I7 – Self-organizing activities I8 – Networking activities[1] I9 – Monitoring activities[1] I10 – Evaluative activities	I8(a) Networking with government[1]
Outcomes (O)	O1 – Social performance measures (e.g., efficiency, equity, accountability, sustainability) [1] O2 – Ecological performance measures (e.g., overharvested, resilience, biodiversity, sustainability)[1] O3 – Externalities to other SESs	O2(a) Quality of the units[1] O2(b) Maintenance of the resource[1] O2(c) Condition of the resource due to the use[1]
Related ecosystems (ECO)	ECO1 – Climate patterns ECO2 – Pollution patterns[1] ECO3 – Flows into and out of focal SES	

Note: Adapted from McGinnis & Ostrom (2014) and Nagendra & Ostrom (2014); [1]Initially selected variables.

The relevance of the initially selected variables is explained as follows, drawing from Nagendra & Ostrom (2014) and Ostrom (2009):

- Size of the resource system (RS3): large territories are difficult to manage due to high costs of boundaries, monitoring, and obtaining knowledge of the SES, among others.
- Number of relevant actors (A1): group size impacts transaction costs, for instance, the challenge for users in obtaining agreements to mobilize labor and resources.
- Excluded socioeconomic groups (A2a): these groups are unlikely to be included in the use or management of the resource.
- Leadership/entrepreneurship (A5): self-organization activities are more likely in the presence of local leaders, as well as practitioners and meaningful elders.
- Norms/social capital (A6): trustworthiness, the existence of networks, and the existence of rules and norms. Norms impact transaction costs; for instance, people with similar

behavior (moral and ethical) tend to trust each other, facilitating agreements and monitoring.

- Importance of the resource (A8): the resource as a livelihood or the value of its sustainability are considered in the cost-benefit analysis by individuals in self-organization.
- Operational-choice rules (GS5): after maintenance or restoration, community-based organizations play a crucial role in setting boundaries and monitoring activities.
- Networking activities (I8): collaboration between community and public agencies can have a positive impact on improving the ecological condition of the resource.
- Monitoring activities (I9): where formal regulatory mechanisms are not properly implemented, some communities develop informal monitoring processes.
- Social performance measures (O1): these are provided by the degree of collective action translated to equity or sustainability, among others; for instance, groups organized to protect the resource.
- Ecological performance measures (O2): related with the environmental condition of the resource such as biodiversity or sustainability, among others; for instance, quality of units, maintenance and condition as a consequence of the use.
- Finally, Pollution patterns (ECO2), pollution is considered as a barrier for collective action towards positive environmental outcomes in urban conditions.

Addressing ES there are different classifications such as those of the Millennium Ecosystem Assessment, The Economics of Ecosystems and Biodiversity (TEEB), the European Environment Agency (EEA), and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (Díaz-Pinzón et al., 2022). The TEEB classification places ES into the following categories: provisioning, regulating, habitat and cultural services. The initially selected variables are shown in Table B.2:

Table A.2. Variables of ecosystem services.

Group	ES[1]
Provisioning	ES1 – Food ES2 – Water ES3 – Raw materials ES4 – Genetic resources ES5 – Medicinal resources ES6 – Ornamental resources
Regulating	ES7 – Air quality regulation ES8 – Climate regulation ES9 – Moderation of extreme events ES10 – Regulation of water flows ES11 – Waste treatment ES12 – Prevention of erosion ES13 – Maintenance of soil fertility ES14 – Pollination ES15 – Biological control
Habitat	ES16 – Maintenance of life cycles ES17 – Genetic diversity
Cultural	ES18 – Aesthetic information ES19 – Opportunities for recreation and tourism ES20 – Inspiration for culture, art and design ES21 – Spiritual experience ES22 – Information for cognitive development ES23 – Existence and bequest values

Note: Adapted from TEEB, (2010); [1] Ecosystem services.

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Appendix B. Profile of individuals

Table B.1. Profile of units of information.

Interviewee	Age[5]	Place of residence	Gender	Educational level	Income level	Place of birth	Profile	Years of contact with the wetland(s)	Wetland
001-U	34	Jamundí[4]	Male	Technical studies	1-2 SMMLV[1]	Buenaventura, Colombia	Wetland warden	12	Charco Azul[2]
002-U	55	Cali	Female	Technical studies	0-1 SMMLV	Buenaventura, Colombia	Social leader	42	Charco Azul
003-U	43	Cali	Male	Technical studies	1-2 SMMLV	Bogotá, Colombia	Social leader	24	Charco Azul
004-U	50	Cali	Female	Technical studies	1-2 SMMLV	Cali, Colombia	University logistics secretary	29	Javeriana[2]
005-U	72	Cali	Female	Postgraduate	>5 SMMLV	Barrancabermeja, Colombia	Retired	18	La Babilla-Zanjón del Burro[2]
006-U	59	La Reforma[4]	Male	Elementary school	0-1 SMMLV	Almaguer, Colombia	Wetland gardener	20	La Babilla-Zanjón del Burro
007-P	55	Cali	Male	Technical studies	1-2 SMMLV	Cali, Colombia	Wetland warden	11	Las Garzas[3]
008-U	21	Cali	Female	High school	0-1 SMMLV	Cali, Colombia	University student	2.5	Javeriana
009-U	73	Cali	Male	PhD	>5 SMMLV	Bogotá, Colombia	Environmental leader	15	La Babilla-Zanjón del Burro
010-U	4	Cali	Female	PhD	>5 SMMLV	Cali, Colombia	Environmental leader	13	La Babilla-Zanjón del Burro
011-P	77	Cali	Male	Master´s degree	>5 SMMLV	Cali, Colombia	Retired	26	Las Garzas
012-P	76	Cali	Female	Bachelor´s degree	>5 SMMLV	Bogotá, Colombia	Retired	26	Las Garzas
013-U	23	Cali	Male	High school	0 SMMLV	Bogotá, Colombia	University student	2	Javeriana

Interviewee	Age[5]	Place of residence	Gender	Educational level	Income level	Place of birth	Profile	Years of contact with the wetland(s)	Wetland
014-U	49	Cali	Male	Technical studies	1-2 SMMLV	Restrepo, Colombia	University maintenance staff	28	Javeriana
015-P	51	Cali	Female	Postgraduate	>5 SMMLV	Cali, Colombia	Club member	40	Club Farallones[3]
016-P	43	Cali	Female	Master´s degree	4-5 SMMLV	Cali, Colombia	Kindergarten coordinator	27	Las Garzas
017-U	33	Cali	Female	Technical studies	0-1 SMMLV	Cali, Colombia	Wetland maintenance staff	33	Charco Azul
018-P	44	Cali	Male	Technical studies	3-4 SMMLV	Bahía Solano, Colombia	Club maintenance staff	20	Club Farallones
019-P	78	Cali	Male	Postgraduate	>5 SMMLV	Cali, Colombia	Club member and environmental leader	40	Club Farallones
020-U	81	Cali	Male	Postgraduate	>5 SMMLV	Cali, Colombia	Retired	43	Acequia Grande[2]
021-P	66	Navarro[4]	Female	High school	0-1 SMMLV	Medellín, Colombia	Eldest group member	5	Pacheco[3]
022-P	68	Navarro	Male	High school	0-1 SMMLV	Cali, Colombia	Eldest group member and social leader	60	Pacheco
023-U	57	Cali	Male	Secondary school	0-1 SMMLV	La Plata, Colombia	Gardener	33	Acequia Grande
024-P	67	Navarro	Male	Technical studies	0-1 SMMLV	Cali, Colombia	Eldest group member and social leader	55	Pacheco
025-P	64	Navarro	Female	Elementary school	0-1 SMMLV	Cali, Colombia	Eldest group member	10	Pacheco
026-P	73	Hormiguero	Female	Secondary school	0 SMMLV	Hormiguero, Colombia	Eldest group member	72	Hormiguero complex[3]
027-P	77	Hormiguero	Female	Elementary school	0-1 SMMLV	Hormiguero, Colombia	Eldest group member	74	Hormiguero complex
028-P	81	Hormiguero	Male	Elementary school	0-1 SMMLV	Palmira, Colombia	Eldest group member	60	Hormiguero complex
029-9	80	Hormiguero	Male	Elementary school	0-1 SMMLV	Padilla, Colombia	Eldest group member	70	Hormiguero complex

Note: [1]Current monthly legal minimum salary, [2]Urban; [3] Peri-urban; [4]Zone close to Cali; [5]Year 2022.

Table B.2. Profile of key informants.

Interviewee	Age[4]	Place of residence	Gender	Educational level	Income level	Place of birth	Institution	Years working in the institution	Department in the institution
001-K	30	Cali	Male	Bachelor´s degree in environmental engineering	3-4 SMMLV[1]	London, UK	DAGMA[2]	2	Ecosystems -Wetland maintenance
002-K	35	Cali	Male	Master's degree in environmental engineering	>5 SMMLV	Bogotá, Colombia	DAGMA	1.5	Quality of water resources
003-K	54	Cali	Male	Master's degree in political sciences	>5 SMMLV	Cali, Colombia	DAGMA	2	Ecosystems
004-K	53	Jamundí[3]	Female	Master's degree in environmental education	4-5 SMMLV	Cali, Colombia	DAGMA	13	Ecosystems – Wetlands

Note: [1]Current monthly legal minimum salary; [2] Department of Environmental Management of Cali; [3] Zone close to Cali; [4] Year 2022

Appendix C. Guidelines for interviews

C1. Guideline for interview with users

INTERVIEWS WITH URBAN AND PERI-URBAN WETLANDS USERS, CALI

Good morning, my name is Lida Diaz, I am doing my doctoral studies in Economics at the Pontificia Universidad Javeriana de Cali and the Universitat Autònoma de Barcelona. This study is part of a doctoral research project to carry out a comprehensive valuation of urban wetlands in Cali. The purpose of this study is to analyze the wetland system in the city, in order to identify factors that encourage collective actions in wetland management. Through this interview I intend to find benefits and non-benefits for Cali's wetlands, actors (or other groups involved), activities that indicate community participation, and management related to these ecosystems. Therefore, I would appreciate your help in this meeting, which will last approximately 1 hour. All data will be processed anonymously, the information will be used only for academic purposes and in relation to this doctoral thesis project. Thank you.

<table>
<tr><td>Interviewer</td><td colspan="3">Lida E. Díaz Pinzón</td><td>Consecutive</td><td></td></tr>
<tr><td>Name of wetland</td><td colspan="2"></td><td rowspan="2">Type</td><td>0 Urban</td><td></td></tr>
<tr><td>Place interview took place</td><td colspan="2"></td><td>1 Peri-urban</td><td></td></tr>
<tr><td>Date</td><td colspan="2"></td><td rowspan="2">Name</td><td>Comuna[37]</td><td></td></tr>
<tr><td>Start time</td><td colspan="2"></td><td>Corregimiento [38]</td><td></td></tr>
<tr><td>Finish time</td><td colspan="2"></td><td rowspan="3">Knowledge of the wetland</td><td>Years</td><td></td></tr>
<tr><td rowspan="2">Gender of interviewee</td><td>0 Woman</td><td></td><td>Months</td><td></td></tr>
<tr><td>1 Man</td><td></td><td>Weeks</td><td></td></tr>
</table>

1. CHARACTERIZATION OF ECOSYSTEM SERVICES

This section is divided in three levels: Individual, *Comuna/Corregimiento*, City

1.1 Characterization of ecosystem services at individual level

Why is this wetland important to you? Note: next step is to ask How does it contribute to your well-being or quality of life? What other things does it offer you?	Note: For each service perceived by the respondent, ask why this service is generated and what it generates

[37] A group of neighborhoods within a city.
[38] A territorial area, the jurisdiction of which depends on the municipality.

1.2. Characterization of ecosystem services at *comuna* or *corregimiento* level

Why is this wetland important for the neighborhood or *comuna*? Note: next step is to ask How does it contribute to your well-being or quality of life? What other things does it provide or offer you?	Note: For each service perceived by the respondent, ask why this service is generated and what it generates

1.3. Characterization of ecosystem services at city level

Why is this wetland important for Cali? Note: next step is to ask How does it contribute to your well-being or quality of life? What other things does it provide or offer you?	Note: For each service perceived by the respondent, ask why this service is generated and what it generates

2. CHARACTERIZATION OF DISSERVICES

What problems are generated by the wetland? Note: next step is to ask Anything bad, negative, annoying?	Note: For each service perceived by the respondent, ask why this service is generated and what it generates
What are you doing to solve these problems?	

3. SOCIAL-ECOLOGICAL SYSTEM (SES)VARIABLES

This section is divided into 9 sub-sections that indicate factors that contribute to facilitate collective actions in the sustainable management of wetlands.

3.1. Resource systems (RS). Size of resource system (RS3)

Has the size of the wetland changed over the years? If so, what situations do you think have caused this change?	What do you think will happen to the wetland in the future?

3.2 Actors (A). Number of actors (A1)

Which people benefit from the services provided by wetlands? Note: next step is to ask What groups control and regulate interactions between people and the wetland?	Note: For each actor perceived by the interviewee, ask: What is your participation in wetland management?

3.3 Actors (A). Excluded socioeconomic groups (A2a)

Which individuals or groups are not eligible for wetland benefits? Next, indicate, e.g., rural inhabitants, communities that are unrepresented.	Note: For each excluded group, ask Why do you think they are excluded?

3.4 Actors (A). Leadership (A5)

Are there local leaders involved in wetland management?	What is your involvement in wetland management?

3.5 Actors (A). Norms (trust-reciprocity)/social capital (A6)

Do old and new inhabitants have channels of communication? next step is to ask Are their experiences considered in wetland management?	Is there confidence in formal (e.g. DAGMA regulations) and informal (e.g. beliefs) rules by the community?

3.6 Actors (A) Importance of the resource (A8)

Is the wetland important to your livelihood, to your life? next step is to ask In what way?	Was it important in the past? Note: If yes, ask: In what way?

3.7 Governance system (GS). Operational-choice rules (GS5)

Are there rules that do or do not allow certain activities in the wetland? Next step is to ask How are they defined?	Do the actors abide by the rules or do they have a different way of handling things?

3.8 Interactions (I). Networking (I8a)

Does the community work as a team with the municipal agencies? Next step indicates, e.g. with DAGMA	With what other entities does the community work on wetland management issues?

3.9 Interactions (I). Monitoring activities (I9)

Has the community implemented any form of wetland management monitoring? If such monitoring is in place, do its recommendations feed into wetland management decision-making?	Note: For each activity ask, can you describe this activity?

4. MANAGEMENT PERFORMANCE*

What do you think the management of this wetland is like? Note: Next ask: What do you think it should be like? What do you think should be evaluated?

5. PERSONAL INFORMATION ABOUT THE INTERVIEWEE

Name					
Email				Telephone	
Comuna			*Corregimiento*		
Neighborhood			Neighborhood		
Address			Address		
Lives in *comuna* or *corregimiento*	Years		Place of birth		
	Months		Year of birth		
	Weeks		Number of people in household		
Level of monthly income	0		Level of education	Primary	
	0-1 SMMLV[39]			Secondary/ High School	
	1-2 SMMLV			Professional	
	3-4 SMMLV			Postgraduate	
	4-5 SMMLV			Other	
	>5 SMMLV		Profession/Type of work		

[39] Colombian current monthly minimum wage.

6. OBSERVATIONS DURING THE INTERVIEW

Comments

Based on Camps-Calvet et al. (2016); McGinnis & Ostrom (2014); Nagendra & Ostrom (2014). Note: *Question introduced by the researcher

C2. Guideline for interview with key informants

INTERVIEWS WITH URBAN AND PERI-URBAN WETLANDS KEY INFORMANTS, CALI

Good morning, my name is Lida Diaz, I am doing my doctoral studies in Economics at the Pontificia Universidad Javeriana de Cali and the Universitat Autònoma de Barcelona. This study is part of a doctoral research project to carry out a comprehensive valuation of urban wetlands in Cali. The purpose of this study is to analyze the wetland system in the city, in order to identify factors that encourage collective actions in wetland management. Through this interview I intend to find benefits and non-benefits for Cali's wetlands, actors (or other groups involved), activities that indicate community participation, and management related to these ecosystems. Therefore, I would appreciate your help in this meeting, which will last approximately 1 hour. All data will be processed anonymously, the information will be used only for academic purposes and in relation to this doctoral thesis project. Thank you.

<table>
<tr><td>Interviewer</td><td colspan="3"></td><td>Consecutive</td><td></td></tr>
<tr><td>Name of institution</td><td colspan="5"></td></tr>
<tr><td>Place interview took place</td><td colspan="5"></td></tr>
<tr><td>Date</td><td colspan="2"></td><td rowspan="2">Area</td><td colspan="2" rowspan="2"></td></tr>
<tr><td>Start time</td><td colspan="2"></td></tr>
<tr><td>Finish time</td><td colspan="2"></td><td rowspan="3">Time in the institution</td><td>Years</td><td></td></tr>
<tr><td rowspan="2">Gender of interviewee</td><td>0 Woman</td><td></td><td>Months</td><td></td></tr>
<tr><td>1 Man</td><td></td><td>Weeks</td><td></td></tr>
</table>

1. CHARACTERIZATION OF ECOSYSTEM SERVICES

This section is divided in three levels: Individual, *Comuna*[40]/*Corregimiento*[41], City

[40] A group of neighborhoods within a city.
[41] A territorial area, the jurisdiction of which depends on the municipality.

1.1 Characterization of ecosystem services at individual level

Why is this wetland important to you? Note: next step is to ask How does it contribute to your well-being or quality of life? What other things does it offer you?	Note: For each service perceived by the respondent, ask why this service is generated and what it generates

1.2. Characterization of ecosystem services at *comuna* or *corregimiento* level

Why is this wetland important for the neighborhood or *comuna*? Note: next step is to ask How does it contribute to your well-being or quality of life? What other things does it provide or offer you?	Note: For each service perceived by the respondent, ask why this service is generated and what it generates

1.3. Characterization of ecosystem services at city level

Why is this wetland important for Cali? Note: next step is to ask How does it contribute to your well-being or quality of life? What other things does it provide or offer you?	Note: For each service perceived by the respondent, ask why this service is generated and what it generates

2. CHARACTERIZATION OF DISSERVICES

What problems are generated by the wetland? Note: next step is to ask Anything bad, negative, annoying?	Note: For each service perceived by the respondent, ask why this service is generated and what it generates

What are you doing to solve these problems?

3. ACTORS (A). Number of actors (A1)

Which people benefit from the services provided by wetlands? Note: next step is to ask What groupings control and regulate interactions between people and the wetland?	Note: For each actor perceived by the interviewee, ask: How is your participation in wetland management?

4. IDENTIFICATION OF COLLECTIVE ACTIONS

This section is divided into 8 sub-sections that indicate characteristics present in strong institutions, which involve collective actions aimed at sustainable resource management

4.1 User and resource boundaries

How is the access to the wetland? Note: next step is to ask Are there people or groups that may be excluded from visiting? Who agreed or defined the process of access to the wetland?	What are the characteristics of wetland boundaries, natural or constructed? Note: next step is to ask: Are there entrance controls, who agreed or defined these boundaries?

4.2 Congruence with local conditions and appropriation and provision

What are the internal and external rules that control and regulate interactions between people and the wetland? Note: next step is to ask What degree do they respond to local social and environmental conditions?	How are wetland management investment items defined? Note: next step is to ask To what extent does the cost or investment required justify the benefits received from the wetland?

4.3 Collective-choice arrangements

How were the operational rules for wetland management defined? Note: next step is to ask who can modify them?

4.4 Monitoring of users and the resource

Are costs and benefits monitored by users? Note: next step is to ask If this oversight is in place, do its recommendations feed into wetland management decision making?	Are the bio-physical conditions of the wetland monitored by the users? Note: next step is to ask If this condition exists, do your recommendations carry over into wetland management decision making?

4.5 Graduated sanctions

What are the sanctions for non-compliance with the rules? Note: next step is to ask Who grants and defines these sanctions?

4.6 Conflict-resolution mechanisms

What are the dispute resolution mechanisms like? Note: next step is to ask Are they easily accessible and inexpensive?

4.7 Minimal recognition of rights to organize

Can users organize themselves in different forms that are recognized by government authorities? Note: next step is to ask If organizations exist, what is their purpose?

4.8 Nested enterprises

Does wetland management spill over into other areas such as education, health, investment in programs at the local level? Note: next step is to ask Does management transcend to the regional or national level with other organizations? Do the relationships that are generated allow making decisions that act in the long term?

5. MANAGEMENT PERFORMANCE*

What do you think the management of this wetland is like? Note: Next ask: What do you think it should be like? What do you think should be evaluated?

6. PERSONAL INFORMATION ABOUT THE INTERVIEWEE

Name				
Email			Telephone	
Comuna			*Corregimiento*	
Neighborhood			Neighborhood	
Address			Address	
Lives in *comuna* or *corregimiento*	Years		Place of birth	
	Months		Year of birth	
	Weeks		Number of people in household	

Level of monthly income	0		Level of education	Primary	
	0-1 SMMLV[42]			Secondary/ High School	
	1-2 SMMLV			Professional	
	3-4 SMMLV			Postgraduate	
	4-5 SMMLV			Other	
	> 5 SMMLV		Profession/Type of work		

7. OBSERVATIONS DURING THE INTERVIEW

Comments

Based on Anderies et al. (2004); Camps-Calvet et al. (2016); McGinnis & Ostrom (2014); Nagendra & Ostrom (2014). Note: *Question introduced by the researcher

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[42] Colombian current monthly minimum wage.

Appendix D. Information validation sources

Table D.1. Information validation sources

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RS3 – Size of resource system	Field visit (CVC, 2010; DAGMA, 2018)	(DAGMA, 2018)			(CVC, 2006; DAGMA, 2018)	(Contreras, R., 2006; DAGMA, 2018)	Field visit (DAGMA, 2018)	
GS4 – Property-rights system	Resolution 055 of 2018 by DAGMA		Field visit Resolution 055 of 2018 by DAGMA		Agreement 0373 of 2014		Resolution 1350 of 2018 by DAGMA	Field visit Agreement 0373 of 2014
GS5 – Operational-choice rules	Agreement 0373 of 2014 https://www.facebook.com/AsomevidCali/ (CVC, 2010)	Agreement 0373 of 2014 https://jacelretiro.com/	(Arias. R., 2018) Agreement 0373 of 2014	Field Visit Agreement 0373 of 2014	https://www.bluradio.com/blu360/pacifico/autoridades-desalojaron-a-mas-de-100-personas-que-de-manera-ilegal-ocupaban-un-predio-en-navarro-rg10 Agreement 0373 of 2014 https://www.cali.gov.co/planeacion/publicaciones/147233/Documentos/	https://bibliotecadigital.univalle.edu.co/handle/10893/12634 Agreement 0373 of 2014 https://www.cali.gov.co/planeacion/publicaciones/147233/Documentos/https://www.cali.gov.co/planeacion/publicaciones/147233/Documentos/	Decree 0438 of 2016 https://occidente.co/opinion/columnistas/parque-de-las-garzas-legado-y-olvido/https://occidente.co/opinion/columnistas/parque-de-las-garzas-legado-y-olvido/	https://clubfarallones.org/mision-y-vision/ Decree 3600 of 2007

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GS8 – Monitoring and sanctioning rules	(CVC, 2010)	(DAGMA, 2012b)	Resolution 921 of 2016	Resolution 921 2016	(CVC, 2006)	(Contreras R., 2006)	(DAGMA, 2012a)	https://cvc.gov.co/documentos/normatividad/regional/resoluciones
A1 – Number of relevant actors	(CVC, 2010)	(DAGMA, 2012b)	(Arias. R., 2018)	Field visit	(CVC, 2006)	(Contreras R., 2006)	(DAGMA, 2012a)	Field visit
	(DAP, 2022)							
A2 – Socioeconomic attibutes A2(a) – Socioeconomic groups excluded	(CVC, 2010)	(DAGMA, 2012b)	Not reported	Field visit	(CVC, 2006)	(Contreras R., 2006)	(DAGMA, 2012a)	https://clubfarallones.org/mision-y-vision/
A3 – History or past experiences	(CVC, 2010)	(DAGMA, 2012b)	https://www.javerianacali.edu.co/institucional	Field visit	https://ejatlas.org/print/sugar-cane-cauca-valley-colombia?translate=es		https://occidente.co/opinion/columnistas/parque-de-las-garzas-legado-y-olvido/	https://clubfarallones.org/nosotros/
A5 – Leadership/entrepreneurship	Leaders and representatives made interviews possible							
A8 – Importance of resource (dependence) A8(a) – Economic dependence A8(b) – Personal benefit (well-being)					https://ejatlas.org/print/sugar-cane-cauca-valley-colombia?translate=es		https://occidente.co/opinion/columnistas/parque-de-las-garzas-legado-y-olvido/	https://clubfarallones.org/mision-y-vision/
I2 – Information sharing			https://www.javerianacali.e					

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			du.co/informes-de-sostenibilidad					
I3 – Deliberation processes		https://www.cali.gov.co/dagma/publicaciones/138795/aclaracion-de-la-accion-popular-en-comuna-22---juzgado-trece-administrativo-oral-del-circuito-de-cali/						
I4 – Conflicts	(CVC, 2010)	https://www.facebook.com/profile.php?id=100081846315449	Field visit	Field visit	https://ejatlas.org/print/sugar-cane-cauca-valley-colombia?translate=es https://www.elpais.com.co/cali/video-enfrentamientos-y-cadenas-humanas-asi-avanza-el-desalojo-a-invasiones-en-navarro.html	https://ejatlas.org/print/sugar-cane-cauca-valley-colombia?translate=es	Field visit	Field visit

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
I5 – Investment activities I5(a) – Public investment activities	(DAP, 2022)							
(b) – Own investment activities	Not reported	Field visit	Field visit	Field visit	Not reported	Not reported	https://occidente.co/opinion/columnistas/parque-de-las-garzas-legado-y-olvido/	https://clubfarallones.org/nosotros/
I7 – Self-organizing activities	https://www.facebook.com/profile.php?id=100081846315449	https://www.facebook.com/profile.php?id=100081846315449	Not reported				https://www.facebook.com/profile.php?id=100081846315449	https://clubfarallones.org/nosotros/
I8 – Networking activities I8(a) Networking with government	https://www.cali.gov.co/dagma/publicaciones/166894/en-cali-los-vecinos-acompanan-al-dagma-en-el-cuidado-y-proteccion-de-61-humedales/	https://www.cali.gov.co/dagma/publicaciones/166894/en-cali-los-vecinos-acompanan-al-dagma-en-el-cuidado-y-proteccion-de-61-humedales/	Field visit	Field visit	https://www.facebook.com/watch/?v=483588206010591	https://www.cali.gov.co/planeacion/publicaciones/149287/con-participacion-comunitaria-se-definen-tres-proyectos-y-16-programas-para-navarro-y-el-hormiguero/	https://www.cali.gov.co/dagma/publicaciones/166894/en-cali-los-vecinos-acompanan-al-dagma-en-el-cuidado-y-proteccion-de-61-humedales/	https://clubfarallones.org/mision-y-vision/
I8(b) Networking with non-governmental organizations	https://alvaralice.org/noticias/abriendo-		Not reported	Not reported		Not reported		https://ebird.org/hotspot/L4886213

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
I8(c) Networking with social networks I8(e) Networking with neighbours	caminos-siembra-esperanza-en-los-barrios-de-comuneros-i-y-charco-azul/							
	https://www.facebook.com/profile.php?id=100081846315449						https://www.facebook.com/profile.php?id=100081846315449	
					https://www.facebook.com/watch/?v=483588206010591			
I9 – Monitoring activities I9(a) – Informal monitoring activities	https://www.cali.gov.co/dagma/publicaciones/174031/dia-mundial-de-los-humedales-un-2023-por-su-restauracion/		Fied visit	Field visit	https://www.facebook.com/watch/?v=483588206010591		https://www.cali.gov.co/dagma/publicaciones/174031/dia-mundial-de-los-humedales-un-2023-por-su-restauracion/	Field visit
O1 – Social performance measures	https://alvaralice.org/noticias/abriendo-	https://www.facebook.com/watch/?ref=se	Not reported	Not reported	https://ejatlas.org/print/sugar-cane-cauca-	https://ejatlas.org/print/sugar-cane-cauca-	https://www.cali.gov.co/dagma/publicacio	Not reported

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	caminos-siembra-esperanza-en-los-barrios-de-comuneros-i-y-charco-azul/	arch&v=147795614899939 4&external_log_id=e9998036-8e5a-45c2-be47-da491410317a&q=Zanjon%20del%20burro%20cali			valley-colombia?translate=es https://www.elpais.com.co/cali/video-enfrentamientos-y-cadenas-humanas-asi-avanza-el-desalojo-a-invasiones-en-navarro.html	valley-colombia?translate=es	nes/158810/ecoparque-de-las-garzas-un-mundo-abierto-para-grandes-y-chicos/	
O2 – Ecological performance measures O2(a) Quality of the units O2(b) Maintenance of the resource O2(cf) Condition of the resource due to the use	(DAGMA, 2020)	(DAGMA, 2022)	Field visit	Field visit	https://www.facebook.com/watch/?v=483588206010591	(Contreras R., 2006)	(DAGMA, 2020)	Field visit
	(DAGMA, 2020)	(DAGMA, 2022)	Field visit	Field visit	(CVC, 2006)	(Contreras R., 2006)	(DAGMA, 2020)	Field visit
	Field visit	Field visit	Field visit	Field visit	https://ejatlas.org/print/sugar-cane-cauca-valley-colombia?translate=es		Field visit	Field visit
ECO2 – Pollution patterns	(CVC, 2010)	(DAGMA, 2012b)	(Arias. R., 2018)	Field visit	(CVC, 2006)	(Contreras R., 2006)	(DAGMA, 2012a)	Field visit
Ecosystem services	(CVC, 2010)	(DAGMA, 2012b)	https://youtu.be/AOGcVZTkJM8	Field visit	(CVC, 2006)	(Contreras R., 2006)	(DAGMA, 2012a)	Field visit https://ebird.org/hotspot/L4886213

Note: (1) Charco Azul, (2) Babilla Zanjón del Burro, (3) Javeriana, (4) Acequia Grande, (5) Pacheco, (6) Hormiguero complex, (7) Las Garzas, (8) Club Farallones.

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Appendix E. intensity of variables among interviewees within each wetland

Table E.1. Intensity of variables among interviewees within each wetland.

	Charco Azul				La Babilla - Zanjón del Burro			
Codes	001-U	002-U	003-U	017-U	005-U	006-U	009-U	010-U
Social, economic and political settings (S)								
○ S1 Economic development	5	0	6	3	3	1	3	1
○ S2 Demographic trends	1	0	0	0	1	0	0	0
○ S3 Political stability	0	0	2	0	3	0	4	3
○ S4 Other governance systems	0	0	1	0	0	0	1	1
Resource systems (RS)								
○ RU3 Interaction among resource units	1	0	1	1	1	1	0	0
Resource units (RU)								
○ RS3 Size of resource	1	1	1	1	1	1	0	1
○ RS9 Location	1	0	1	0	3	0	1	1
Governance systems (GS)								
○ GS4 Property-rights systems	0	0	0	0	0	0	1	3
○ GS5 Operational-choice rules	3	3	1	2	1	1	0	4
○ GS8 Monitoring and sanctioning rules	1	0	1	1	3	0	3	1
Actors (A)								
○ A1 Number of relevant actors	0	1	0	0	0	0	0	0
○ A2 Socioeconomic attributes	5	0	4	4	3	1	0	2
○ A2a Socioeconomic groups excluded	1	5	3	2	2	3	1	1
○ A3 History of past experiences	8	2	8	9	10	2	8	10
○ A5 Leadership/entrepreneurship	6	5	6	3	4	1	2	8
○ A6 Norms (trust-reciprocity)/social capital	4	1	1	1	8	2	2	0
○ A7 Knowledge of SES/mental models	0	1	0	0	0	0	0	1
○ A8 Importance of resource (dependence)	3	2	2	2	0	0	1	0
Interactions (I)								
○ I2 Information sharing	4	0	3	4	7	2	7	6
○ I3 Deliberation processes	0	0	0	0	0	0	0	0
○ I4 Conflicts	6	2	8	7	10	2	10	10
○ I5 Investment activities	0	0	2	2	1	0	4	1
○ I7 Self-organizing activities	0	0	0	0	0	0	0	0
○ I8a Networking with government	11	6	12	4	10	12	2	6
○ I8b Networking with NGO	1	2	0	0	0	0	0	0
○ I8c Networking with social networks	4	1	7	1	0	1	0	9
○ I8d Networking within government	0	0	3	0	0	0	0	1
○ I8e Networking with neighborhoods	8	0	11	10	3	10	2	10
○ I9 Informal norms for monitoring	1	0	1	1	2	0	0	0
Outcomes								
○ O1 Social performance measures	0	5	0	0	0	0	0	1
● O2 (a) Resource sustainability: quality of the units	2	0	0	0	0	2	0	0
● O2 (b) Resource sustainability: maintenance	4	0	0	2	4	4	1	0
● O2 (c) Resource sustainability: condition of the resource	0	1	2	1	2	1	1	0

	Charco Azul				La Babilla - Zanjón del Burro			
Related ecosystems (ECO)								
○ ECO1 Climate patterns	0	0	1	0	1	0	0	0
○ ECO2 Pollution patterns	2	4	2	0	0	0	0	1
○ ECO3 Flows into and out of focal SES	1	1	0	0	0	0	0	1
Others								
○ Allocation rules	0	0	0	0	0	0	0	0
○ Boundary rules	1	0	0	0	0	0	1	2
○ Input rules	1	0	0	0	0	0	0	0
○ Penalty rules	1	0	3	0	2	2	0	1
○ Trust on informal rules	2	3	1	3	2	2	0	0
○ Disruption	2	0	0	6	3	0	4	2
○ Management	2	0	1	2	4	1	6	1
○ Model to follow	0	1	0	0	0	0	0	0
○ Personal Benefit	0	0	3	0	0	2	0	1
○ Well-being	1	0	4	0	0	0	1	3
Design principles								
● 1A User boundaries	0	0	2	0	1	0	0	3
● 1B Resource boundaries	3	1	2	0	2	1	0	1
● 2A Congruence with local conditions	0	1	0	0	0	0	0	0
● 2B Appropriation and provision	0	0	0	1	0	0	0	2
● 3 (a) Collective-choice arrangements: options to express their needs and concerns	3	2	1	1	4	5	3	3
● 3 (e) Collective-choice arrangements: actions to alter the operational or collective choice rules	1	0	0	0	3	0	1	1
● 4A (b) Monitoring users and the resource: the records of the withdrawals are kept in a systematic way	0	0	0	0	0	0	0	0
● 4A (d) Monitoring users and the resource: the records of the condition of the resource are kept in a systematic way	0	0	0	0	2	0	0	0
● 4B (a) Monitors' accountability: informal monitoring	1	0	0	1	5	2	0	1
● 4B (b) Monitors' accountability: formal monitoring	2	0	0	1	1	2	2	1
● 5 Graduated sanctions: gradation of social, physical, and official sanctions	1	0	0	0	1	0	0	1
● 6 Conflict-resolution mechanisms	0	0	5	0	3	0	1	6
● 7 Minimal recognition of rights to organize	2	0	2	2	3	0	1	2
● 8 (a) Nested enterprises: the administrator reports to any external or higher authority	0	0	1	0	2	0	0	0
● 8 (b) Nested enterprises: the appropriators are part of more than one organization	0	0	0	0	0	0	0	0
Ecosystem services								
○ ES1 Food	5	4	6	5	2	0	0	1
● ES2 Water	9	1	3	9	5	2	8	2
● ES3 Raw materials	2	1	2	0	0	0	1	0
● ES4 Genetic resources	0	1	0	0	0	0	0	0
● ES5 Medicinal resources	0	0	0	0	0	0	0	0
● ES6 Ornamental resources	1	0	0	1	0	0	2	0
● ES7 Air quality regulation	0	0	1	0	1	1	0	0

	Charco Azul				La Babilla - Zanjón del Burro			
● ES8 Climate regulation	0	0	2	0	2	1	0	2
● ES9 Moderation of extreme events	1	0	1	1	0	0	0	0
● ES10 Regulation of water flows	2	1	4	1	2	1	1	1
● ES11 Waste treatment	2	0	8	12	4	2	1	0
● ES12 Erosion prevention	0	0	0	0	2	0	0	0
● ES13 Maintenance of soil fertility	0	0	0	0	0	0	0	0
● ES14 Pollination	0	0	0	2	0	0	0	0
● ES15 Biological control	2	0	0	2	1	0	0	0
● ES16 Maintenance of life cycles	3	0	4	3	2	1	0	2
● ES17 Maintenance of genetic diversity	5	1	4	4	6	6	5	3
● ES18 Aesthetic information	3	0	4	1	2	3	4	3
● ES19 Opportunities for recreation and tourism	7	0	2	2	2	3	4	2
● ES20 Inspiration for culture, art and design	0	0	3	1	0	0	0	0
● ES21 Spiritual experience	2	0	3	3	1	0	2	1
● ES22 Information for cognitive development	7	1	0	2	3	1	2	2
● ES23 Existence, bequest values	2	3	4	3	2	0	2	3
○ Disservices	3	6	6	6	3	0	4	9
Total	150	66	158	128	145	81	97	130

Note: values refer to the absolute frequency of citations; total refers to the number of citations coded by code or interviewee.

Table E.2. Intensity of variables among interviewees within each wetland.

	Javeriana				Acequia Grande	
Codes	004-U	008-U	013-U	014-U	020-U	023-U
Social, economic and political settings (S)						
○ S1 Economic development	0	1	1	1	4	2
○ S2 Demographic trends	1	0	0	1	0	0
○ S3 Political stability	0	0	2	0	2	0
○ S4 Other governance systems	0	0	2	0	1	0
Resource systems (RS)						
○ RU3 Interaction among resource units	0	0	0	3	2	2
Resource units (RU)						
○ RS3 Size of resource	0	1	1	0	1	4
○ RS9 Location	0	2	0	1	0	0
Governance systems (GS)						
○ GS4 Property-rights systems	0	0	0	0	5	0
○ GS5 Operational-choice rules	1	1	0	1	4	2
○ GS8 Monitoring and sanctioning rules	2	1	3	3	1	2
Actors (A)						
○ A1 Number of relevant actors	0	1	0	0	1	4
○ A2 Socioeconomic attributes	0	1	0	0	2	0
○ A2a Socioeconomic groups excluded	1	1	1	1	0	0
○ A3 History of past experiences	5	5	1	11	5	5
○ A5 Leadership/entrepreneurship	3	2	3	2	0	1
○ A6 Norms (trust-reciprocity)/social capital	2	3	1	2	2	1

	Javeriana			Acequia Grande		
○ A7 Knowledge of SES/mental models	0	0	0	0	3	7
○ A8 Importance of resource (dependence)	1	0	0	1	1	4
Interactions (I)						
○ I2 Information sharing	1	5	8	4	3	2
○ I3 Deliberation processes	0	0	0	0	1	0
○ I4 Conflicts	2	2	1	4	4	1
○ I5 Investment activities	0	0	1	6	1	3
○ I7 Self-organizing activities	0	0	0	0	0	0
○ I8a Networking with government	1	2	4	5	5	2
○ I8b Networking with NGO	0	0	0	0	0	0
○ I8c Networking with social networks	1	1	4	0	0	2
○ I8d Networking within government	0	0	0	0	0	0
○ I8e Networking with neighborhoods	4	3	8	0	2	2
○ I9 Informal norms for monitoring	1	2	1	1	1	3
Outcomes						
○ O1 Social performance measures	0	0	0	0	0	0
● O2 (a) Resource sustainability: quality of the units	1	0	1	0	0	0
● O2 (b) Resource sustainability: maintenance	2	2	0	2	1	1
● O2 (c) Resource sustainability: condition of the resource	1	0	0	2	0	0
Related ecosystems (ECO)						
○ ECO1 Climate patterns	0	0	1	0	0	0
○ ECO2 Pollution patterns	0	1	1	1	0	2
○ ECO3 Flows into and out of focal SES	0	0	0	0	0	0
Others						
○ Allocation rules	0	0	0	1	0	0
○ Boundary rules	0	0	1	0	0	1
○ Input rules	1	0	0	0	0	1
○ Penalty rules	1	0	1	0	0	0
○ Trust on informal rules	2	2	1	0	0	1
○ Disruption	2	0	1	0	4	0
○ Management	2	3	3	7	0	1
○ Model to follow	0	0	0	0	0	1
○ Personal Benefit	6	0	1	1	0	0
○ Well-being	7	2	3	1	1	3
Design principles						
● 1A User boundaries	2	1	0	0	0	2
● 1B Resource boundaries	2	0	0	2	2	1
● 2A Congruence with local conditions	0	0	0	0	0	0
● 2B Appropriation and provision	0	0	0	0	1	0
● 3 (a) Collective-choice arrangements: options to express their needs and concerns	1	1	3	0	1	1
● 3 (e) Collective-choice arrangements: actions to alter the operational or collective choice rules	0	0	1	0	0	0
● 4A (b) Monitoring users and the resource: the records of the withdrawals are kept in a systematic way	0	0	0	0	0	1

	Javeriana			Acequia Grande		
● 4A (d) Monitoring users and the resource: the records of the condition of the resource are kept in a systematic way	0	0	0	1	0	1
● 4B (a) Monitors' accountability: informal monitoring	0	1	3	1	1	0
● 4B (b) Monitors' accountability: formal monitoring	2	0	2	0	1	0
● 5 Graduated sanctions: gradation of social, physical, and official sanctions	0	0	0	0	0	0
● 6 Conflict-resolution mechanisms	0	0	0	0	0	0
● 7 Minimal recognition of rights to organize	1	1	1	0	0	0
● 8 (a) Nested enterprises: the administrator reports to any external or higher authority	0	0	0	0	0	0
● 8 (b) Nested enterprises: the appropriators are part of more than one organization	0	0	0	0	0	0
Ecosystem services						
○ ES1 Food	2	2	0	1	1	3
● ES2 Water	6	5	6	9	7	2
● ES3 Raw materials	0	0	0	0	0	0
● ES4 Genetic resources	0	0	0	0	0	0
● ES5 Medicinal resources	0	0	0	0	0	0
● ES6 Ornamental resources	0	0	0	0	0	0
● ES7 Air quality regulation	0	0	1	0	1	0
● ES8 Climate regulation	0	0	2	1	1	3
● ES9 Moderation of extreme events	0	0	0	2	0	0
● ES10 Regulation of water flows	1	1	0	2	2	7
● ES11 Waste treatment	2	3	2	1	0	5
● ES12 Erosion prevention	0	0	0	0	0	0
● ES13 Maintenance of soil fertility	0	0	0	0	0	1
● ES14 Pollination	0	0	0	0	0	0
● ES15 Biological control	1	0	0	1	0	4
● ES16 Maintenance of life cycles	3	3	1	1	2	15
● ES17 Maintenance of genetic diversity	6	4	2	3	5	9
● ES18 Aesthetic information	4	3	4	1	2	3
● ES19 Opportunities for recreation and tourism	3	4	2	2	3	2
● ES20 Inspiration for culture, art and design	0	0	1	1	0	0
● ES21 Spiritual experience	5	2	1	1	3	0
● ES22 Information for cognitive development	0	4	3	2	3	0
● ES23 Existence, bequest values	5	7	5	2	4	2
○ Disservices	4	0	2	0	0	11
Total	97	80	89	86	77	121

Note: values refer to the absolute frequency of citations; total refers to the number of citations coded by code or interviewee.

Table E.3. Intensity of variables among interviewees within each wetland.

	Pacheco				Hormiguero complex			
Codes	021-P	022-P	024-P	025-P	027-P	026-P	028-P	029-P
Social, economic and political settings (S)								
○ S1 Economic development	6	7	1	4	8	6	7	5
○ S2 Demographic trends	1	2	1	0	2	2	0	1
○ S3 Political stability	0	2	0	1	1	2	2	0
○ S4 Other governance systems	0	2	2	0	1	0	0	0
Resource systems (RS)								
○ RU3 Interaction among resource units	0	1	1	1	0	1	4	1
Resource units (RU)								
○ RS3 Size of resource	0	2	3	1	2	1	1	2
○ RS9 Location	2	3	0	4	2	3	2	1
Governance systems (GS)								
○ GS4 Property-rights systems	2	4	4	1	4	6	4	0
○ GS5 Operational-choice rules	3	2	3	2	3	2	1	1
○ GS8 Monitoring and sanctioning rules	1	2	0	1	2	4	1	1
Actors (A)								
○ A1 Number of relevant actors	0	2	4	0	1	0	0	0
○ A2 Socioeconomic attributes	3	6	1	5	0	6	2	1
○ A2a Socioeconomic groups excluded	4	0	3	5	1	0	3	1
○ A3 History of past experiences	3	7	1	7	8	13	12	5
○ A5 Leadership/entrepreneurship	3	4	12	2	2	5	2	3
○ A6 Norms (trust-reciprocity)/social capital	1	2	3	0	2	2	1	0
○ A7 Knowledge of SES/mental models	0	2	6	0	0	0	1	0
○ A8 Importance of resource (dependence)	3	1	3	0	3	1	2	2
Interactions (I)								
○ I2 Information sharing	6	3	1	5	1	2	0	2
○ I3 Deliberation processes	0	0	0	0	0	0	0	0
○ I4 Conflicts	6	15	3	4	7	13	8	2
○ I5 Investment activities	2	2	1	3	1	2	2	0
○ I7 Self-organizing activities	0	2	0	0	0	0	0	0
○ I8a Networking with government	11	10	5	13	3	4	2	4
○ I8b Networking with NGO	2	1	2	1	0	0	0	0
○ I8c Networking with social networks	0	4	2	1	2	1	1	1
○ I8d Networking within government	1	0	0	0	0	0	0	0
○ I8e Networking with neighborhoods	10	10	1	7	2	3	0	2
○ I9 Informal norms for monitoring	0	1	0	1	0	0	0	0
Outcomes								
○ O1 Social performance measures	0	1	0	0	0	0	0	0
● O2 (a) Resource sustainability: quality of the units	1	1	0	1	2	0	1	0
● O2 (b) Resource sustainability: maintenance	2	3	2	0	4	1	2	0
● O2 (c) Resource sustainability: condition of the resource	2	4	0	0	2	2	2	0
Related ecosystems (ECO)								
○ ECO1 Climate patterns	0	2	1	0	0	1	0	0
○ ECO2 Pollution patterns	1	10	11	0	7	3	5	1

	Pacheco				Hormiguero complex			
○ ECO3 Flows into and out of focal SES	0	0	0	0	2	0	0	0
Others								
○ Allocation rules	1	0	1	0	0	0	0	0
○ Boundary rules	0	0	0	1	0	0	0	1
○ Input rules	1	0	0	0	0	0	0	0
○ Penalty rules	0	0	0	0	1	0	0	0
○ Trust on informal rules	2	1	0	2	1	0	0	0
○ Disruption	1	8	0	0	3	9	1	2
○ Management	2	5	5	2	4	3	0	1
○ Model to follow	0	1	0	0	0	0	0	0
○ Personal Benefit	5	1	2	0	3	1	0	6
○ Well-being	0	0	0	2	2	1	0	1
Design principles								
● 1A User boundaries	2	0	5	2	0	0	0	1
● 1B Resource boundaries	1	3	2	1	2	0	0	0
● 2A Congruence with local conditions	0	0	0	0	0	0	0	0
● 2B Appropriation and provision	0	0	2	0	0	0	0	0
● 3 (a) Collective-choice arrangements: options to express their needs and concerns	3	3	5	2	3	4	2	2
● 3 (e) Collective-choice arrangements: actions to alter the operational or collective choice rules	0	1	0	1	0	1	0	0
● 4A (b) Monitoring users and the resource: the records of the withdrawals are kept in a systematic way	0	0	0	1	0	0	0	0
● 4A (d) Monitoring users and the resource: the records of the condition of the resource are kept in a systematic way	0	0	1	1	0	0	0	0
● 4B (a) Monitors' accountability: informal monitoring	1	2	5	3	0	0	0	1
● 4B (b) Monitors' accountability: formal monitoring	1	1	2	4	0	0	0	1
● 5 Graduated sanctions: gradation of social, physical, and official sanctions	0	0	0	0	0	0	0	0
● 6 Conflict-resolution mechanisms	0	1	0	0	0	1	0	0
● 7 Minimal recognition of rights to organize	1	2	0	1	0	2	0	1
● 8 (a) Nested enterprises: the administrator reports to any external or higher authority	0	0	0	1	0	0	0	0
● 8 (b) Nested enterprises: the appropriators are part of more than one organization	0	0	0	1	0	0	0	0
Ecosystem services								
○ ES1 Food	4	8	4	3	11	8	7	10
● ES2 Water	9	10	9	7	8	10	8	8
● ES3 Raw materials	3	2	0	0	3	0	2	0
● ES4 Genetic resources	0	1	0	0	0	0	0	0
● ES5 Medicinal resources	0	0	0	0	0	0	0	0
● ES6 Ornamental resources	0	0	0	0	0	0	0	0
● ES7 Air quality regulation	1	2	0	1	0	0	0	0
● ES8 Climate regulation	1	1	0	1	0	0	0	0
● ES9 Moderation of extreme events	0	0	0	0	0	0	3	0
● ES10 Regulation of water flows	0	1	4	0	0	0	4	3

	Pacheco				Hormiguero complex			
● ES11 Waste treatment	6	5	0	10	2	1	2	1
● ES12 Erosion prevention	0	0	0	0	0	0	0	0
● ES13 Maintenance of soil fertility	0	0	0	0	0	0	0	0
● ES14 Pollination	0	0	0	0	0	0	0	0
● ES15 Biological control	1	1	0	0	0	0	0	0
● ES16 Maintenance of life cycles	3	3	2	2	1	0	0	1
● ES17 Maintenance of genetic diversity	6	4	0	6	5	1	1	6
● ES18 Aesthetic information	2	1	1	3	0	0	0	0
● ES19 Opportunities for recreation and tourism	4	2	3	8	4	5	1	1
● ES20 Inspiration for culture, art and design	1	0	0	0	0	0	0	0
● ES21 Spiritual experience	3	2	0	1	2	1	1	2
● ES22 Information for cognitive development	0	2	2	3	1	2	0	2
● ES23 Existence, bequest values	4	3	0	1	0	0	1	0
○ Disservices	2	7	0	0	2	9	0	2
Total	132	177	117	126	108	118	79	77

Note: values refer to the absolute frequency of citations; total refers to the number of citations coded by code or interviewee.

Table E.4. Intensity of variables among interviewees within each wetland.

	Las Garzas				Club Farallones		
Codes	007-P	011-P	012-P	016-P	015-P	018-P	019-P
Social, economic and political settings (S)							
○ S1 Economic development	2	1	0	1	2	3	0
○ S2 Demographic trends	1	0	0	0	0	2	1
○ S3 Political stability	2	0	0	0	0	1	1
○ S4 Other governance systems	0	0	0	1	3	4	1
Resource systems (RS)							
○ RU3 Interaction among resource units	2	0	0	0	0	4	1
Resource units (RU)							
○ RS3 Size of resource	1	1	0	2	2	0	1
○ RS9 Location	1	0	1	0	0	0	1
Governance systems (GS)							
○ GS4 Property-rights systems	0	0	0	0	1	4	2
○ GS5 Operational-choice rules	1	4	5	1	2	3	3
○ GS8 Monitoring and sanctioning rules	4	3	0	3	0	3	2
Actors (A)							
○ A1 Number of relevant actors	1	0	4	0	0	0	0
○ A2 Socioeconomic attributes	2	1	0	1	0	4	0
○ A2a Socioeconomic groups excluded	1	1	3	1	5	1	2
○ A3 History of past experiences	8	18	0	4	2	8	9
○ A5 Leadership/entrepreneurship	2	3	3	3	3	1	5
○ A6 Norms (trust-reciprocity)/social capital	1	2	2	2	2	1	4
○ A7 Knowledge of SES/mental models	0	0	0	0	3	0	1
○ A8 Importance of resource (dependence)	1	0	0	0	0	2	0
Interactions (I)							

	Las Garzas				Club Farallones		
○ I2 Information sharing	6	4	1	1	3	8	4
○ I3 Deliberation processes	0	0	0	0	0	0	0
○ I4 Conflicts	8	9	0	7	1	4	4
○ I5 Investment activities	0	0	1	4	2	2	1
○ I7 Self-organizing activities	0	0	0	0	1	0	1
○ I8a Networking with government	6	4	11	8	2	5	2
○ I8b Networking with NGO	0	1	0	1	1	0	1
○ I8c Networking with social networks	2	2	2	5	1	4	6
○ I8d Networking within government	4	0	0	1	0	0	0
○ I8e Networking with neighborhoods	5	6	0	6	0	4	2
○ I9 Informal norms for monitoring	1	2	2	0	0	0	3
Outcomes							
○ O1 Social performance measures	0	0	2	0	0	0	1
● O2 (a) Resource sustainability: quality of the units	0	0	0	0	0	1	2
● O2 (b) Resource sustainability: maintenance	0	2	3	2	5	0	1
● O2 (c) Resource sustainability: condition of the resource	0	1	3	1	0	2	1
Related ecosystems (ECO)							
○ ECO1 Climate patterns	0	0	0	0	0	1	0
○ ECO2 Pollution patterns	0	1	1	0	0	0	2
○ ECO3 Flows into and out of focal SES	1	0	1	0	1	1	1
Others							
○ Allocation rules	0	0	5	0	0	0	0
○ Boundary rules	0	0	0	1	1	0	1
○ Input rules	0	0	4	0	0	1	0
○ Penalty rules	2	0	0	0	0	0	0
○ Trust on informal rules	0	1	1	3	1	0	2
○ Disruption	2	1	1	2	0	3	1
○ Management	6	5	3	2	5	7	2
○ Model to follow	3	0	1	0	0	3	0
○ Personal Benefit	1	0	0	0	2	4	0
○ Well-being	1	0	0	1	0	0	4
Design principles							
● 1A User boundaries	0	0	0	1	1	0	2
● 1B Resource boundaries	2	0	0	0	2	2	1
● 2A Congruence with local conditions	0	0	2	0	0	0	0
● 2B Appropriation and provision	0	0	0	0	3	0	1
● 3 (a) Collective-choice arrangements: options to express their needs and concerns	2	2	5	4	3	2	7
● 3 (e) Collective-choice arrangements: actions to alter the operational or collective choice rules	1	0	1	0	0	0	6
● 4A (b) Monitoring users and the resource: the records of the withdrawals are kept in a systematic way	0	0	0	0	0	1	0
● 4A (d) Monitoring users and the resource: the records of the condition of the resource are kept in a systematic way	0	0	0	0	0	1	1

	Las Garzas				Club Farallones		
● 4B (a) Monitors' accountability: informal monitoring	2	1	2	2	0	2	0
● 4B (b) Monitors´ accountability: formal monitoring	2	1	1	1	0	2	0
● 5 Graduated sanctions: gradation of social, physical, and official sanctions	2	0	0	0	0	0	1
● 6 Conflict-resolution mechanisms	0	0	0	0	0	0	3
● 7 Minimal recognition of rights to organize	1	0	0	0	0	1	3
● 8 (a) Nested enterprises: the administrator reports to any external or higher authority	0	0	0	0	0	2	1
● 8 (b) Nested enterprises: the appropriators are part of more than one organization	0	0	0	0	0	0	0
Ecosystem services							
○ ES1 Food	3	0	0	0	0	2	1
● ES2 Water	6	2	0	2	1	15	8
● ES3 Raw materials	0	0	0	0	1	0	1
● ES4 Genetic resources	0	0	1	0	0	0	0
● ES5 Medicinal resources	0	0	0	0	0	0	0
● ES6 Ornamental resources	0	0	1	0	0	2	0
● ES7 Air quality regulation	2	1	2	0	0	1	1
● ES8 Climate regulation	2	1	0	0	0	1	1
● ES9 Moderation of extreme events	0	0	1	0	3	3	2
● ES10 Regulation of water flows	1	0	1	0	3	4	4
● ES11 Waste treatment	1	2	0	2	0	2	0
● ES12 Erosion prevention	1	0	0	0	0	0	0
● ES13 Maintenance of soil fertility	0	0	0	0	0	0	0
● ES14 Pollination	0	0	1	0	0	0	0
● ES15 Biological control	0	0	0	0	0	1	1
● ES16 Maintenance of life cycles	1	3	3	1	5	3	5
● ES17 Maintenance of genetic diversity	3	3	1	3	1	6	10
● ES18 Aesthetic information	1	2	3	3	2	1	3
● ES19 Opportunities for recreation and tourism	3	4	6	5	5	4	6
● ES20 Inspiration for culture, art and design	0	0	1	0	0	0	3
● ES21 Spiritual experience	2	4	3	3	0	1	1
● ES22 Information for cognitive development	5	3	1	6	4	5	5
● ES23 Existence, bequest values	2	4	4	4	1	5	3
○ Disservices	2	1	4	2	4	3	0
Total	111	98	98	95	80	139	144

Note: values refer to the absolute frequency of citations; total refers to the number of citations coded by code or interviewee.

Table E.5. Intensity of variables among key informants.

Codes	Key informants				Total
	001-K	002-K	003-K	004-K	
Social, economic and political settings (S)					
○ S1 Economic development	5	8	6	2	76
○ S2 Demographic trends	1	4	3	0	21
○ S3 Political stability	2	4	2	2	22
○ S4 Other governance systems	3	4	3	5	29
Resource systems (RS)					
○ RU3 Interaction among resource units	0	4	3	1	26
Resource units (RU)					
○ RS3 Size of resource	0	0	0	1	24
○ RS9 Location	5	4	4	0	33
Governance systems (GS)					
○ GS4 Property-rights systems	1	1	1	6	41
○ GS5 Operational-choice rules	5	6	4	7	60
○ GS8 Monitoring and sanctioning rules	3	2	2	3	39
Actors (A)					
○ A1 Number of relevant actors	3	0	0	2	21
○ A2 Socioeconomic attributes	5	8	5	1	51
○ A2a Socioeconomic groups excluded	1	3	1	2	38
○ A3 History of past experiences	9	10	5	1	135
○ A5 Leadership/entrepreneurship	2	2	6	1	65
○ A6 Norms (trust-reciprocity)/social capital	3	1	2	0	32
○ A7 Knowledge of SES/mental models	2	3	5	3	33
○ A8 Importance of resource (dependence)	0	1	1	4	28
Interactions (I)					
○ I2 Information sharing	11	3	11	1	75
○ I3 Deliberation processes	0	0	0	0	0
○ I4 Conflicts	6	18	6	3	125
○ I5 Investment activities	6	2	6	0	40
○ I7 Self-organizing activities	0	0	3	0	7
○ I8a Networking with government	6	2	4	14	118
○ I8b Networking with NGO	1	1	0	0	12
○ I8c Networking with social networks	3	4	4	3	50
○ I8d Networking within government	7	3	4	6	26
○ I8e Networking with neighborhoods	7	4	9	0	80
○ I9 Informal norms for monitoring	3	0	3	0	19
Outcomes					
○ O1 Social performance measures	2	1	1	0	8
● O2 (a) Resource sustainability: quality of the units	0	1	0	2	12
● O2 (b) Resource sustainability: maintenance	2	2	1	3	36
● O2 (c) Resource sustainability: condition of the resource	0	1	1	3	25
Related ecosystems (ECO)					
○ ECO1 Climate patterns	0	0	3	0	8
○ ECO2 Pollution patterns	1	8	1	2	56

	Key informants				
○ ECO3 Flows into and out of focal SES	3	1	0	0	11
Others					
○ Allocation rules	0	4	0	1	12
○ Boundary rules	1	0	0	1	8
○ Input rules	0	1	0	0	8
○ Penalty rules	2	1	1	0	7
○ Trust on informal rules	0	0	0	2	17
○ Disruption	5	9	2	0	50
○ Management	12	7	7	2	81
○ Model to follow	2	2	0	1	14
○ Personal Benefit	0	0	1	2	28
○ Well-being	0	0	2	1	18
Design principles					
● 1A User boundaries	0	0	0	2	18
● 1B Resource boundaries	2	2	2	2	25
● 2A Congruence with local conditions	0	0	0	4	6
● 2B Appropriation and provision	0	0	0	0	6
● 3 (a) Collective-choice arrangements: options to express their needs and concerns	3	3	3	5	64
● 3 (e) Collective-choice arrangements: actions to alter the operational or collective choice rules	0	0	0	2	13
● 4A (b) Monitoring users and the resource: the records of the withdrawals are kept in a systematic way	1	0	0	0	4
● 4A (d) Monitoring users and the resource: the records of the condition of the resource are kept in a systematic way	1	0	0	0	6
● 4B (a) Monitors' accountability: informal monitoring	0	0	0	2	23
● 4B (b) Monitors' accountability: formal monitoring	2	2	1	1	22
● 5 Graduated sanctions: gradation of social, physical, and official sanctions	1	3	0	1	8
● 6 Conflict-resolution mechanisms	1	2	2	6	16
● 7 Minimal recognition of rights to organize	1	0	1	4	18
● 8 (a) Nested enterprises: the administrator reports to any external or higher authority	0	1	1	1	7
● 8 (b) Nested enterprises: the appropriators are part of more than one organization	0	1	0	0	2
Ecosystem services					
○ ES1 Food	4	3	5	3	79
● ES2 Water	5	19	12	0	141
● ES3 Raw materials	0	1	0	0	13
● ES4 Genetic resources	0	0	0	0	2
● ES5 Medicinal resources	0	0	0	0	0
● ES6 Ornamental resources	1	0	1	0	5
● ES7 Air quality regulation	2	2	3	1	19
● ES8 Climate regulation	2	1	2	2	18
● ES9 Moderation of extreme events	0	1	4	1	18
● ES10 Regulation of water flows	1	2	3	3	41

	Key informants				
● ES11 Waste treatment	1	7	4	0	51
● ES12 Erosion prevention	0	0	1	2	4
● ES13 Maintenance of soil fertility	0	0	0	2	3
● ES14 Pollination	1	0	0	1	3
● ES15 Biological control	0	0	2	0	10
● ES16 Maintenance of life cycles	4	3	4	1	60
● ES17 Maintenance of genetic diversity	2	6	6	1	80
● ES18 Aesthetic information	1	3	7	0	36
● ES19 Opportunities for recreation and tourism	3	4	8	3	81
● ES20 Inspiration for culture, art and design	1	1	1	0	8
● ES21 Spiritual experience	3	0	3	0	32
● ES22 Information for cognitive development	3	0	13	2	59
● ES23 Existence, bequest values	2	2	3	0	41
○ Disservices	5	9	2	1	66
Total	158	181	189	114	2462

Note: values refer to the absolute frequency of citations; total refers to the number of citations coded by code or interviewee.

Appendix F. Supplementary results of chapter 3

1. Barriers and facilitators

A common goal is affected by a set of combinations of barriers. For instance, findings in peri-urban wetlands located in low-income levels show both the size of the resource and the number of actors to be irrelevant because the common goal corresponds to the landowner, or those who have the right of appropriation of the resource. This is the case of the lease of *ejidos,* defined by law as goods for public or common use (National Constitution Art. 63). Despite express prohibition by constitutional mandate, many of the *ejidos* have acquired the appearance of private property (e.g. rural interviewed inhabitants do not know who the legal landowner where the peri-urban wetland is, therefore some accept that they cannot access or use the resource, or some landowners manage *ejidos* through permits which are given by public administration). In this case, barriers such as property-rights systems (GS4), weak public operational-choice rules (GS5), existence of excluded socioeconomic groups (A2a), conflicts (I4), and polluted patterns (ECO2), diminish the importance of the resource (A8) affecting collective actions and decreasing the common goal in wetlands. Therefore, both negative social and ecological outcomes are generated (O1, O2). That was the situation after 1958 in Navarro and the Hormiguero complex; unfortunately, networking with government and leadership has not facilitated the improvement of collective actions and positive outcomes around these wetlands (see Figure F.1). Furthermore, in urban and peri-urban wetlands located in private land and high-income levels, institutional barriers such as issues with property-right systems (GS4), and private operational-choice rules (GS5) are relevant because they limit access to and use of the resource. Thus, networking with government is not the target for the landowner.

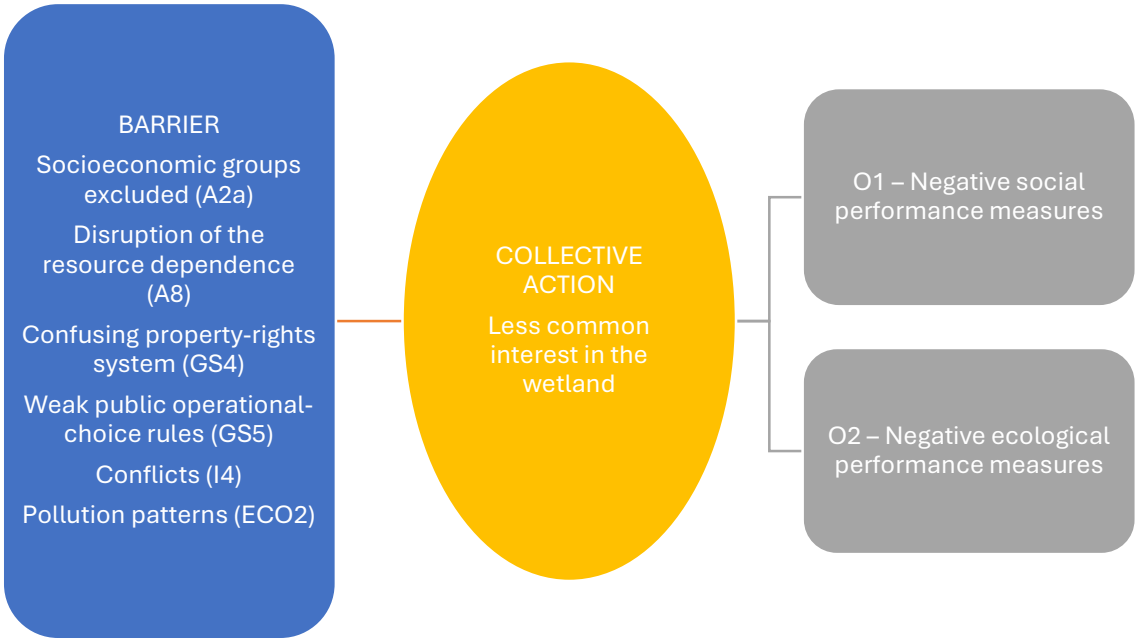

Figure F.1. Barriers affecting collective actions and outcomes in Navarro and Hormiguero complex after 1958.

A common goal is improved by a set of combinations of facilitators. We find that in urban wetlands located in public land and high-income levels factors such as norms (trust-reciprocity)/social capital (A6), self-organization activities (I7), and community operational-choice rules (GS5) enable collective actions. That was the case of La Babilla-Zanjón del Burro and Las Garzas wetlands, where community activities had started in 2012 and 1995 respectively. In addition, if leadership/entrepreneurship (A5) and networking with government, and private agencies and neighbours (I8) are in the arena, this will increase the common goal in wetlands. As a consequence, facilitators such as the importance of the resource (A8), information sharing (I2), deliberation processes (I3), public and own investment activities (I5), and informal monitoring activities (I8) were enabled, thus generating positive ecological outcomes (O2a, O2b, Oc) (see Figure F.2).

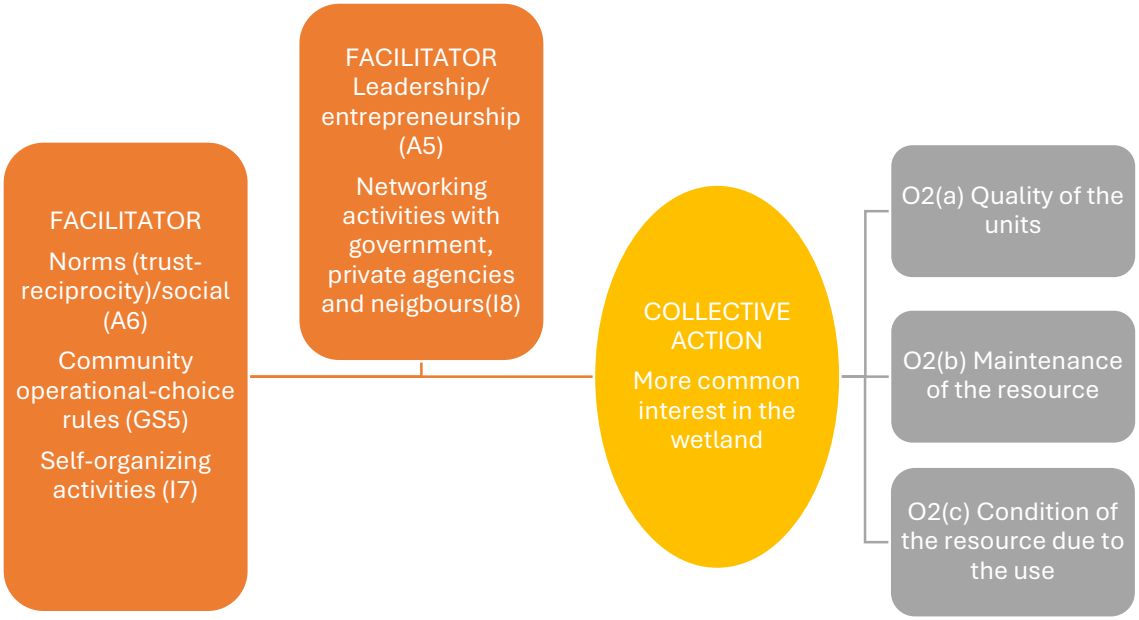

Figure F.2. Facilitators improving collective actions and outcomes in La Babilla-Zanjón del Burro and Las Garzas by 2012 and 1995.

At the present time contradictory public operational-choice rules (GS5) are in use. Despite the presence of leadership, and networking, as well other facilitators, wetlands have been affected with regard to the quality of the units (O2a). This is due to contradiction between environmental rules and land use planning, which gives priority to the construction activity in the city (POT, 2014) (see Figure F.3).

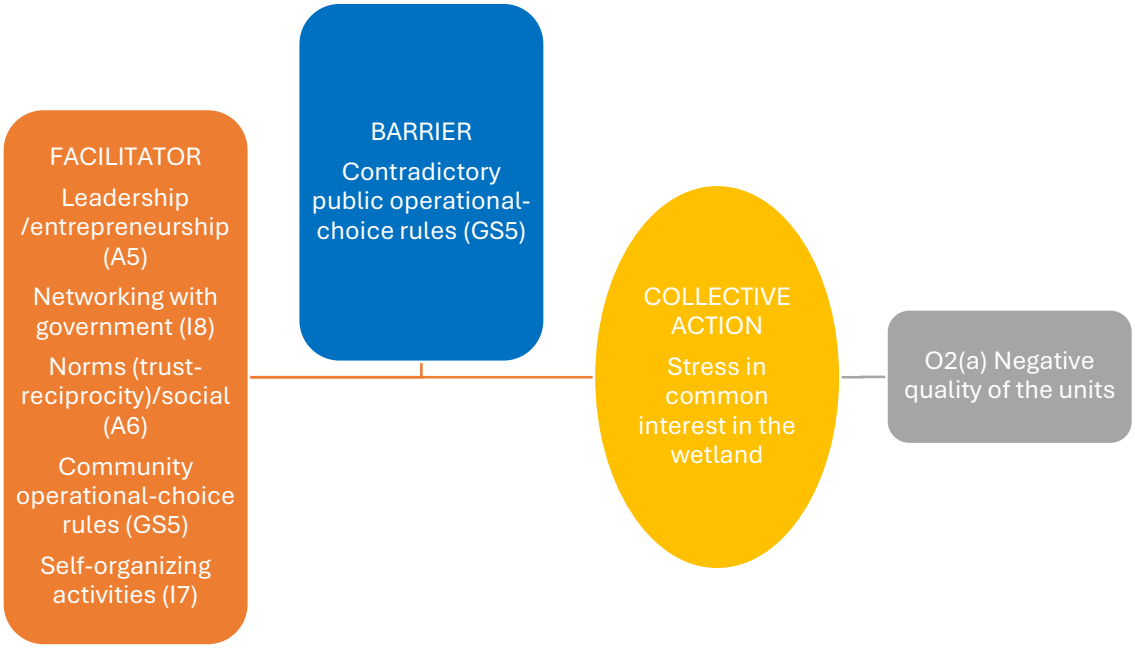

Figure F.3. Facilitators and barriers affecting collective actions and outcomes in La Babilla-Zanjón del Burro and Las Garzas at the present time.

2. Leadership and networking

Leaders influence networking with government, neighborhoods, and non-government organizations, and are associated with social networks, for instance, *comanejo* committees, *Asociación Mejorando Vidas*, and the *Red de Humedales* (a wetland community network). In addition, they are key players in social media, posting environmental messages, or calling meetings, i.e., Facebook in La Babilla-Zanjón de Burro and WhatsApp in Charco Azul.

Furthermore, interviews show evidence of other variables where leaders are key players in three main fields: interactions, information and rules. First, self-organizing activities (I7), own-investment activities (I5) and monitoring activities (I9 are related through a common objective around wetlands, for instance, families that came together after the American Airlines disaster, wanting to leave a footprint of their missing relatives. They searched and chose the appropriate place (Las Garzas), collected money to recover biodiversity, invested in maintenance activities, visited the park periodically to take care of it, monitored the appropriation activities of other

users, and interacted with neighbours and different governance systems, all of this taking place over a number of years until its transfer to DAGMA as a legacy of the city (see Figure F.4). It is important to clarify that despite having networking with government, there is a mismatch with public agencies in the case of wetlands located in private lands. This is because landowners do not want environmental agencies to make decisions affecting their properties. As a consequence, direct benefits of these ecosystems are enjoyed by selected groups (e.g., in Club Farallones and Acequia Grande wetlands).

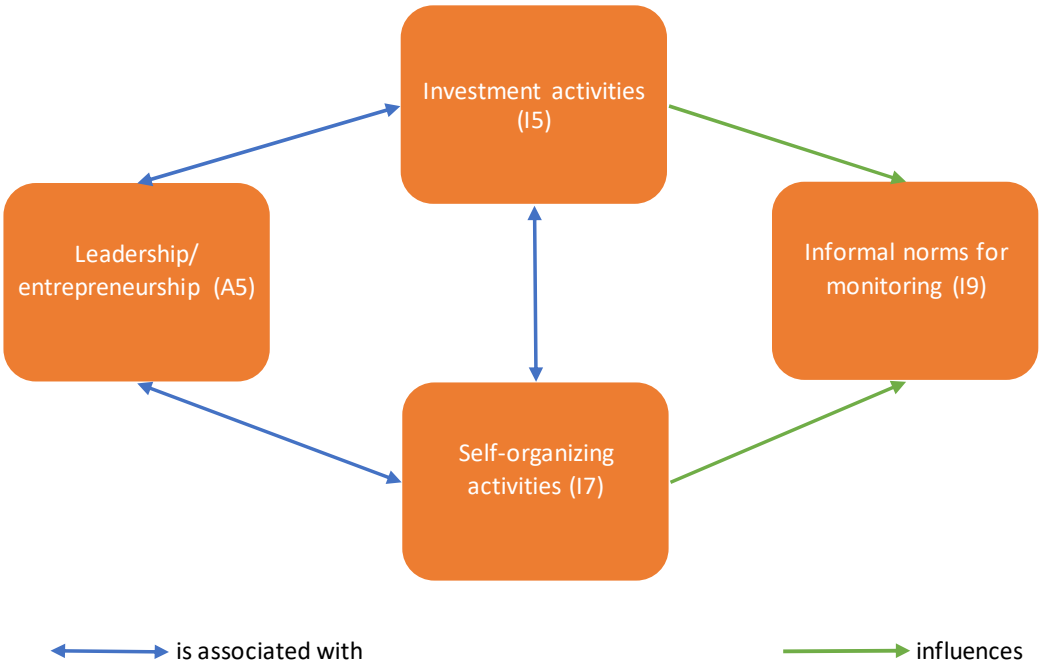

Figure F.4. Relationships among leadership and interactions in La Babilla-Zanjón del Burro and Las Garzas.

Note: is associated with: co-occurrence of two variables; influences: one variable enhances the other.

Second, information sharing (I2), history of past experiences (A3), and knowledge of SES/mental models (A7) are associated with leaders (see Figure F.5). They foster interaction

with government and a sense of belonging (e.g., meetings with regard to relocation of inhabitants at the risk of flooding in Pacheco, the park serving as a means to bear the burden of the death of loved ones in Las Garzas). There is also a case for understanding the social-ecological system that influences resource sustainability (O2b), (e.g., learning, implementing and teaching about fauna and flora which are suitable for the wetland in Charco Azul).

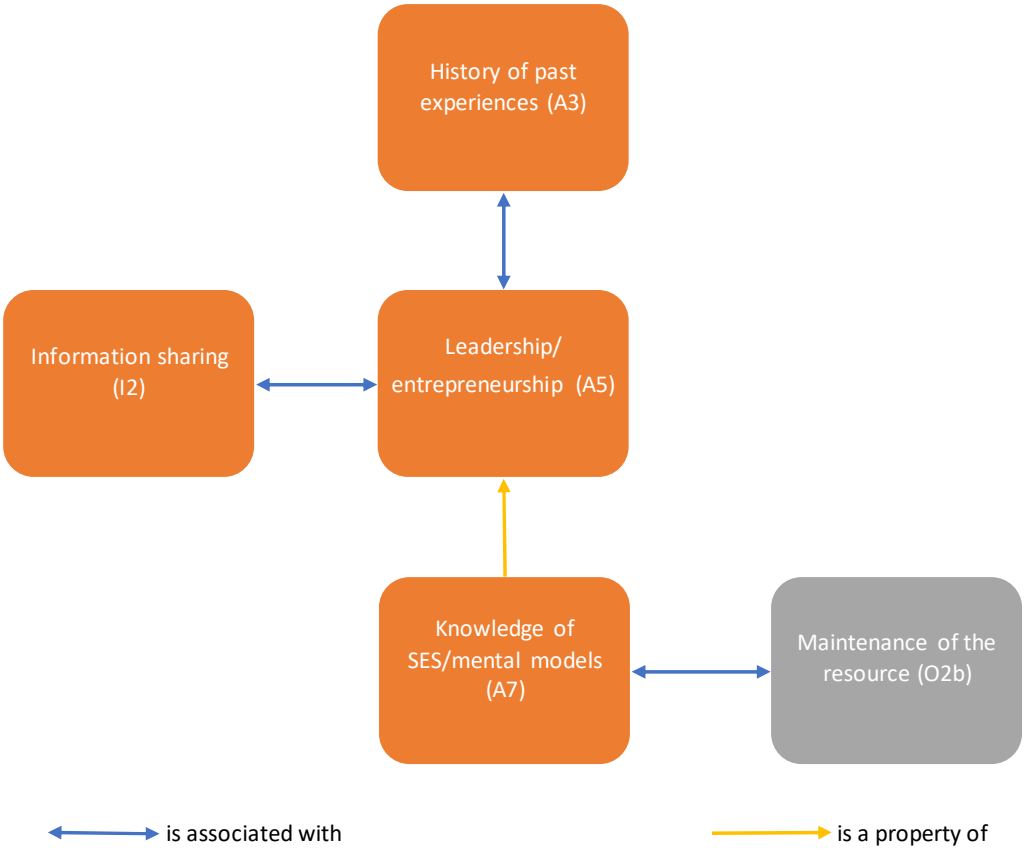

Figure F.5. Relationships among leadership and information in Charco Azul, La Babilla-Zanjón del Burro, and Las Garzas.

Note: is associated with: co-occurrence of two variables; is a property of: one variable belongs to the other.

Finally, norms (trust-reciprocity)/social capital (A6), and operational-choice rules (GS5) are related by leaders (see Figure F.6). As a result, inhabitants are drawn into a blurred line between monitoring and sanctioning rules (GS8), and penalty rules, which are implemented by

government agencies (e.g., neighbours requesting the presence of police to enforce rules, because they believe there is no environmental culture among the users in La Babilla-Zanjón del Burro). Despite networking with government, to a certain extent, the leaders harbour distrust towards policy makers due to investment projects that do not fit the needs of the community, i.e., *comanejo* committees where DAGMA socializes investment projects of wetlands, but members do not make decisions.

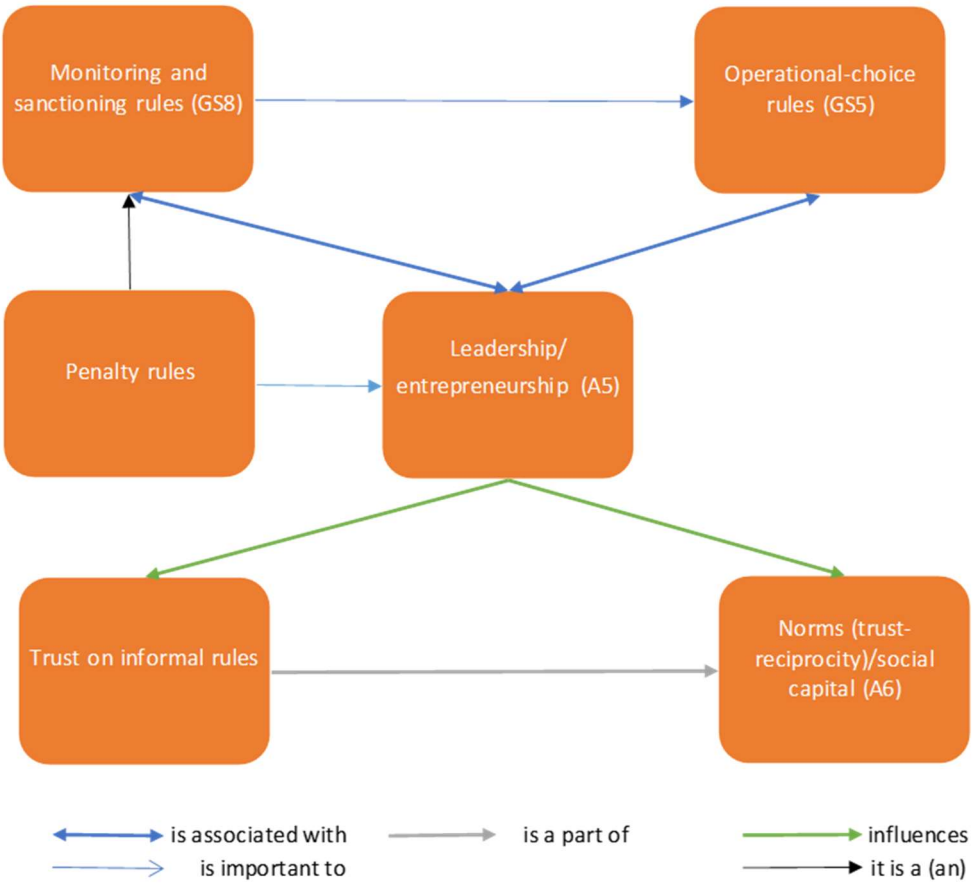

Figure F.6. Relationships among leadership and rules in La Babilla-Zanjón del Burro.

Note: is associated with: co-occurrence of two variables; is a part of: one variable is into the other; influences: one variable enhances the other; is important to: one variable has a value for the other; it is a(an): one variable is perceived similarly such as the other.

3. Excluded socioeconomic groups, conflicts and outcomes

There are latent environmental conflicts in urban and peri-urban wetlands located in high-income levels, due to the activity of the construction sector, which has legal permits, thus, some wetlands are embedded in private lands. This situation tends to cause biodiversity loss, affecting ES flows, where conflicts are associated with property-rights systems (I4). As a result, a new excluded socioeconomic group arises, which has had mainly constrained provisioning and cultural ES, i.e., information for cognitive development (ES22), opportunities for recreation and tourism (E19), and aesthetic information (ES18). In this case, affected users are spread over the city, i.e., those people who are not members of sporting or recreational clubs, or inhabitants who do not live, study or work in private properties that contain wetlands. Moreover, people that live in high-income housing areas are accustomed to having a fence around their property, due to security concerns, and this situation limits interaction and trust among neighbours (confirmed by interviewee from DAGMA). In addition, wetlands located in public lands and wealthy neighbourhoods seem to be in better condition than those in deprived zones, thus, the former have a large flow of visitors from different areas of the city. Therefore, household incomes place constraints on users visiting these ecosystems, hence excluded socioeconomic groups become more ′excluded′ (e.g., the number of people who live in the east of Cali have to solve their living needs before investing in recreational activities; the Charco Azul neighbourhood is home to people who are drug addicts, are homeless, and those who recycle waste and garbage, and who have low-income). Finally, places with recreational activities contain urban infrastructure; it is thus inferred that they have visible investment (I5) and maintenance activities reflected in resource sustainability (O2a, O2b) such as La Babilla and Las Garzas (see Figure F.7).

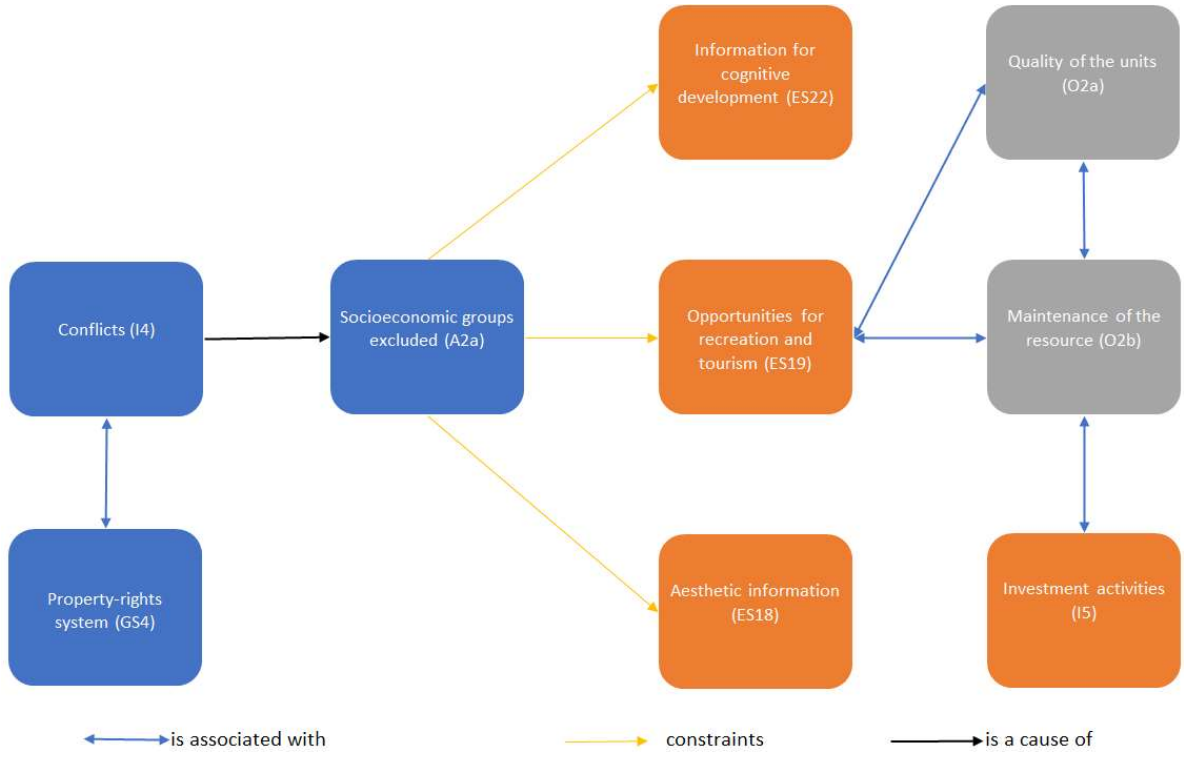

Figure F.7. Relationships among socioeconomic groups excluded in La Babilla-Zanjón del Burro, Las Garzas, Javeriana, Acequia Grande and Club Farallones.

Note: is associated with: co-occurrence of two variables; is a cause of: one variable is the origin of the other; constraints: one variable assign limits the other.

References

POT. (2014). *Acuerdo N° 0373 de 2014 por medio del cual se adopta la revisión ordinaria de contenido de largo plazo del Plan de Ordenamiento Territorial del Municipio de Santiago de Cali*. Consejo Santiago de Cali. https://www.cali.gov.co/planeacion/publicaciones/106497/pot_2014_idesc/ (accessed on 21 April 2021).

Appendix G. Survey

G.1. Questionnaire

SURVEY OF WETLANDS IN CALI

This survey, conducted as part of doctoral research at the Pontificia Universidad Javeriana de Cali and the Universitat Autònoma de Barcelona, aims to analyze the perceptions of the inhabitants of the metropolitan area of the city of Cali in relation to wetlands. Its purpose is to determine to what extent they contribute to the well-being of society, as well as the degree of importance they represent for people.

The data collected will be treated in aggregate form for academic purposes, in accordance with the provisions of Law 1581 of 2012 on the processing of personal data.

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1. I authorize the use of the data collected in the survey and the results obtained during the research for academic and scientific purposes, provided that the confidentiality of the personal information of those involved is preserved.

Mark only one option.

◯ Accepted

Wetlands

Are ecosystems that connect terrestrial and aquatic life. Main components: soil, water, microorganisms, animals and plants adapted to wet and solid soils.

Other names used for **wetlands: lake, lakes, pond.**

Example:
Charco Azul (Blue Lake) wetland - Photograph: Lida Díaz.

2. Name of person conducting this survey

Mark only one option.

- ◯ Lida Díaz
- ◯ Others: _____

3. Place where this survey is conducted

_____

4. Date

_____
Example: January 7, 2019

5. Select the name of the wetland on which you are responding to this survey

Mark only one option.

- ◯ Charco Azul
- ◯ El Pondaje
- ◯ Isaías Duarte Cancino
- ◯ Puerto Mallarino reservoir
- ◯ Others: _____

6. The wetland on which you are responding…

Mark only one option.

- ◯ I have visited it (walking or stayed there for a while) *Go to numeral 2 ECOSYSTEM SERVICES and continue with question 7*
- ◯ I have passed by *Go to numeral 2 ECOSYSTEM SERVICES and continue with question 9*
- ◯ I have neither visited it nor passed by, but I know that it exists *Go to numeral 2 ECOSYSTEM SERVICES and continue with question 9*

1.HABITS AND USES OF THE WETLAND	This section seeks to assess how often you go to the wetland and how long you REMAIN there. If you have visited a wetland, answer the following two questions.

7. How frequently do you visit the wetland?

Mark your answer in each row.

Mark only one option per row.

	Every day	At least once per week	At least once per month	At least one every 3 months	At least once every 6 months	At least once per year	I do not visit
Weekdays	⬭	⬭	⬭	⬭	⬭	⬭	⬭
Weekends	⬭	⬭	⬭	⬭	⬭	⬭	⬭

8. On average, how much time do you spend at the wetland?

Mark your answer in each row.

Mark only one option per row.

	Less than 30 minutes	30-60 minutes	1-2 hours	2-5 hours	More than 5 hours	I do not visit
Weekdays	⬭	⬭	⬭	⬭	⬭	⬭
Weekends	⬭	⬭	⬭	⬭	⬭	⬭

Go to question 13

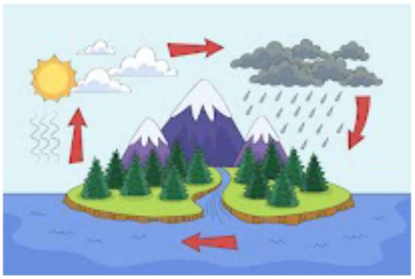
2. ECOSYSTEM SERVICES

This section seeks to assess which benefits of wetlands are important for the well-being of the community.

Read carefully the following groups of benefits offered by wetlands.

Provisioning: Benefits obtained from the consumption of resources and raw materials produced by nature.
Photograph: Designed by Freepik.

Regulating: Benefits related to the functions of nature that allow the care of human health and the functioning of the environment.
Photograph: Designed by Freepik.



Habitat: habitat-related benefits provided by ecosystems for the life cycle of migratory species, as well as genetic diversity of great importance for sustaining life on earth.
Photograph: Designed by Freepik.

Cultural: Benefits that the population obtains from nature, through spiritual enrichment, environmental education, recreational and aesthetic experiences.
Photograph: Designed by Freepik.

9. Indicate to what extent the **wetland you have selected** provides **benefit to the community** because it provides resources and raw materials produced by nature.

Photograph: Grupo Natura - Icesi.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	**Strongly agree**

10. Please indicate to what extent the wetland you have selected provides benefit to the community because it supports the care of human health and the functioning of the environment.

Photograph: Grupo Natura - Icesi.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	**Strongly agree**

11. Indicate to what extent the wetland you have selected provides community benefit because it provides habitat for the life cycle of migratory species, as well as genetic diversity of great importance for sustaining life on earth.

Photograph: Grupo Natura - Icesi.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	**Strongly agree**

12. Indicate to what extent the wetland you have selected provides benefit to the community because it provides spaces for spiritual enrichment, environmental education, recreational and aesthetic experiences.

Photograph: Lida Díaz.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	**Strongly agree**

Go to section 5 (3. SOCIO-CULTURAL VALUATION)

13. If you have visited the wetland, how long does a trip take (leaving your home and returning home) when you make your visit?
Think only about the time of the trip. Note the time in minutes.
Example: 45

_____

14. If you have visited the wetland, how much money do you spend on a trip (from leaving your home to returning home) when you visit the place?
Note the amount of money (Colombian pesos/trip).

_____

15. What is the average monthly income of your home?
Note the minimum monthly salary (SMMLV/month) that your family (including you) receives.
Note: 1 SMMLV = $1.000.000 Colombian pesos.

Mark only one option.

- ◯ 0
- ◯ 0-1
- ◯ 1-2
- ◯ 2-3
- ◯ 3-4
- ◯ 4-5
- ◯ 5-10
- ◯ More than 10

Go to question 35

3. NON-MONETARY VALUATION	This section seeks to make a non-monetary assessment of the cultural benefits provided by wetlands.

Non-monetary valuation

Rate 1 to 10 of the following cultural benefits of wetlands based on how important they are to you.

Aesthetic information

The wetland you have selected **is important for you because…**

16. … its nature, colors, smells, sounds enrich the human mind.

Photograph: Lida Díaz.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	**Strongly agree**

Opportunities for recreation and tourism
The wetland you have selected **is important for you because…**

17. … it serves as an area for recreation as well as sports among other activities. Its spaces and green areas are attractive to tourists.

Photograph: Lida Díaz.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	**Strongly agree**

Inspiration for culture, art and design
The wetland you have selected **is important for you because…**

18. …. its nature and components inspire the human mind in different creations.

Photograph: Lida Díaz.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	**Strongly agree**

Spiritual and/or religious experience

The wetland you have selected **is important for you because…**

19. ... its landscapes and locations create a sense of place that stimulates spiritual experiences.

Designed by Freepik.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	**Strongly agree**

Research and environmental education

The wetland you have selected **is important for you because….**

20. … its natural environment provides an opportunity for environmental education of the population.

Designed by Freepik.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	**Strongly agree**

Existence and legacy

The wetland you have selected **is important for you because…**

21. … it generates environments that are conducive to beliefs, stories and / or it is the legacy of future generations.

Designed by Freepik.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	**Strongly agree**

4. COLLECTIVE ACTIONS	Collective actions refer to the process of channelling efforts towards the common interest (e.g. working together for wetland restoration).

22. Do you consider that your needs are taken into account by those who make decisions in relation with the wetland?

Mark only one option.

- ◯ Yes
- ◯ No *Go to question 24*
- ◯ Don't know *Go to question 24*

23. If you answered 'yes', please state the extent to which your needs are taken into account in the decision-making in relation to the wetland.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
To a limited extend	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	**To a great extent**

24. Do you know or have you seen any rules, regulations or provisions of wetland use? Examples: signs, established uses, sanctions for non-compliance with rules.

Mark only one option.

- ◯ Yes
- ◯ No *Go to question 27*
- ◯ Don't know *Go to question 27*

25. If you answered 'yes', please state the extent to which you trust the rules for wetland use.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
To a limited extend	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	**To a great extent**

26. If you are aware of any rules, regulations or provisions, identify the extent to which the community has participated in defining it.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
To a limited extend	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	**To a great extent**

27. Do you receive income from working in wetland activities?

Mark only one option.

◯ Yes
◯ No *Go to question 2*
◯ Sometimes

28. If you answered 'yes', please state the extent to which your income is a result of activities related to the wetland.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
To a limited extend	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	**To a great extent**

29. Is the wetland a source of benefits for your personal well-being?

Mark only one option.

◯ Yes
◯ No *Go to question 31*
◯ Don't know *Go to question 31*

30. If your answer is ‘yes’, state how much your well-being depends on the benefits provided by the wetland.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
To a limited extend	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	**To a great extent**

31. Do you know if there are wetland-related relationships or workspaces between the community and public bodies?

Mark only one option.

⬭ Yes
⬭ No *Go to question 33*
⬭ Don’t know *Go to question 33*

32. If you answered ‘yes’, please state to what extent these relationships or work opportunities between the community and public offices generate specific actions related to the wetland.

Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
To a limited extend	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	**To a great extent**

33. Apart from state organizations, do community members monitor the wetland? Example: records of extraction or status of resources?
Mark only one option.

⬭ Yes
⬭ No *Go to question 35*
⬭ Don’t know *Go to question 35*

34. If your answer was ‘yes’. please state the extent to which monitoring by members of the community is taken into account by those who make decisions in relation to the wetland.
Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
To a limited extend	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	**To a great extent**

Go to question 38

35. What is your perception of the degree of water pollution found in by the wetland at the moment?
Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Very low quality	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	**Very high quality**

36. What is your perception of the current maintenance of the wetland?
Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Very little maintenance	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	**A lot of maintenance**

37. What is your perception of the condition of the wetland as a consequence of its use?
Mark only one option.

	1	2	3	4	5	6	7	8	9	10	
Very bad condition	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	**Very good condition**

Go to question 9

38. Do you know local leaders who represent community interests on wetland-related issues?

Mark only one option.

- ◯ Yes
- ◯ No *go to question 40*
- ◯ Don't know *go to question 40*

39. Since your answer was 'yes', please state to what extent the community's interests in matters wetland-related are represented by local leaders.

Mark only one option

	1	2	3	4	5	6	7	8	9	10	
To a limited extend	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	**To a great extent**

40. To deal with wetland-related issues, in which of the following initiatives of community or public offices have you participated?

Select all appropriate options.

- ☐ Training activities
- ☐ Meetings of the environmental committee or wetland network, community action or local action board
- ☐ Meetings with farmers or industries or other participants
- ☐ Meetings with tour operators
- ☐ Meetings on product promotion
- ☐ Meetings on cultural heritage
- ☐ Meetings on biodiversity
- ☐ Meetings on deterioration and environmental contamination
- ☐ Public demonstrations for the protection of wetlands
- ☐ Activities on social networks for the protection of wetlands
- ☐ Contributions of money or time for work on reforestation and clean
- ☐ I haven't participated

41. State to what extent you have participated in the initiatives of the previous paragraph.

Mark only one option.

	0	1	2	3	4	5	6	7	8	9	10	
I haven't participated	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	**I have participated to a great extent**

42. **If you have not participated** in any initiative, why not?

Mark only one option.

- ◯ I knew it existed, but I'm not interested in these kinds of initiatives
- ◯ I knew it existed, but I never had the opportunity or time to participate
- ◯ I didn't know of its existence, but I wouldn't have participated anyway
- ◯ I didn't know it existed, but I would have considered taking part
- ◯ This question does not apply to me.
- ◯ Others: _____

4. PERSONAL INFORMATION

This section will request personal information for statistical purposes. The use and access to this information is reserved exclusively to the aforementioned research, the publications that are derived and other works of scientific and academic interest.

43.Gender

Mark only one option.

- ◯ Man
- ◯ Woman
- ◯ Prefer not to say
- ◯ Others: _____

44. Age in years

Mark only one option.

- ◯ 18-24
- ◯ 25-34
- ◯ 35-44
- ◯ 45-54
- ◯ 55-64
- ◯ 65-74
- ◯ Over 75

45. Nationality

Mark only one option.

- Colombian(a)
- Foreign

46. Place of birth

Mark only one option.

- Cali
- Others: _____

47. Level of studies completed

Mark only one option.

- Primary
- Secondary
- Professional
- Postgraduate
- Others: _____

48. Occupation

Mark only one option.

- Full-time employment
- Part-time employment
- Unemployed
- Undergraduate student
- Postgraduate student
- Pensioned/retired
- Others: _____

49. Type of work

Mark only one option.

- ◯ Agriculture, farming and forestry
- ◯ Fishing and agriculture
- ◯ Industry and crafts (conversion of raw materials)
- ◯ Construction
- ◯ Wholesale and retail trade
- ◯ Hotel industry
- ◯ Rentals, travel agencies, business support services
- ◯ Transport and storage
- ◯ Finance, insurance and real estate
- ◯ Professional, scientific, and technical
- ◯ Teaching
- ◯ Public administration
- ◯ Student
- ◯ Others: _____

50. Place of residence

Mark only one option.

- ◯ Cali
- ◯ *Corregimiento* *Go to question 52*
- ◯ Others: _____

51.State the *comuna* in which your residence is situated

Mark only one option.

- ◯ *Comuna* 1
- ◯ *Comuna* 2
- ◯ *Comuna* 3…
- ◯ *Comuna* 22

Go to question 53

52. State the name of the *corregimiento* where you live

Mark only one option.

- ◯ Navarro
- ◯ El Hormiguero
- ◯ Pance
- ◯ La Buitrera
- ◯ Villacarmelo
- ◯ Los Andes
- ◯ Pichinde
- ◯ La Leonera
- ◯ Felidia
- ◯ El Saladito
- ◯ La Elvira
- ◯ La Castilla
- ◯ La Paz
- ◯ Montebello
- ◯ Golondrinas

53. How long have you lived in your place of residence

Mark only one option

- ◯ 1-5 years
- ◯ 6-10 years
- ◯ More than 10 years

54. Number of persons who live with you (including yourself)

_____

55. Socioeconomic level of your place of residence

Mark only one option

- ◯ Strata 1-2
- ◯ Strata 3-4
- ◯ Strata 5-6
- ◯ Others: _____

Note: Based on Brady & Ratajczyk (2015); Langemeyer et al. (2015); McGinnis & Ostrom (2014); Nagendra & Ostrom (2014); Ostrom et al. (1989) and TEEB ES classification (2010).

G2. Pebble Distribution Method

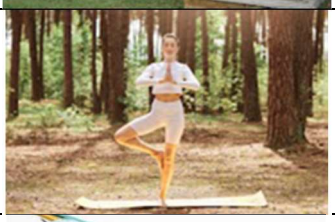
Cali Wetlands Survey - Monetary valuation

Consider your total motivation for visiting the wetland as **10**, therefore you have been awarded **10 coins** (representing a monetary value).

You must **distribute the 10 coins among 6 benefits**.

One benefit may receive more coins than another. If you feel that any benefit does not inspire you to visit the wetland, leave the space blank.

Each benefit is represented by an image, a description and an example.

Photograph	Description	Examples	Allocate coins
	Aesthetic information	…attractive and peaceful landscapes	
	Opportunities for recreation and tourism	…hiking, walking, cycling, bird-watching	
	Inspiration for culture, art, and design	…photography art, painting	
	Spiritual and /or religious experience	…contact with nature	
	Environmental education	…visits from schools, universities, scientists	
	Existence and legacy	…beliefs, stories, the possibility that future generations may enjoy the wetland	

Full name	
E – mail	

This survey, carried out as part of doctoral research at the Pontificia Universidad Javeriana de Cali and the Universitat Autònoma de Barcelona, aims to analyze the perceptions of the inhabitants of the metropolitan area of the city of Cali in relation to wetlands. Its purpose is to determine to what extent they contribute to the well-being of society, together with the degree of importance they represent for people. The data collected will be treated in aggregate form for academic purposes, in accordance with the provisions of Law 1581 of 2012 on the processing of personal data.

Note: Based on Langemeyer et al. (2015) and TEEB ES classification (2010).

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Appendix H. Supplementary results of chapter 4

1. Monetary valuation, educational level and time of visit

Findings did not show significant differences either in monetary valuation regarding educational level or time visiting on weekdays regarding wetland location. Nevertheless, significant differences were shown in the findings in hours spent on visiting at weekends considering wetland location (p=0.0001) with at least one of the groups. For instance, hours spent on visiting on weekends had significant differences among urban wetlands located in low-income levels and peri-urban in high-income levels (p=0.0001) (see Table H.1 for significant differences between groups). These findings indicate that inhabitants take into account different motivations and enjoy cultural services depending on wetland location.

Table H.1. Effect of wetland location on hours spent on the visit on weekends.

Zone	(1)-(2)	(1)-(3)	(1)-(4)	(1)-(5)	(2)-(3)	(2)-(4)	(2)-(5)	(3)-(4)	(3)-(5)	(4)-(5)
P value	0.0592	0.1702	0.0455*	0.0001*	0.539	0.0051*	0.0016*	0.0161*	0.0002*	0.0017*

Note: [1]Zone of the city in which wetlands are located; (1) Urban high-income level, N=78; (2) Urban medium-income level, N=23; (3) Urban low-income level, N=48; (4) Peri-urban low-income level, N=14; (5) Peri-urban high-income level, N=20; [2]Krustal-Wallis probability; *p-value<0.05: there are significant differences between groups (α=0.05).

2. Multiple Correspondence Analysis

Multiple Correspondence Analysis was carried out to summarize categorical variables by representing their interdependence or association. This technique is applied to nonmetric data that contains attributes among respondents, specifically focusing on factors that enhance collective actions. Chart H.1 shows that 93.8% of attributes belong to dimension 1. On the right-hand side of the chart, there are respondents with attributes related to factors that encourage collective actions. On the left-hand side, there are respondents who do not have these attributes. Thus, there are 2 groups of respondents, those who have attributes of collective

actions and those who do not. On the one right-hand, points 1, 11 and 13 are the closest associated; this means that the inclusion of groups networking with government and participating in other networking activities are patterns that share this group of respondents. In addition, the proximity between points 1 and 15 shows that feeling included in decisions and accomplishing informal monitoring are associated. On the left-hand, points 4 and 14 are also more closely associated, however they are respondents that neither feel represented by leaders nor participate in networking activities. Points 2, 12, 16 are closely associated and less fitted than 4 and 14 due to their proximity to the origin. Therefore, feeling unrepresented by leaders nor participating in networking is stronger than feeling excluded from wetland decisions, with neither networking with government nor informal monitoring of the resource. Moreover, points 5 and 9 are opposite to 6, 10; the former include respondents who know operational-choice rules and have wetland dependence (well-being), while the latter do not have these attributes. Points 3 and 14 have a negative relationship, which means that those who recognize leaders participate in networking activities, and vice versa. Finally, point 8 corresponds to those who have no economic dependence on the resource, nevertheless its proximity with the origin means that its attributes have no strength.

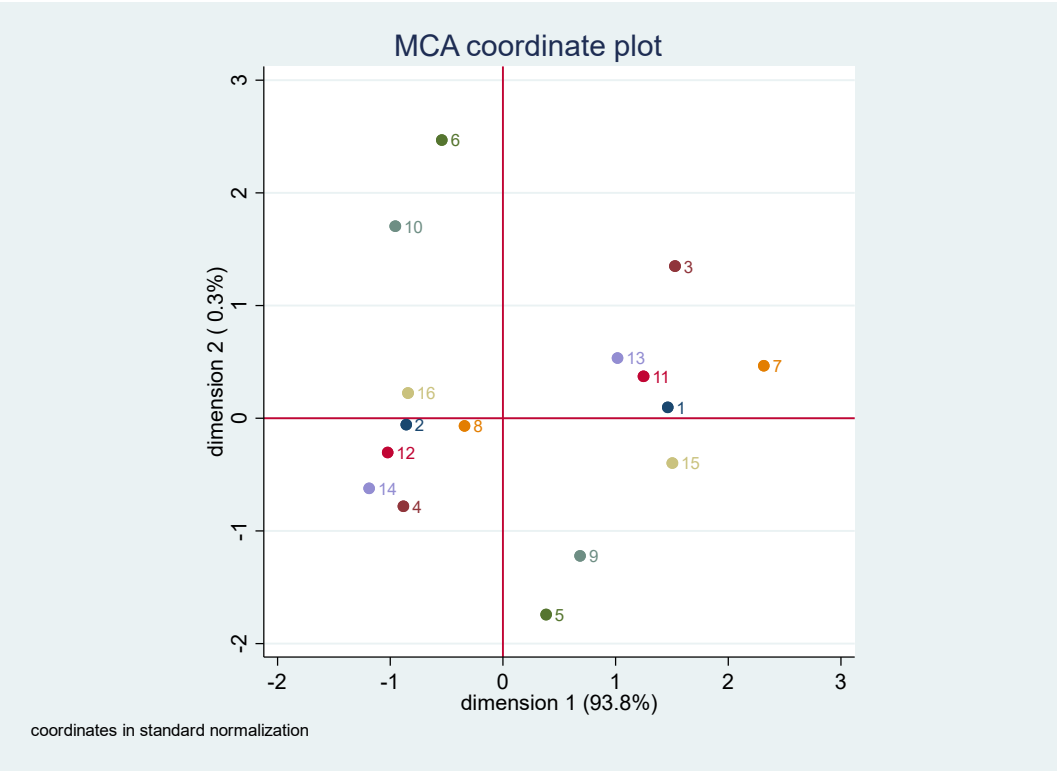

Chart H.1. Map of perceptions of collective actions and respondent characteristics.

Note: Group 1: Points 1 inclusion of socioeconomic groups, 3 leadership, 5 operational-choice rules, 7 resource dependence (economic), 9 resource dependence (well-being), 11 networking with government, 13 other networking activities, 15 informal monitoring. Group 2: Points 2, 4, 6, 8, 10, 12, 14, 16 those who do not have these attributes.

3. Integration between monetary and non-monetary valuation

In this section, both monetary and non-monetary dimensions were analyzed spatially and graphically. First, the average valuations of these dimensions were distributed across different *comunas* and *corregimientos* of Cali, where selected wetlands are located, as seen in the similarities and differences depicted in Figure H.1. Notably, monetary valuation showed significant contrasts between low-income and high-income urban and peri-urban areas (see *corregimientos* of Pance and Hormiguero, and *Comuna* 13). In contrast, non-monetary valuation exhibited less variation across different areas. Furthermore, non-monetary valuation yielded a higher value than monetary valuation. This suggests that factors beyond economic considerations play a consistent role in assessing wetland value.

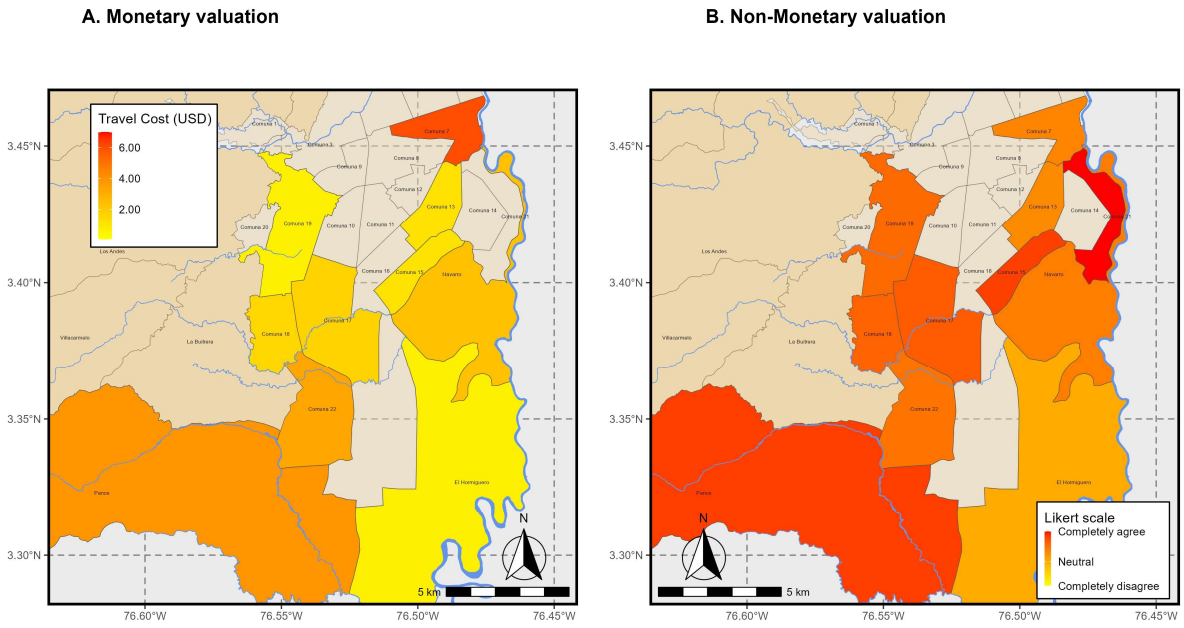

Figure H.1 Mapping comparison between monetary and non-monetary valuation.

Note: **Figure H.1A.** Individual travel cost of visiting wetlands in *comunas* (urban) and *corregimientos* (peri-urban) of Cali. **Figure H.1B.** Importance of cultural ecosystem services of wetlands in *comunas* (urban) and *corregimientos* (peri-urban) of Cali. Yellow color refers to low valuation and red color refers to high valuation. Cream color refers to other urban and peri-urban areas.

Second, the Pebble Distribution Method was employed to determine WTP for each cultural ES. This approach took into account the motivations reported by respondents for visiting the wetland. The resulting values were standardized and then compared with non-monetary valuation. Chart H.2 shows the comparison for aesthetic information (ES18), opportunities for recreation and tourism (ES19), inspiration for culture, art and design (ES20), spiritual experience (ES21), information for cognitive development (ES22) and existence and bequest values (ES23). Non-monetary valuation shows a similar trajectory in whole ES, being higher than monetary valuation. Notably ES23 shows monetary valuation below non-monetary, meaning motivation to visit the wetland due to existence and bequest values is less than the perception of importance of this ES. Medians of non-monetary valuation for ES18, ES19, ES21 and ES22 are skewed to quartile 3, meaning values between 50% and 75% of the population are less dispersed than those between 25% and 50%. Notice that inspiration for culture, art and

design (ES20) shows the least variability of ES. In contrast, monetary valuation has greater variability in distribution of values between 50% and 100% of the population. Medians of WTP in whole ES are skewed to quartile 1, meaning values between 25% and 50% of the population are less disperse than those between 50% and 75%. These results indicate that perceptions of the importance of cultural ES are beyond monetary valuation, and WTP to visit the wetland has values that suggest the effect of distance from site: low for nearby inhabitants, high for those that are more distant.

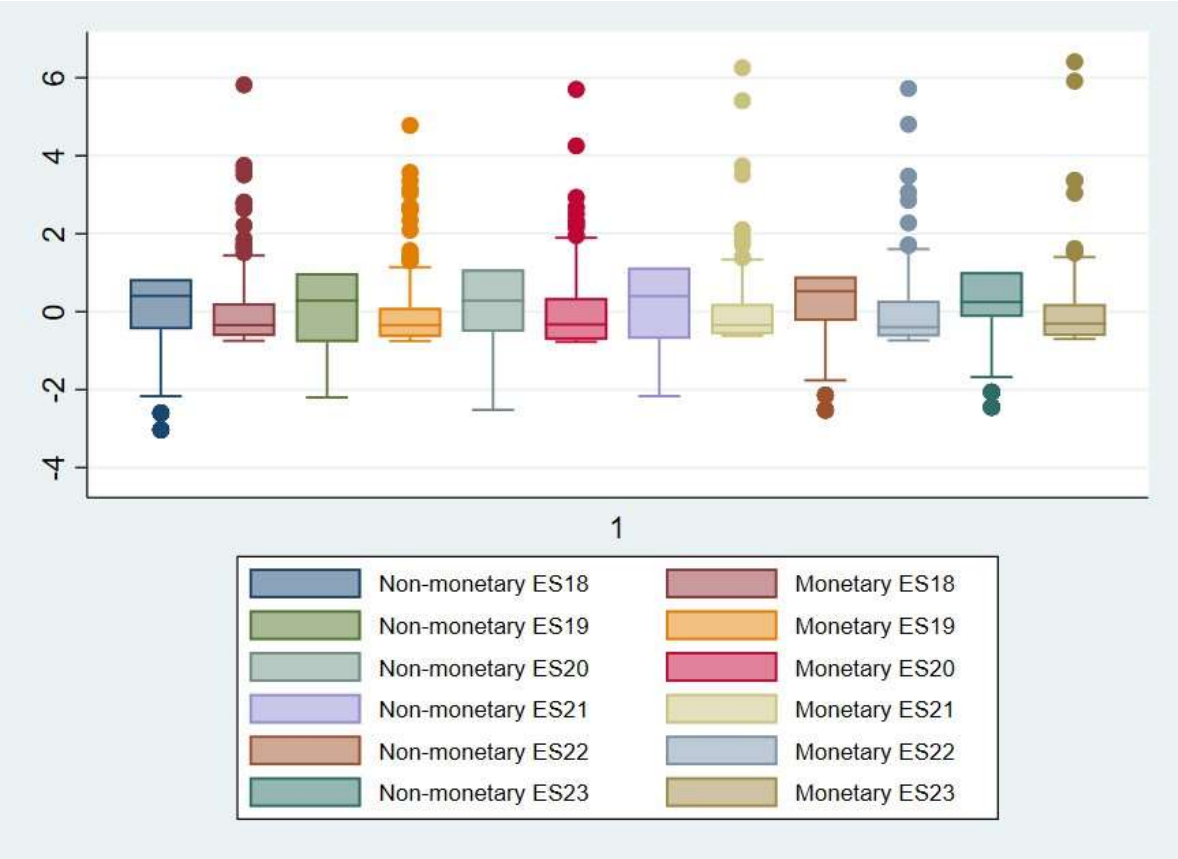

Chart H.2. Non-monetary and monetary valuation of cultural ecosystem services.

Note: Standardized values; aesthetic information (ES18); opportunities for recreation and tourism (ES19); inspiration for culture, art and design (ES20); spiritual experience (ES21); information for cognitive development (ES22); existence and bequest values (ES23).