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SOCIOCULTURAL VALUATION OF ECOSYSTEM SERVICES OF THE BAJO SINÚ MARSH COMPLEX IN THE DEPARTMENT OF CÓRDOBA, COLOMBIA

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Abstract

Wetlands are one of the most productive ecosystems on earth; however, they are threatened by multiple factors. Despite society's interdependence and continuous interaction with these ecosystems, they are often overlooked in management and decision-making. Therefore, this research aims to socially value the Bajo Sinú Marsh Complex (Marshes: Momil, Zapal, and Guartinaja) according to the importance that the local community and experts place on the ecosystem services they provide. For its development, an environmental characterization was carried out, covering the biophysical and social dimensions. Subsequently, different ecosystem services validated with professionals were identified and then valued through semi-structured surveys and analyzed using statistical software such as SPSS. The results show that, for the community, the most important ecosystem services are cultural (35.86%), regulation (33.72%), and provisioning (30.42%), while experts rank regulation as the most important (36.3%), followed by cultural services (35.1%) and provisioning (28.6%). The results provide a necessary knowledge base for the analysis of the use and exploitation of services, as well as for developing guidelines for the sustainable management of the resources provided by these wetlands.

Keywords: *Sociocultural Valuation; Wetlands; Importance perception; Local communities; Experts.*

Introduction

Wetlands are considered to be the most valuable ecosystems worldwide due to their high provision of ecosystem services (ES) [1], which means they make essential positive contributions to multiple dimensions of human well-being [2]. From an ecosystem and productive point of view, the objective is to satisfy the needs of populations [3], therefore, the ES they provide are essential for the survival and maintenance of them, particularly in developing countries such as Colombia [4]. However, wetlands are affected by activities such as pollution, changes in hydrological dynamics, desiccation, appearance of species, reduction of floodable surface, construction of dikes and levees [5] ,use of agrochemicals, establishment of monocultures and exotic species [6]**,** which affect ecological processes, reducing the supply of goods and services associated with this resource [7].

In the definition of E.S., there is an anthropocentric connotation [8] where society, according to its particular use and management, assigns importance or "value" [9], to perceived benefits [10, 11]. However, to know the integral [12] or total value of wetlands, the ecological, economic, and of course, the socio-cultural scope [13], must be taken into account, with the

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latter being very rarely considered [14, 15]. From an ecological perspective, the recognition of the ecosystems that provide them is contemplated; social inquiry into the degree of integrity that relies on the appreciations of the actors involved, and economics incorporates valuation methods focused on determining technical and political viability [16].

The approach used in this research is socio-cultural, through which the aim is to give meaning or assign importance to E.S. according to the performance [17] estimated by the different actors involved [18], being related both to one's own level of satisfaction [19] as reflected due to a given situationcomo [20], it is an approach that allows us to appreciate the diversity of values that arise from ecosystems [21]. The classification of services was divided into provisioning, regulation/support, and cultural services, where it was possible to integrate those of support or assistance with those of regulation, since if they were considered independently, double counting could be generated during the evaluation process [22–25].

It is essential to mention that sociocultural values are not limited to cultural ecosystem services, but are linked to all interactions with nature [26], that is, the three types of services. Those of a cultural type refer to immaterial goods or benefits provided by ecosystems [27], [28], the conservation of biodiversity, the protection of the historical-cultural heritage of communities, and environmental, economic, and social sustainability [29].

According to *M. García Llorente et al.* [30], this type of valuation allows for: the inclusion of beneficiaries in decision-making, given that it provides knowledge of the social actors' needs [31], the type of knowledge they possess (i.e. experiential or experimental), their attachment to the place [32, 33], their interaction with their natural environment [34], environmental perception defined as how each human being perceives and values the environment [35] in a holistic way [36], thus, through surveys, the importance of ES [37, 38] and the explicit inclusion of stakeholders can be evaluated.

Indeed, the methodologies applied in wetlands use different tools such as: semi-structured or structured surveys with scoring scales, SE tables [37, 38], free listing techniques [39]**,** direct interviews [40], a combination of the aforementioned with participant observation, life stories and workshops [41] and in few cases, the Q methodology focused on studying human subjectivity [41]**.** It should be noted that in other areas such as tropical forests [42]**,** natural parks [43] or urban areas [44] the same tools are used. From the above, it is possible to say that this type of valuation may have deliberative, narrative, or perception-based foundations from stakeholders [45], sin embargo no existe un protocolo normalizado que se haya empleado de manera regular para propósitos de valoración social [46]**.**

The objective of this study was to determine the importance of the ecosystem services provided by the Cenagoso del Bajo-Sinú Complex (CCBS), as well as the level of intensity and use, with the participation of certain actors in the territory. This study will provide a perspective on those ecosystem services most relevant for integrated management and conservation, according to the needs of the participants.

Methodology

Study Area

The Complex Cenagoso del Bajo Sinú (CCBS) is born from the most important water factory in the department of Cordoba: the majestic Sinu River, characterized by an average flow of 350 m3/second per year. It is an integrated system composed of a complex network of canals and shallow depressions, consisting of a set of 17 marshes, 18 pools, 4 wells, and 4 canals [47], It is considered a highly productive wetland recognized worldwide [48] with a protected area categorization established in the SINAP (National System of Protected Areas). The connection with social systems [49] lies in the countless ecosystem services (E.S) it provides. Thus, the target population was focused on two municipalities in the area, such as Momil and Purisima,

areas that intersect with three important marshes belonging to the CCBS called Momil, Zapal, and Guartinaja (Fig. 1).

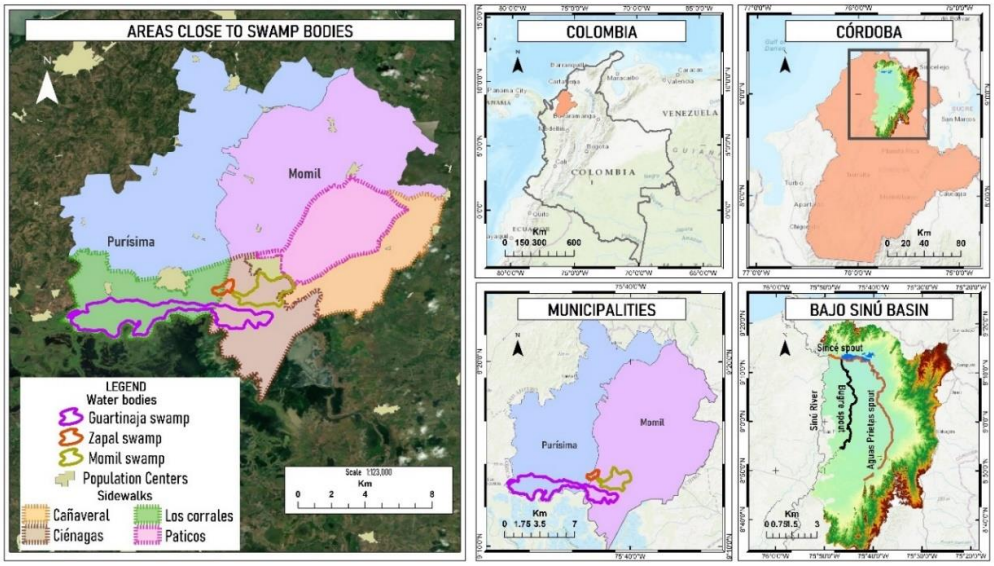

Fig. 1. Bajo Sinu Swamp Complex, Municipalities**.**

The Bajo Sinu Swamp Complex is part of the wetland system of the Sinu River basin, covering an area of approximately 50,000 hectares. It is one of the wetlands in the Caribbean region that provides habitat for birds [50, 51], as part of the Sinu River basin, it has a similar climate, with a semi-dry condition characterized by relative humidity of over 80%, an average temperature of 27.6°C, and a high level of solar radiation (5.4 hours of sunshine per day) [47, 52].

At the basin level, the Sinu River is made up of three large geologically and structurally differentiated units: the northern end of the Western Cordillera, the San Jacinto Belt, and the Sinu Belt. The CCBS is located between the fragmented San Jacinto Belt and the Sinu Belt to the south [52, 53] between the municipalities of Momil and Purísima. The soils of the Bajo Sinu are in a state of hydromorphism, being saturated or covered with water at least periodically, leading to redox processes [54]**.** They are composed of recent alluvial deposits from suspended sediment from the river [55] belonging to soil classes II and VIII, used for agricultural, livestock, and forestry purposes [56].

The geomorphology of the CCBS is a flat-concave fluvial-lacustrine plain [54, 57], therefore, it is considered a flood-prone zone, receiving water and sediment inputs from the Sinu River and the Aguas Prietas creek. The municipalities of Momil and Purísima, which are located near the CCBS, have two main units: the irregular hilly terrain in San Jacinto and the flat terrain [52, 53]. This terrain morphology, with very gentle slopes in the north and northeast direction experiences the highest levels of flooding.

Methodological Desing

The methodology used in this study is a descriptive-analytical design. The descriptive aspect allows for the collection, organization, summarization, presentation, and generalization of the results of observations, surveys/interviews, and review of secondary sources. The analytic aspect provides a complement through logical procedures, making it possible to mentally decompose a whole into its parts and qualities, as well as its multiple relationships, properties, and components [58]. The methodological process of this research was developed in three phases, as described in figure 2.

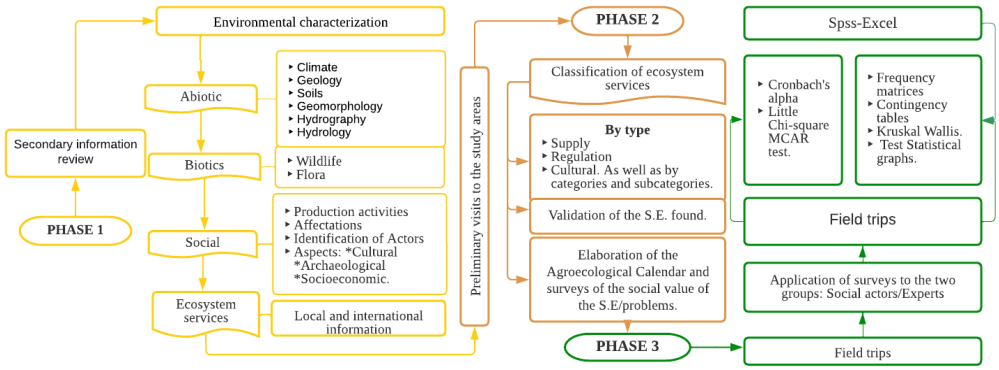

Fig. 2. Methodology for socio-cultural valuation

Phase I

In this phase, a review and documentary compilation were carried out following the contributions of *K.C.D. Cortés Duque and L.M. Estupiñán Suárez* [59] in order to describe the territorial context where the valuation of ecosystem services was applied, taking into account the biophysical dimension, which includes the physical and biotic environment, such as: climate, soil, water, biodiversity, among others, as well as the social dimension, which covered productive activities, cultural-archaeological aspects, and impacts. These topics allowed for an understanding of the areas [60] as well as the relationship of certain components with the provision of ecosystem services.

Regarding the identification of local actors, information was collected in the field regarding the communal organizations present in the territory prior to secondary review in databases such as the Montería Chamber of Commerce, online directories, records provided by the municipalities, as well as non-structured interviews, through which a "snowball" sampling was generated, which consisted of identifying other people, associations or organizations [61], compiled in a modified field format from the author *B. Martín López et al.* [62] On the other hand, for the compilation of all actors (intergovernmental, institutional, social, economic, academic, and public service providers) with influence on the wetlands. Preliminary visits were fundamental, as they generated a first approach with the community, making known what activities they carry out [63], In the same way, part of the diversity and ecosystem services was evidenced through non-structured observation.

The groups aimed at socio-cultural valuation were divided into two: the first group refers to social actors, which are individuals or organizations that can affect, manage, be affected, and/or depend on the services provided by ecosystems [62], directly or indirectly, they can play an active role, in the sense of controlling the management and handling of services according to the degree of importance they have for them, as well as a passive role where they are affected by the management of positive or negative service flow [64].

In the second instance, there are experts who, although they are social actors, are characterized by belonging to institutions or academies. As they are knowledgeable about the areas of interest, they make contributions aimed at preserving, sharing, and disseminating knowledge [65] associated with the functioning and preservation of the marshes in the department of Córdoba.

The technique used for the selection of actors was non-probabilistic convenience sampling, as it allows for the selection of the population that wishes to be included, generating a sample available in the time or period of research [66]. Despite generating rapid and inexpensive information [67], they have a disadvantage in the representativeness of the sample, as it is not possible to quantify it since the researcher determines it subjectively [68].

Phase II

In this phase, two aspects were considered: first, the classification of the ecosystem services (ES) in the area of interest, and second, the intensity and use of these services. For the classification of ES in the areas, those identified during the bibliographic review of specific documents of the areas [69–72], were taken into account, as well as other studies that have been conducted in the areas [47, 55, 57, 73–76], The ecosystem services were divided according to the typology proposed by the VIBSE (Comprehensive Assessment of Biodiversity and Ecosystem Services) of *A. Rincón Ruíz et al.* [12] into three main groups: provisioning/supplying, regulation, and cultural services, which were in turn classified into categories and subcategories, as done by *S.P. Vilardy et al.* [77], and adjusted and complemented by reviewing other sources [78–80].

The validation of the services found was carried out in collaboration with experts, who provided input on those ES that were not being considered, but are relevant for the assessment.

The second section was related to understanding the level of intensity, use of certain ecosystem services, and activities carried out by the population. Semi-structured surveys were conducted to create a seasonal calendar, which is a useful tool when implementing better resource management [81], based on the climate, nature, productive activities, agroecological cycles, and festivities [82], this allows for an understanding of the complexity of dynamics in ecosystems and the role that humans play in this network of physical and spiritual connections. Furthermore, it maintains traditional knowledge, which is vital to achieve a comprehensive and holistic vision of the territory and life [83]. The surveys are represented through drawings, and their origin comes from the profound knowledge of the communities about nature management.

Phase III

For socio-cultural assessment at the community and expert levels, an ordinal numerical measure of importance was established to collect the social value that each person assigns to each subcategory of ecosystem service, according to their perception through the question 'How important is a particular ecosystem service to you?.

This survey was designed with a Five-point Likert scale, which can be observed in figure 3.

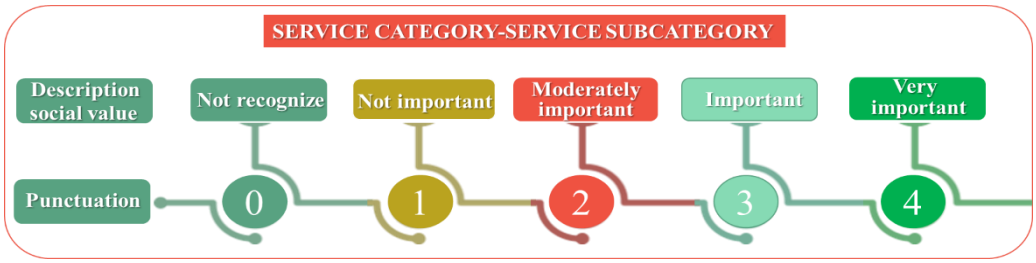

Fig. 3. Social valuation score for subcategories of ecosystem services.

The field phase was carried out in two campaigns. The closed surveys (information collected through the Kobo Collect tool) were divided into several stages, such as:

1. Brief explanation of the survey objective and the aspects that would be addressed
2.Filling out of general data
3.A section on environmental issues
4.A list of ecosystem services to assign importance

On the other hand, the agroecological calendar was collected through written forms. As for the experts, only questions regarding the level of importance of each ecosystem service were covered through the creation of an online instruction manual that allowed for autonomous completion.

The starting point for data processing was to quantify the Cronbach's alpha (α), responsible for providing reliability and validity of the instrument (survey) after it was applied [84], In addition, the Little's MCAR test was implemented to reflect the behavior of responses classified as "don't know / don't recognize", determining whether they are random or there is a marked tendency in such responses.

The statistical tool used for data processing was the SPSS software (Statistics 26), which generated contingency tables or matrices to analyze the association of two or more variables, producing both absolute and percentage frequencies. Non-parametric tests, such as Kruskal-Wallis, were adopted to compare the mean rank of independent samples and evaluate whether there is a difference between them or not. This was used to evaluate the importance of each ecosystem service when three or more variables were present, such as educational level and length of residence. Post hoc rank tests were then used to determine which measures differed. The U Mann-Whitney-Wilcoxon method was used for two exact variables, corresponding to municipalities and gender.

Results and discussion

The ecosystem functions of wetlands, and ultimately the goods and services they provide to society, depend on the characteristics of their components, structure, and processes. Therefore, the biophysical characterization of the study area was supported by a documentary collection that described the territorial context, including the physical, biotic, and anthropic environment. The following is a brief summary of these aspects:

Characterization of the study area

Flora

In the CCBS, the families with the greatest diversity and quantity are the leguminous Mimosaceae (including trees, shrubs, and aquatic or non-aquatic herbs) and Poaceae (a type of grass) [69, 72, 85]**,** It also records 1235 species, including: relict forest (448), gallery forest (184), floodplain forests (87), swamp vegetation (269), and scrub species (247) [54].

Regarding the predominant terrestrial vegetation for the municipalities of Momil and Purísima, they include: wine palm (*Bactris minor*), bitter palm (*Sabal mautitaformis*), matarratón (*Gliricida sepium*), oak (*Tabebuia rosae*), totumo (*Crescentia cujete*), carbonero (*Calliandra sp*), piñon (*Enterollobium cyclocarpum*), ceiba de gua (*Pochota quinata*), camajon (*Sterculia apétala*), leucaena, among others [52, 53]**.**

Aquatic or macrophytic vegetation also has significant representation. According to *N. Pérez Vasquez et al.* [86], 39659 individuals were recorded in the Bajo Sinú Wetland Complex distributed in 24 families, 30 genera, and 35 species. For the Purísima sector specifically, *Y. Cataño Vergara et al.* [87] identified a total of 39 species of macrophytes, differentiating species in the transition of hydrological periods since their morphological and physiological adaptations are different. *N. Pérez Vásquez et al.* [86] stated that of the 4 studied wetlands (María Arriba, San Sebastián, Purísima, and Momil), Momil had the highest abundance (18582 individuals), followed by Purísima (11829 individuals).

The level of phytoplankton is heterogeneous in terms of distribution and abundance dynamics, with high values in the Bajo Sinú, indicating conditions of eutrophication or nutrient enrichment, especially in low-water seasons [88], the *Chlorophytas* [89] are the most represented phytoplankton classes.

Fauna

The Sinú River basin exhibits high representativeness [54] of species (71 amphibians, 88 reptiles, 415 birds, and 77 mammals), table 1 shows the percentage of each animal group in the Bajo Sinú, the value it represents in the entire basin, and the department.

Table 1. Fauna groups for the Lower Sinú

Fauna Group	Species	Order/Suborder	Family	Genus	% of the Basin	% In Córdoba
Amphibians Reptiles Birds Mammals Fish fauna	23	2/0	7	15	=(23*100)/71 =32.39	31,9444444
Reptiles	37	3 /2	12	31	42	37,3737374
Birds	183	17/0	36	94	44	36,3095238
Mammals	35	13/0	19	30	26	26,3157895
Fish fauna	148*	-	-	-	-	.

Note: * The ichthyofauna is divided into 68 freshwater and 80 diadromous species [90, 91].

Anthropogenic Environment

In general, most of the Cordoba territory was inhabited by the Zenú culture, one of the chieftainships: Finzenú, historically characterized by using irrigation engineering works in the form of "fishbone" [92], in the Momil and Guartinaja swamps [55]. These works still persist, and Apropaur is an association that maintains this legacy.

These works still persist, and Apropaur is an association that maintains this legacy such as rice, beans, and Creole corn. These crops are planted based on natural flood cycles, allowing families to guarantee their subsistence supplemented with fishing and hunting [93]. The production of anthropomorphic figures, clay utensils, vases, hats, and other woven implements are products that contribute to the local economy when sold both within and outside the region.

Despite the agricultural potential of the Bajo Sinú marsh complex, livestock farming occupies the highest percentage (26.4%) of the other 10 land uses [54, 94]**.**

Identification of Ecosystem Services

From the literature review, 40 ecosystem services were identified, classified into three types of services: provisioning, regulating, and cultural, which were further categorized and subcategorized. Within the provisioning type of service, 6 categories and 17 subcategories were identified; for regulating services, 4 categories and 14 subcategories were identified, and finally, for cultural services, 3 categories and 9 subcategories were identified, as shown in Table 2.

Table 2. Type, category, and subcategory of ecosystem service

Service Type	Service category	Service sub-category
Supply	**Food**	Fishing
		Hunting
		Livestock.
		Agriculture
	Water supply	Water for livestock and other livestock activities
		Water for agriculture
		Water for fish crops
		Water for domestic use
	Raw materials	Wood (construction)
		Wood (fuel)
		Vegetable Fiber (Forage)
		Extraction of Mud or Clay
		Enea extraction
	Genetic materials	Natural Medicine.
		Ornamental plant resources
	Related to plants/animals	Materials to improve resistance of crops and/or animal offspring to pathogens and pests.
	Transport/Physical Support	River or water transportation.
Regulation	**Cycles**	Climate regulation.
		Hydrological regulation.

Service Type	Service category	Service sub-category
		Pollination.
		Nutrient cycling
		Soil formation.
		Soil retention
	Prevention	Flood cushioning
		Storm protection
		Pest prevention
	Sink	Water quality
		Air Quality
		Waste and organic matter treatment.
	Biodiversity	Habitat Maintenance for resident or transient species.
		Maintenance of biodiversity
Cultural	**Educational**	Didactics and research.
		Local ecological knowledge
	Cultural heritage and identity	Spiritual and religious value.
		Archaeological Aspects
		Value as a source of inspiration
		Own sense
	Enjoyment	Ecotourism
		Landscape beauty
		Relaxation and/or recreation

Note: The service categories were divided into subcategories, which refer to the different forms of use that were identified in the literature review.

Agroecological Calendar

The second part of Phase 2 considers the level of intensity and use of the different benefits obtained by agricultural and fishing communities by being deeply rooted in the cyclical notion [95], cycles that are materialized in the form of calendars as a tool to integrate dialogues of knowledge, which respond to agroecological production reflecting a concrete reality, their peculiar ways of life, [96] regarding the development of productive activities [97] and those related to the tradition of the people [98]. Thus, figure 4 captures the knowledge of communities in the form of a calendar.

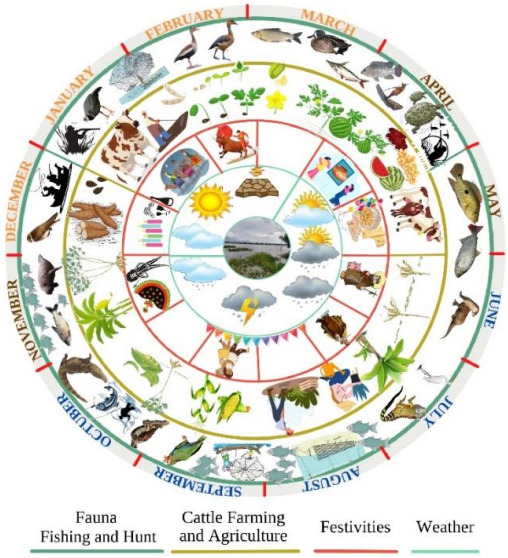

Fig. 4. Agroecological Calendar of the Bajo Sinú Complex Wetland.

The ethnomodels have several axes. The first one shows the seasons when hunting is prevalent, the most abundant fishing period, the types of fish that can be found during the year, fishing methods, and the fauna present in the Ciénaga related to different species of reptiles, birds, and mammals, all associated with their sighting during the annual cycle.

In the case of the Complejo Cenagoso del Bajo Sinú, the highest hunting season occurs from January to April with a high capture of emydids (Hicotea family) during Holy Week. Regarding fishing, it is deduced that abundance depends largely on water availability (rainy seasons), among the named species are: Bocachico, Dorada, Yalúa, Doncella, and Mojarra Amarilla. Fishing methods used in the Ciénagas include mesh or rake, trammel net, and cast net all year round. However, during high water seasons, the most commonly used method is the hook, while the traps and arrows are no longer in use.

Regarding fauna, the presence of birds in the territory is all year round, with a predominance of the Anatidae family (ducks) during dry seasons, such as Barraquete, Pisingo, and Malibu, as well as Swallows, Ospreys, Herons, Parrots, Chavarri, among others. Concerning mammals, the Manatee and Otter have a greater presence in the Cenagoso Complex. As for reptiles, such as iguana, Hicotea, Crocodile, and Boa, as well as the group of amphibians, they are present all year round with sightings in some months (January, April, July, October) as shown in the Calendar.

In the second axis, the activities of livestock and agriculture are shown, within the latter, the most abundant crops are covered, and approximate planting and harvesting periods of them. Thus, due to being in the department of Córdoba, one of the main economic activities is livestock, with the predominant crops during summer being banana, watermelon, various types of grain, and vegetables, highlighting maize and watermelon crops in great predominance.

The third axis deals with the festivities held in the municipalities of the CCBS. In the case of Purísima, the date of its birthday, May 10, is highlighted, along with the festival of soda crackers and diabolín. In Momil, on June 13, San Antonio, the patron saint of the town, is commemorated with a procession and religious ceremonies. During Holy Thursday and Friday, a mini-craft fair takes place on the Ciénaga beach, accompanied by canoe races. Finally, the last circle covers the different times of the year, highlighted mainly by a dry season and a rainy one.

Sociocultural valuation of ecosystem services

Statistical Analysis

The Cronbach's alpha of the questionnaire for the community of the municipalities of Bajo Sinu and the experts was categorized as excellent with values of 0.907 and 0.912, respectively [99]**.** These results suggest that the different dimensions of human well-being are highly correlated.

MCAR Test (Missing Completely at Random) - Values denoted as "unrecognized/unknown", whose responses are supported by the lack of knowledge regarding different ecosystem services by social actors, for the case of the CCBS community, showed a marked tendency towards certain sets of ecosystem services, being significant for regulation ($x2 = 387.847$, $df = 322$, Sig. = .007) and cultural services ($x2 = 149.619$, $df = 69$, Sig. = .000) in contrast to provisioning services ($x2 = 335.977$, $df = 311$, Sig. = .158), while for the case of experts, the behavior of this response ($x2 = 249.753$; $df = 379$; Sig = 1.000) was random (Sig> 0.05).

Recognition of ecosystem services - The results obtained show that some of the 40 subcategories proposed were specified with total recognition in terms of importance scale, i.e., the absence of "does not recognize/does not know". For the CCBS community, six subcategories (15%) were recognized, while for experts, it increased to 27 (67.5%). Both groups identified fishing, agriculture, natural medicine, ecotourism, and relaxation/recreation, but water for agriculture was only fully identified by local communities.

In general terms, 92.66% of the direct beneficiaries of the wetland bodies (Fig. 5) and experts (97.88%) (Fig. 6) recognized that ecosystems directly and indirectly generate services to society.

Fig. 5. Recognition of Ecosystem Services in the CCBS Community.

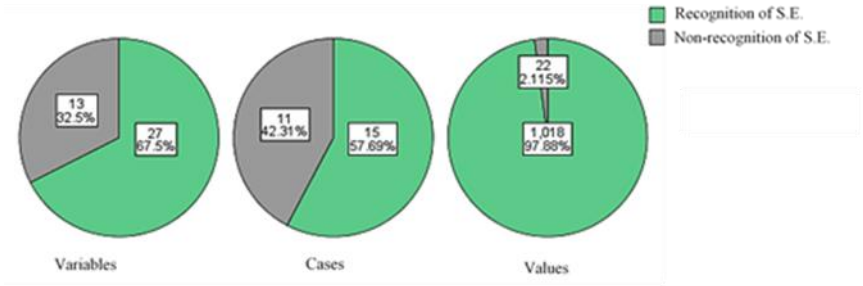

Fig. 6. Recognition of Ecosystem Services by Experts.

On the other hand, the recognition according to the typology of the three ecosystem services consulted (provisioning, regulating, and cultural) was in the following order for the local community: cultural (34.3%), provisioning (33.9%), and regulating (31.7%). Alternative research confirms the results found, where the regulation services by communities are perceived to a lesser extent, [25, 100, 101], since direct-use populations generally do not recognize to a great extent the processes and functioning of ecosystems as they are intermediate services, which prevents them from being used directly (unlike provisioning services), as their understanding goes far beyond being visible [32], or they do not have a direct link with human components [33] such as relaxation and/or recreation, in the case of cultural services, bearing in mind that this relationship is essential in the provision of ecosystem services [102].

Among those services that were least recognized by the inhabitants, are: soil formation, nutrient cycling, and soil retention, the latter obtaining the highest percentage of unfamiliarity for the Bajo Sinú; understanding these services could promote awareness in the face of any intention of land use change or degradative action.

On the contrary, the experts distinguish cultural services in first place (33.9%), followed by regulating services (33.6%) and provisioning services (32.6%).

Services aimed at management and maintenance

It is important to note that, although the community gave less recognition to regulation services, certain subcategories received high ratings when they were considered. In terms of conservation and integrated work, the most prioritized ecosystem services according to the Bajo Sinú community were cultural services (35.86%), regulation (33.72%), and provisioning (30.42%), despite the fact that the latter are easier to physically identify and are essential for life due to their direct dependency [103, 104].

Previous research [62, 105] supports these findings, where intangible or indirect-use services are increasingly important , and cultural services are often among the most relevant values [106] and identified [107] and identified [108], which includes habits, customs, and both material and immaterial heritage whose value is assigned by society. Therefore, understanding and conserving these services over time is crucial [28, 109].

Various scholars [47, 54, 55, 74, 88, 110, 111] have pointed out that both intrinsic (natural) and anthropic external impacts on wetlands are factors that may have contributed to this perception. This situation has led to a decrease in provisioning services provided by these ecosystems. This does not mean that these services are not important for the community, but rather that they have discontinued the extraction of certain resources due to their deteriorated condition or because some of the resources are currently replaced.

In the case of Bajo Sinú, hunting, the extraction of Enea and vegetable fiber or fodder, are considered irrelevant. However, according to experts, regulation services were in first place (36.3%), followed by cultural services (35.1%), and finally provisioning services (28.6%). These results are due to the technical knowledge and education levels of the experts [112, 113] which allow them to understand the "invisible" functions of ecosystems and therefore reflect their valuation of a wide range of regulation services [100].

Importance of subcategories of ecosystem services: Community

The community of the Complex Cenagoso del Bajo Sinú determined that among the supply services considered as very important, fishing is considered the most important service with a percentage of 75.0%, followed by agriculture with 51.1%. The supply of water for fish farming is also a priority with 48.9%, while water for domestic purposes has a percentage of 34.8%. In contrast, hunting (37.0%), extraction of enea (33.7%), and vegetable fiber (forage) (30.4%) are subcategories of lesser importance. Figure 7 shows the other services according to this typology.

It should be noted that although the fishing subcategory was classified as the main one, fluctuations induced by climate variations [114, 115] and the implementation of the Urra I hydrological project in 2000 generated changes in the historical flow rates of the river and therefore in the natural supply of the main food source. This means that the river no longer provides large amounts of larvae, fry, eggs, and spawned fish that enriched its ichthyological fauna, significantly affecting the fishing resource. 30 years ago, this resource was exploited by many villages, districts, or municipalities, but currently, the available quantity is much lower [116]. This situation has generated territorial pressure on the communities that live in the Cenagoso del Bajo Sinú Complex, known as the amphibian people named so for developing their activities surrounded by water and soil [76]. As a result, they have had to adapt their socioeconomic and cultural activities, moving from fishing to others such as tourism, commerce in shops or restaurants, day labor, moto-taxi services, cage fish farming projects, pre-breeding confinement, and direct repopulation in the swamp. This is why cultural services largely received better categorization.

Other important economic activities are agriculture and water for fish farming crops. The former is carried out according to the natural flooding cycles, as during the dry season, playones are generated, and the land is prepared for watermelon crops from January to December, which will be harvested in late March and April, as expressed in the agroecological calendar, a tool used by various authors [82] to understand and systematize agricultural production activities in order to generate strategies for better planning in the territory [117].

Regarding the regulation services (Fig. 8), those classified as very important belong to the biodiversity category. In particular, the maintenance of biodiversity (54.3%) and the conservation of habitat for resident or transitory species (51.1%) are highly valued by the inhabitants of the area, who are aware of the natural riches they possess. It should be noted that this area is classified as AICAS (Area of Importance for the Conservation of Birds) [52], the only quantitative criterion used by the RAMSAR Convention to determine the international

importance of a wetland, added to multiple fauna and flora research, which records an unmatched number of species [50], the only quantitative criterion used by the RAMSAR Convention to determine the international importance of a wetland, added to multiple fauna and flora research, which records an unmatched number of species [87, 90, 118, 119]

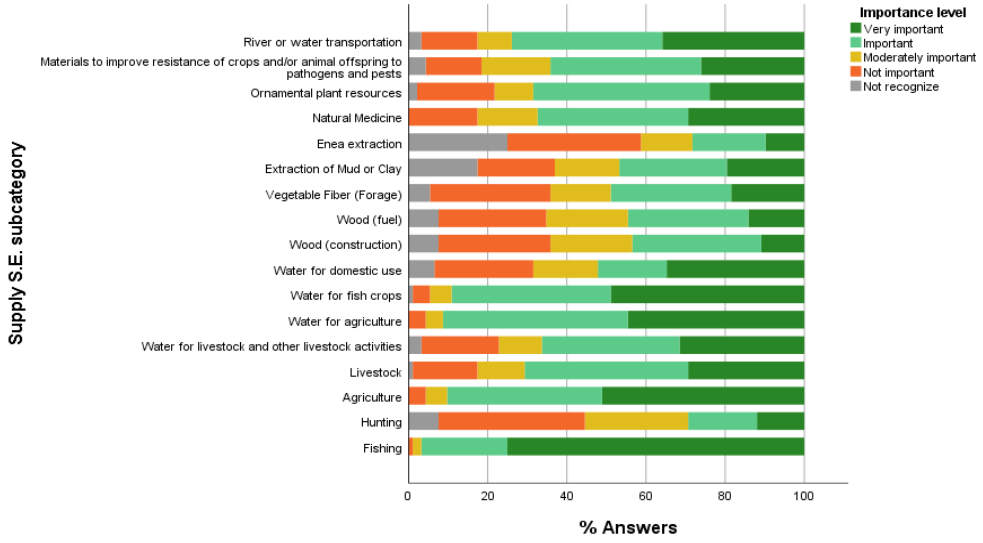

Fig. 7. Subcategory of supply chain management

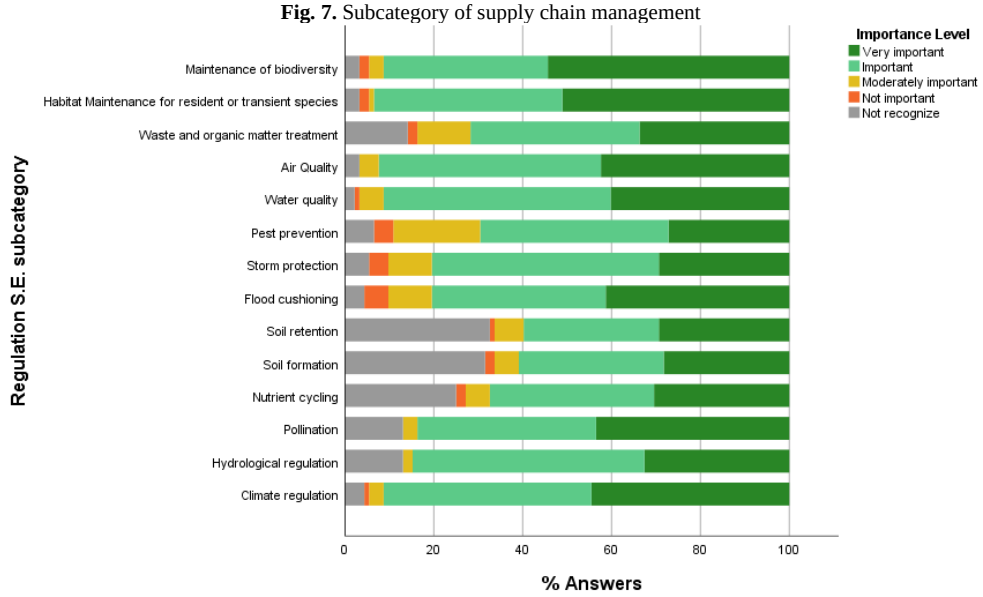

Fig. 8. Subcategory of Ecosystem Services of Regulation.

Additionally, various investigations have recorded a large number of fauna and flora species in the area. Likewise, water quality or water purification is considered essential for agricultural and fish farming activities. Water quality is fundamental to the health of ecosystems and human populations [120]. Additionally, various investigations have recorded a large number of fauna and flora species in the area. Likewise, water quality or water purification is

considered essential for agricultural and fish farming activities. Water quality is fundamental to the health of ecosystems and human populations.

On the other hand, soil retention is the only regulation service that has a high percentage of unknowns by the community (32.6%).

The cultural services identified in the figure 9, are not only fully recognized and highly valued, but also relaxation and/or recreation (51.1%), education and research (48.9%), local ecological knowledge (45.7%), and spiritual and religious values (35.9%) are seen as very important.

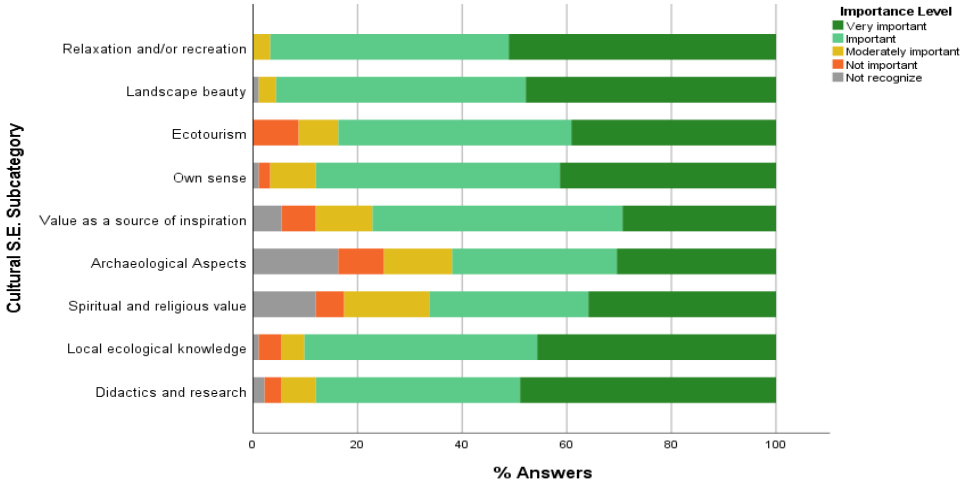

Fig. 9. Subcategory of Cultural Ecosystem Services

The remaining services were considered important: landscape beauty (47.8%), value as a source of inspiration (47.8%), personal sense (46.7%), ecotourism (44.6%), and archaeological aspects (31.5%). According to Troitiño Torraxlba (2014) [121] these services are now being considered a resource, not only as a symbol of identity and a symbolic reference but also as a crucial factor in the quality and attractiveness of a territory. This would allow for a greater maximization of the tourism sector and its cultural heritage, which are topics of high interest both nationally and internationally. The relationship between the two is the essence that would promote tourists' tastes and preferences towards these places [122].

Difference in perception between communities

Due to geographic, cultural, moral convictions, life experiences [123–125], Due to geographic, cultural, moral convictions, life experiences [126] and sources of income [127], local preferences among socio-ecological systems [128] can differ. Thus, the perception between the two municipalities (Momil-Purísima) was not the same, indicating that the benefits offered by wetlands are not visualized or used in the same way (Table 3). Therefore, the methodology used has advantages as it allows to demonstrate which ecosystem services are part of the idiosyncrasy and daily life of the inhabitants [77] in a particular way.

Table 3. Subcategories of ES with predominant differences

Ecosystem Services Category	x^2	Gl	Sig
Hunting	15,090762	1	0,000102
Water for Fish Farming	6,406316	1	0,011372
Water for Domestic Use	4,874756	1	0,027252
Extraction of Mud or Clay	30,928097	1	0,000000
Extraction of Reeds	4,215074	1	0,040066
Archaeological Aspects	11,337390	1	0,000760

The ecosystem service: water for fish crops, is more important in the municipality of Purísima than in Momil, due to the high representation of associations dedicated to this economic activity, a good water quality is essential for the continuous development and income diversification strategy of the peasant producers, thus increasing production in planting and obtaining a good harvest.

Likewise, fresh water for domestic purposes is typified as very important in Purísima, unlike in Momil, although the community has a municipal aqueduct, water is not constant in certain periods, so they resort to this means to supply this basic need.

The vegetable fiber or forage service is another of the services with a higher importance rating in Purísima than in Momil, due to the fact that the local owners of cattle use these areas as feeding and development zones during the dry season, and it is worth mentioning that cattle raising is one of the activities with the greatest repercussions on environmental problems, from the local to the global level [129].

On the other hand, the extraction of mud or clay plays an essential role in Momil. The number of associations dedicated to the production of anthropomorphic figures, clay utensils, and vessels is higher than in Purísima. They even have a crafts exhibition date in April with this raw material from the Ciénagas. The extraction of bulrush in this area is considered of greater importance since it is used for the production of mats or commonly known as "esterillas."

In Momil, the cultural service, archaeological aspects carry a greater weight in value, as it has guardian hills: Cerro Grande and El Mohán. The latter, located at the foot of the town, was the site of an indigenous cemetery whose remains and archaeological artifacts were investigated by Gerardo and Alicia Reichel Dolmatof.

Importance of subcategories of ecosystem services by the Expert group.

Within the provisioning services (Fig. 10), considered of little importance are hunting (30.8%) and ornamental plant resources (30.8%). In the moderately important category, the extraction of enea (46.2%), wood for construction (42.3%), extraction of clay or mud (38.5%), and firewood (34.6%) stand out. On the other hand, in the category of important, we find: vegetable fiber (feed) (50%), river or aquatic transport (46.2%), materials to improve crop and/or animal resistance to pathogens/pests (38.5%), and natural medicine (34.6%). Meanwhile, those considered as very important are agriculture (61.5%), water for domestic purposes (57.7%), fishing (53.8%), water for agriculture (53.8%), livestock (46.2%), water for fish farming (42.3%), and water for livestock and/or other livestock activities (38.5%).

In regulation (Fig. 11), there is only classification as important and very important. Within the former, Soil formation (46.2%) and Pest prevention (38.5%) are covered. The remaining 12 subcategories are classified as very important: Flood mitigation (84.6%), Biodiversity maintenance (84.6%), Habitat maintenance for resident or migratory species (76.9%), Water quality (69.2%), Hydrological regulation (65.4%), Air quality / Air purification (65.4%), Soil retention (61.5%), Waste and organic matter treatment (57.7%), Pollination (53.8%), Climate regulation (50%), Storm protection (46.2%), and Nutrient cycling (46.2%).

The cultural services (Fig. 12) identified as important were: Inspiration value (42.3%) and Spiritual/religious value (38.5%); furthermore, in terms of being rated as very important on a scale of 50%, the following aspects are included: Local ecological knowledge (73.1%), Didactics and research (65.4%), Landscape beauty (65.4%), Relaxation and/or recreation (57.7%), Personal meaning (57.7%), Ecotourism (53.8%), and Archaeological aspects (46.2%).Of these, local ecological knowledge and teaching and research were the most prioritized services, the former acquired through direct interaction with the natural environment [130], generating a close connection with natural spaces and increasing the demand to know them, thus enhancing recreation and tourism [131]. On the other hand, the latter encompasses scientific and educational value, associated with the use of wetlands for conducting scientific studies and learning about nature.

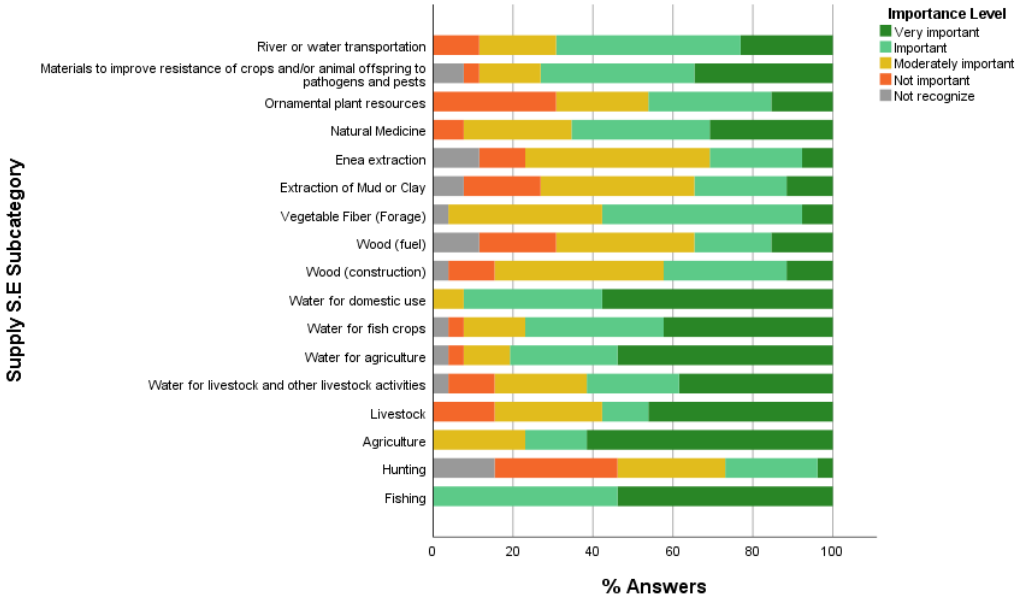

Fig. 10. Subcategory of ecosystem services of provisioning.

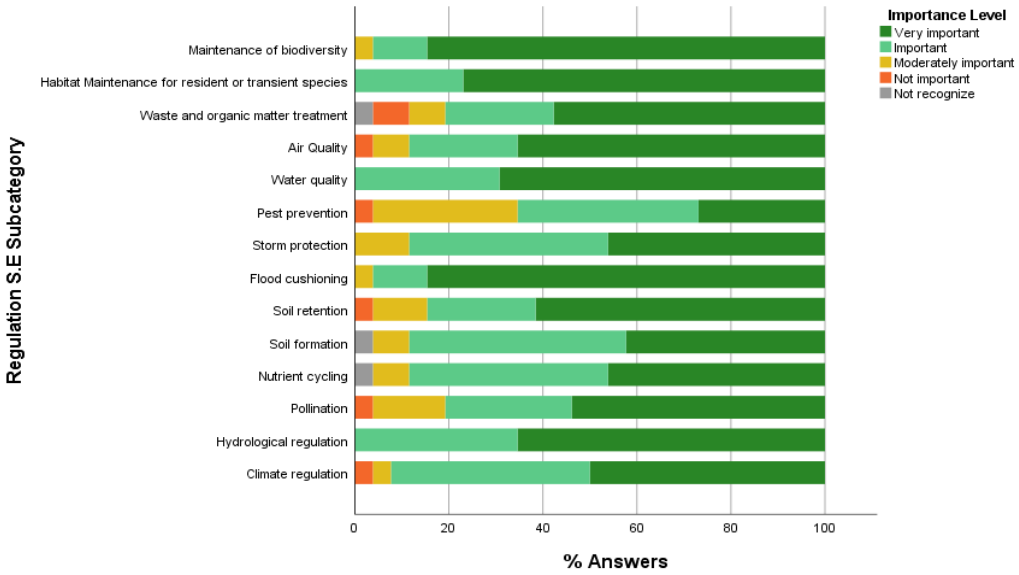

Fig. 11. Subcategory of Ecosystem Services of Regulation.

Environmental problems according to the Bajo Sinú Community.

Local residents recognize some factors of change that deteriorate certain ecosystem services provided by wetlands. Of the 12 problems, 50% represented a high condition, with Water Pollution (70.7%), Decrease in fish (75%), Disappearance of native fauna species (59.8%), Threat of native animal species (60.9%), Disappearance of vegetation species (55.4%), and Use of agrochemicals (55.4%) being the most prominent. In a medium-high condition, there is the Cutting of trees (71.74%), Drying of bodies of water (85.87%), Presence of soil salinization (64.13%), and Implementation of Forest monocultures (81.52%). The burning of

waste is in a low-medium state (56.52%), and finally, the Construction of dikes is in a null-low state (59.78%).

The quality of bodies of water is affected by different anthropogenic activities such as deforestation of stream watersheds, discharge of sewage and waste from municipalities [57, 88], as well as washing of clothes, people, and animals in the stream currents and in the Ciénaga itself [132].

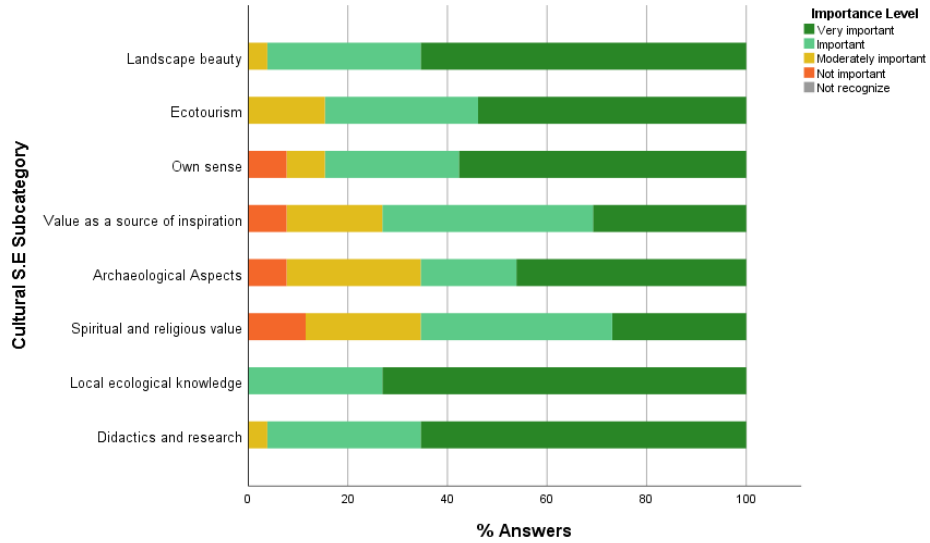

Fig. 12. Subcategory of Cultural Ecosystem Services

In figure 13, there is a graph of the state of problems in the Bajo Sinú Ciénaga regarding the community's vision, on a scale ranging from Null, Low, Medium, and High.

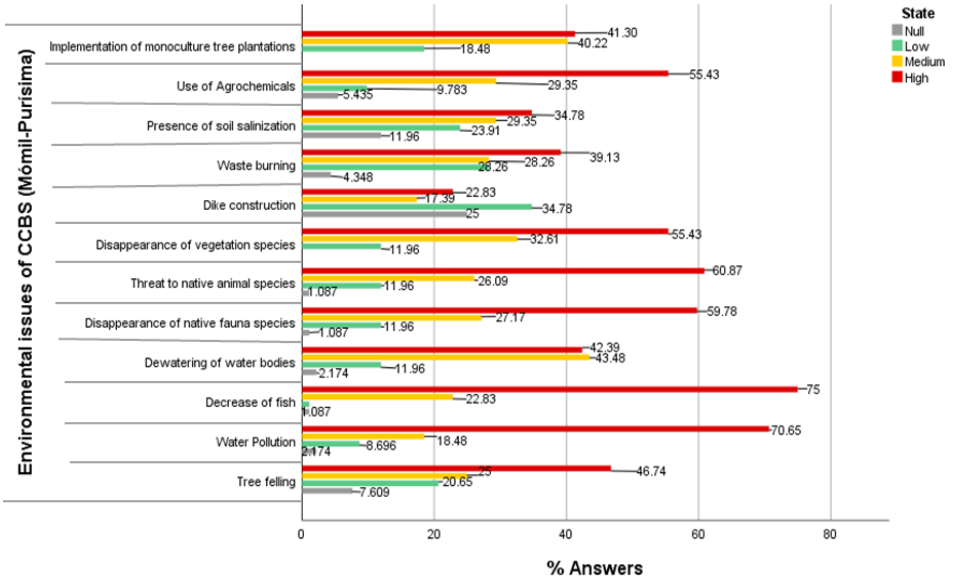

Fig. 13. Environmental issues in the Bajo Sinu wetland complex

Conclusions

The development of this study allowed to identify and evaluate the different sociocultural and environmental aspects associated with the Cenagoso Complex of Bajo Sinú, which define the importance and the way in which the community and experts perceive the supply of ecosystem services provided by these ecosystems. With the first phase, it was possible to know in detail the general and particular characteristics of the studied area through the biophysical and social dimensions, which was essential because by collecting, processing, and analyzing this information, it was a fundamental tool to recognize the territory, as well as to identify and value the ecosystem services. The latter were categorized into three types: provisioning, cultural, and regulating, which were divided into 13 categories, which in turn were subdivided according to the different forms of use identified in the documentary review, generating a total of 40 subcategories. According to the community, the most valued ecosystem services were cultural, followed by regulating and provisioning services. For experts, it started with regulating services, then cultural, and finally provisioning services. It should be noted that there was a change in perception of importance between the two municipalities (Momil-Purísima) according to their respective needs. Therefore, it is essential to point out that the heterogeneity of perceptions facilitates governmental and political decisions to design action measures. Similarly, the resulting agroecological calendar, which monthly records the productive activities (agricultural and livestock), festivities in the villages, and climate, is an effective tool when implementing better resource management, allowing for an understanding of the complexity of dynamics in ecosystems and the role that the community plays.

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