water

MDPI

Article

Perception of Mangrove Social–Ecological System Governance in Southeastern Cuba

Yanet Cruz Portorreal [1,*], Natalie Beenaerts [2], Nico Koedam [2,3,4,5], Orlando Joel Reyes Dominguez [6], Celene B. Milanes [7,8,*], Farid Dahdouh-Guebas [3,5,9,10] and Ofelia Pérez Montero [1]

[1] Center for Multidisciplinary Studies of Coastal Zones, Universidad de Oriente, Ave. Las Américas s/n, Santiago de Cuba 90100, Cuba; ofelia@uo.edu.cu
[2] Centre for Environmental Sciences, Hasselt University, Agoralaan z/n, B3590 Diepenbeek, Belgium; natalie.beenaerts@uhasselt.be (N.B.); koedamnico@gmail.com (N.K.)
[3] Systems Ecology and Resource Management, Department of Organism Biology, Faculty of Sciences, Université Libre de Bruxelles—ULB, Av. F.D. Roosevelt 50, CPi 264/1, B1050 Brussels, Belgium; farid.dahdouh-guebas@ulb.be or farid.dahdouh-guebas@vub.be
[4] Marine Biology Research Group, Universiteit Gent, Krijgslaan 281-S8, B9000 Gent, Belgium
[5] Mangrove Specialist Group (MSG), Species Survival Commission (SSC), International Union for the Conservation of Nature (IUCN), 1196 Gland, Switzerland
[6] Eastern Center for Ecosystems and Biodiversity (BIOECO), Museo de Historia Natural "Tomás Romay" José A. Saco # 601, Esquina a Barnada, Santiago de Cuba 90100, Cuba; joel@bioeco.cu
[7] Facultad de Ingeniería, Universidad del Magdalena, Calle 29H3 No 22-01, Santa Marta 470004, Magdalena, Colombia
[8] Estación Científica (Coiba AIP), Gustavo Lara Street, Building 145B, City of Knowledge, Clayton, Panama City 0801, Panama
[9] bDIV: Ecology, Evolution & Genetics, Department of Biology, Faculty of Sciences and Bio-Engineering Sciences, Vrije Universiteit Brussel—VUB, Pleinlaan 2, B1050 Brussels, Belgium
[10] Interfaculty Institute of Social-Ecological Transitions, Université Libre de Bruxelles—ULB, Av. F.D. Roosevelt 50, B1050 Brussels, Belgium
* Correspondence: yanetc@uo.edu.cu (Y.C.P.); cmilanes@unimagdalena.edu.co (C.B.M.); Tel.: +57-605-4381000 (C.B.M.)

check for updates

Citation: Cruz Portorreal, Y.; Beenaerts, N.; Koedam, N.; Reyes Dominguez, O.J.; Milanes, C.B.; Dahdouh-Guebas, F.; Pérez Montero, O. Perception of Mangrove Social–Ecological System Governance in Southeastern Cuba. *Water* **2024**, *16*, 2495. https://doi.org/10.3390/w16172495

Academic Editor: Michele Mistri

Received: 27 June 2024
Revised: 20 August 2024
Accepted: 27 August 2024
Published: 2 September 2024

Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

Abstract: This study examined local communities' perceptions of mangroves in coastal southeastern Cuba. A variety of methods were employed, including mixed and structured questionnaire surveys, interviews with key informants, and document reviews. Data were gathered from 334 respondents living in communities adjacent to four mangrove social–ecological systems (SESs). The analysis focused on five variables: community use of mangrove resources, ecosystem services, threats to the ecosystem, management activities, and social–ecological relationships. To qualitatively assess the influence of social–ecological relationships and governance, a matrix was created based on anthropogenic activities identified by respondents and their perceptions of ecosystem services. A Spearman's rank correlation analysis was performed between demographic variables and identified mangrove uses. The Kruskal–Wallis test was used to compare the frequency of mangrove uses and the perception of ecosystem services among the studied areas. The results indicate that, while local people recognise the uses and ecosystem services of mangroves, they do not rely on them for their livelihoods. Perceptions of ecosystem services vary significantly depending on the occupation of the respondents and the locality. They also showed moderate to full awareness of management responsibilities and activities at each site. The most commonly identified threats were climate change, drought, and deforestation. Three types of social–ecological relationships were identified based on the characteristics of the communities, their economic activities, and their impacts on the mangroves: urban–industrial, rural–agricultural, and rural–agricultural/tourism. Based on the results, recommendations are made for ecosystem governance in the southeast of Cuba.

Keywords: ecosystem service; mangroves; ecosystem services; management; climate change; mitigation; adaptation; nature-based solution; citizen participation

1. Introduction

Addressing climate change mitigation requires a comprehensive understanding of natural processes and the impacts of human development on these processes. In this context, the framework of social–ecological systems (SESs) is pertinent. SESs represent complex adaptive systems where human societies are closely integrated with nature [1,2]. Within the SES framework, the social component encompasses all human activities, while the ecological component refers to the biosphere and its associated natural processes [3]. These components are interrelated, and their boundaries depend on the perspective of the analysis. The interaction between these components is dynamic, and their limits are defined according to the analytical perspective adopted. Ecosystem services, defined as the benefits society derives from ecosystems, illustrate this interaction [3]. Analysing the relationships within a defined SES facilitates the search for integrated solutions to problems arising from human activities in specific ecosystems. This integrated approach is essential for developing strategies that not only mitigate the negative effects of human development on natural processes but also increase the resilience and sustainability of human and ecological systems.

Understanding and managing social–ecological relationships is crucial for the sustainability of mangrove socioecological systems, ensuring that both human and ecological needs are addressed in a balanced and sustainable manner. SESs comprising mangroves are characterised by complex social and ecological relationships [2,4–7], including the provision of ecosystem services and human activities [3] affecting them. The ecosystem services encompass supporting, provisioning, regulating, and cultural or spiritual services [8,9]. For example, coastal ecosystems contribute to climate regulation through carbon sequestration. Mangroves, along with marshes and seagrasses, are classified as blue carbon ecosystems due to their significant capacity to sequester atmospheric carbon [10–13]. They can absorb and sequester substantial amounts of carbon through aboveground and belowground biomass [13]. Moreover, the environmental conditions of these ecosystems favour the long-term accumulation of organic matter in the soil [14]. Mangroves provide critical regulatory services to coastal communities by mitigating the impact of waves, wind, and flooding [15–18]. The climate regulation ecosystem service not only addresses the causes of climate change but also mitigates its impacts. They also directly contribute to the subsistence of coastal communities, as some species living in the mangrove ecosystem are an important food resource; thus, mangroves support the local economy or household livelihoods [19–22].

Despite their importance, mangroves are threatened by human activities, mainly those that transform the spaces where these ecosystems develop [17,23,24]. Human activities include overexploitation of resources, land use change, agricultural development, damming of freshwater sources hydrological change in general, and pollution. The reduction or loss of mangroves leads to the reduction or loss of the ecosystem services they provide, thus diminishing the benefits for local communities [16,25,26]. In response, the international scientific community is striving to integrate the value of ecosystem services into decision-making processes regarding human development and conservation efforts [8,27].

Initiatives such as the Global Mangrove Alliance and the International Blue Carbon Initiative recognise mangroves as high-priority ecosystems for climate change mitigation through climate regulation [17,20]. Moreover, the way coastal communities perceive mangrove ecosystem services influences the success of conservation efforts [28–30] and the acceptance or not of management measures. Therefore, the priorities and preferences of these communities should be integrated into the decision-making process [27,31,32]. It is essential to work with both the mangrove ecosystem and the surrounding social system to analyse how society benefits from nature [33,34]. Identifying the reasons for protecting ecosystem services helps determine which services are relevant to stakeholders and informs on the options to consider for management decisions [18]. There is substantial evidence indicating that coastal communities significantly influence the ecological health of mangroves, the quality of ecosystem services [35,36], and their governance structures [37–39]. Inadequate participation hinders, for example, the establishment of governance norms within the existing political framework, which in turn affects the management and conservation of mangroves [39].

In Cuba, mangroves are recognised as vulnerable and significant coastal wetlands [24]. Globally, Cuba ranks 10th in terms of mangrove surface area [40], covering 5.1% of the national territory and constituting 27% of the total forest area. Approximately 35% of mangroves are legally safeguarded by the National System of Protected Areas (SNAP) and are managed through various conservation measures [41]. Within SNAP, environmental education initiatives, such as training sessions, workshops, and festivals, are exclusively conducted in the communities surrounding the protected mangrove areas. The objective of these activities is to foster community participation in mangrove conservation [42]. Although mangroves are primarily valued for their role in protecting coastal communities and infrastructure from the effects of climate change, such as coastal flooding and strong winds [24], efforts to quantify the ecosystem services they provide in terms of provisioning, regulating, and supporting functions are gaining momentum in the country [43].

Despite the limited research on the analysis of perceptions within coastal communities and governance to improve mangrove management in Cuba, existing evidence underscores the local recognition of the importance of coastal ecosystems, particularly mangroves, in sustaining subsistence activities such as fishing, tourism, and agriculture [24,44]. To date, comprehensive studies are lacking in exploring the intricate social, ecological, and governance dynamics within mangrove habitats. This study aims to elucidate the interactions between SESs and governance in the mangroves of southeastern Cuba, focusing on community perceptions of this valuable ecosystem, which are essential for its integrated and sustainable management.

This research contributes to addressing climate change impact in Cuba by highlighting the role of these ecosystems in carbon capture and storage to mitigate greenhouse gases. Additionally, it promotes the sustainable use of terrestrial ecosystems by generating knowledge on how to manage mangroves to maximise carbon retention. Furthermore, it supports the development of sustainable coastal urban communities by revitalising urban green spaces for carbon capture. Finally, this research contributes to sustainable development goals, specifically to SDG 13 “Life of Terrestrial Ecosystems” and 14 “Marine Life” [45].

2. Materials and Methods

2.1. Study Area

The study area in Cuba is part of the Northwest Atlantic Province [46] and experiences significant influence from seasonal tropical cyclones, which bring heavy rainfall that reduces salinity and increases nutrient loads in watersheds draining into mangrove ecosystems [47]. Cuban mangroves typically form narrow strips, which vary from approximately 0.25 to 0.80 m [47]. The extent and structure of these mangroves are influenced by geomorphology, characteristics of rivers and tributaries, as well as local climatic conditions [47]. Mangrove development is more extensive in the southern central part of the island, while the northeastern coast generally shows mangroves of a lower canopy height. Mangrove coverage is notably limited in eastern Cuba. Our study focused on the southeastern region of Cuba, defined as a natural and political entity extending along the eastern part of the island, south of an imaginary line from the centre of Guacanayabo Bay to the northern edge of Banes Bay [48]. This region is bordered to the north by the Central Region, to the northeast by the Atlantic Ocean, to the east by the Paso de los Vientos, to the south by the Caribbean Sea, and to the west by the Gulf of Guacanayabo [48]. The climate in this region is classified as tropical savannah (type AW according to the Köppen classification [46,49]), with annual average temperatures ranging from 25.6 °C in Las Tunas to 26.8 °C in Guantánamo. Annual rainfall varies from 792 mm in Santiago de Cuba to 1130 mm in Las Tunas. Coastal geomorphological and hydrodynamic characteristics create diverse environments, some of which are conducive to mangrove development.

For this study, four mangrove localities were chosen in southeastern Cuba based on specific criteria, including proximity of communities to mangroves and community accessibility sites: Monte Cabaniguán/Ojo de Agua (MCOA) in Las Tunas province, Guamá (GUAM) and San Miguel de Parada (SAM) in Santiago de Cuba province, and Hatibonico (HAT) in Guantánamo province (Figure 2). A social–ecological survey was designed, and a structured questionnaire was administered from March to October 2023 in selected communities within these specific mangrove localities.

Features of the mangrove SES studied are the following:

(1) Ojo de Agua-Monte Cabaniguán (MCOA) (See Table 1)

This mangrove site is a fragment of the Delta del Cauto vegetation [50], under the administration of the Ojo de Agua-Monte Cabaniguán Wildlife Refuge of the National System of Protected Areas of Cuba. It is located between the municipalities of Jobabo and Colombia in the extreme southwest of the province of Las Tunas next to the Gulf of Guacanayabo (Figure 2A). This sector was selected to represent the Cauto Delta Wetland ecosystem, which contains the largest extent of mangroves in the study area and the second largest in Cuba and the Caribbean Archipelago [50]. Located in a coastal deltaic–alluvial plain, these mangroves, together with the marshes, form an extensive vegetation formation formed by tidal activity and contributions from the Cauto River delta (Figure 1) [47]. The area covers 3929.18 ha and represents 57% of the Delta del Cauto Faunal Refuge [51].

This area is predominantly rural [54]. Economic activities include extensive livestock farming, commercial fishing, and charcoal production made of *Dichrostachys cinerea* Wight et Arn, an exotic leguminous terrestrial tree species. Fishing, as well as poaching, are considered the most impactful activities, including the capture and illegal trade of key mangrove-associated species: the American crocodile, *Crocodylus acutus* (Cuvier), the Cuban iguana, *Cyclura nubila* Gray, and hutias (*Capromys pilorides* Say) [51]. Livestock production also has an impact through uncontrolled animal entry into the reserve. It contributes to the spread of exotic species like *Dichrostachys cinerea* and soil compaction. Despite the measures taken to manage the reserve, these problems continue to exist [51]. Finally, the supply of freshwater and sediment to the mangroves has been significantly reduced by the construction of upstream reservoirs.

Figure 1. Assemblage along a tidal creek, with *Rhizophora mangle* and *Avicennia germinans* in Ojo de Agua-Monte Cabaniguán Wildlife Refuge (credits to Nico Koedam).

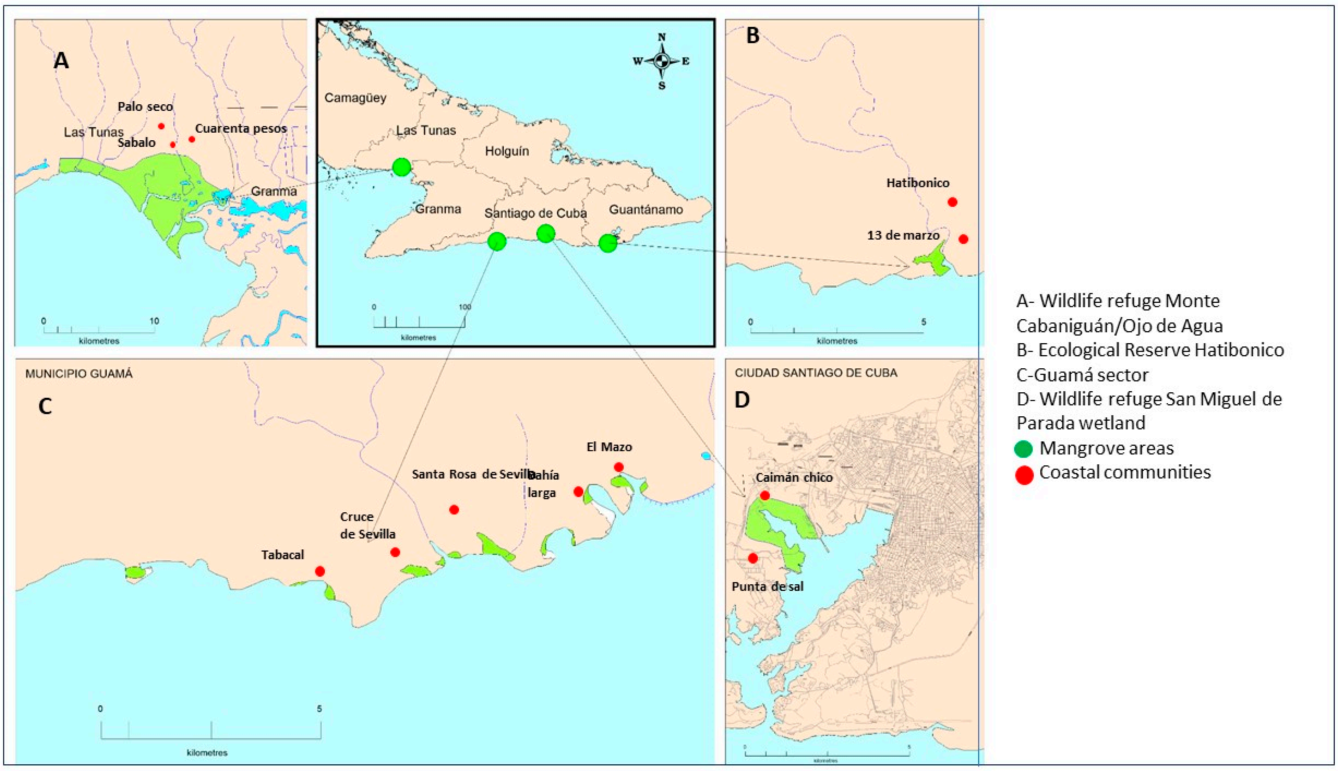

Figure 2. Map of eastern Cuba (inset: Cuba island) with mangrove localities under survey (Maps (**A**)—Wildlife Refuge Monte Cabaniguán/Ojo de Agua, Las Tunas [51]; (**B**)—Ecological Reserve Hatibonico, Guantánamo [52]; (**C**)—Guamá Sector, Santiago de Cuba [20]; and (**D**)—Wildlife Refuge San Miguel de Parada, Santiago de Cuba [53]). Sections with green shades show the mangrove areas, while the red circles indicate the coastal villages that were surveyed.

(2) Guamá Sector (GUAM) (See Table 1)

This sector is located in Guamá municipality to the south of the Sierra Maestra in the province of Santiago de Cuba (Figure 2C) [55–57]. Mangroves in Guamá municipality are not under any type of official management system [20]. They are located along the coastline and are mostly subject to marine influence. However, they can also receive contributions from local terrestrial runoff. Water input comes from land runoff, the Los Lirios stream, and the Sevilla River. The mangroves in the sector from Mazo Bay to Seville were selected because of the concentration of patches, the number and proximity of coastal settlements, and the variety of activities that occur. There are five coastal communities in the vicinity. All four mangrove species reported in Cuba are present there [20], with the highest abundance of *Avicennia germinans* (L.) Stearn. and *Rhizophora mangle* L. (Figure 3). The estimated mangrove area of 162 ha generally occurs as patches [20].

The main activities are agriculture, livestock farming, and forestry. Agricultural impacts include changing land use, such as clearing mangroves to grow crops, which is mainly performed by farmers. Livestock farming is considered one of the most impactful activities, mainly due to soil compaction and erosion. It requires clearing mangroves or other coastal vegetation to plant grasses and fodder. The main activities of the Integrated Forestry Company include the production, collection, and marketing of a range of agricultural products. The company also promotes and manages forests and fruit trees. Mangrove bark production and marketing in local currency and wholesale are also included. Another activity in this area is aquaculture in the Bay of Mazo, where PESCASAN has its El Mazo oyster farm, which covers 30% of the bay. It is exclusively dedicated to the cultivation of oysters (*Crassostrea rhizophorae* Guilding) for the local market.

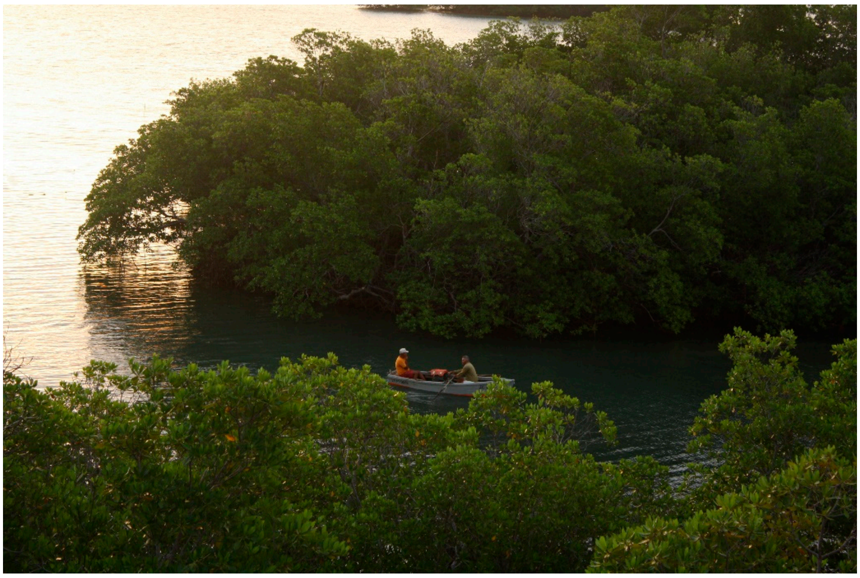

Figure 3. *Rhizophora mangle* stand in Guamá Sector (credits to Yanet Cruz Portorreal), a patch facing open sea.

(3) San Miguel de Parada Wildlife Refuge (SAM) (See Table 1)

The San Miguel de Parada Wildlife Reserve is situated in the Bay of Santiago de Cuba, surrounded by the bay's industry zone (Figure 2D) [53,58]. Due to environmental changes caused by industry, settlements, and the city of Santiago de Cuba (approx. 500,000 inhabitants) itself at 2 km across the bay, this area is currently considered disturbed. There is no industrial activity within the protected area itself, but there are several industrial and social service infrastructures in the vicinity that have an impact on the functioning of the ecosystem. However, the dumping and leaking of polluting products in the area, such as oil and its derivatives and untreated sewage, is one of the main problems associated with the presence of these facilities. This wetland area covers an area of 55 hectares of contiguous mangroves [53] (Figure 4).

Figure 4. Stands with a low canopy of *Avicennia germinans* in San Miguel de Parada Wildlife Reserve about 2 km from Santiago de Cuba town (credits to Yanet Cruz Portorreal).

(4) Hatibonico Ecological Reserve (HAT) (See Table 1)

The Hatibonico Ecological Reserve lies southwest of Guantánamo Province, between Niceto Pérez and Caimanera (Figure 2B) [52,59,60]. According to the management plan [52], the main function of the local mangrove is "coastal protection", although it is considered important as a forest reserve. Subsistence fishing is allowed and supervised by the Forest Ranger Corps and the Alejandro de Humboldt Environmental Services Unit. Crab fishing of *Ucides cordatus* (Linnaeus, 1763) is a traditional activity that is still allowed in the area for local consumption. There are 64 hectares of low-canopy mangrove forest bordering the mouth of the Hatibonico River (Figure 5).

Figure 5. Low-canopy stands with *Rhizophora mangle*, on the opposite shore *Batis maritima*, a small coastal shrub in Hatibonico Ecological Reserve (credits to Hayler María Pérez Trejo).

2.2. Study Design

2.2.1. Design of the Social–Ecological Study

In this study, we employed a qualitative research approach [61] with exploratory data summary using a structured questionnaire technique [27,32,62–65]. The objective was to gather the perceptions of coastal communities in the mangrove SES regarding the following variables: (1) ecosystem services provided by mangroves, (2) use of mangrove resources, (3) current management practices in place, (4) potential threats posing risks to these ecosystems, and (5) social–ecological relationships existing within the localities. Indeed, for Cuba, and particularly for this region, data are scarce, and there is a need to obtain descriptive data to understand the mangrove social–ecological systems. In a later phase, hypotheses can be put forward regarding the causes of similarities and differences within Cuba, between localities and in comparison, to insights elsewhere.

The questionnaire (Table S1) was structured into three parts, as follows:

Part 1: Community use of mangrove resources.

The following uses were considered: (1) the use of marine species (fish, molluscs, crustaceans) for eating or selling, (2) the use of mangroves bark or wood as dye resource. A three-point Likert scale was used to determine the frequency of use for the following population groups: 1 (never used), 2 (sometimes), and 3 (always, frequently).

Part 2: Perception of ecosystem services.

The perception of ecosystem services was assessed by evaluating the importance of various services to both individual and community life. These included: (i) Supporting

Services, such as providing shelter for the juvenile stages of many species, supporting the feeding and production of a diverse range of marine and terrestrial organisms, and offering habitat for numerous marine and terrestrial fauna; (ii) Provisioning Services, acting as a source of food for consumption and sale and providing natural medicines for various diseases; (iii) Regulatory Services, such as protecting coastal areas from storms, cyclones, and waves; maintaining seawater quality by trapping sediments; and mitigating climate change effects through carbon sequestration; (iv) Cultural Services, serving as recreational and educational sites and representing symbols of local culture and heritage.

Participants rated the importance of these services using the following scale: 1 (not important), 2 (important), and 3 (very important), following the classification proposed by MEA (Millennial Ecosystem Assessment) [8].

Part 3: Perceptions of mangrove ecosystem threats and management framework.

Awareness of mangrove management activities was assessed using a scale ranging from 1 to 3: 1 (unaware), 2 (somewhat aware), and 3 (fully aware). This evaluation focused on several aspects: (i) the existence of a specific management plan or programme for mangroves; (ii) participation in seminars or training sessions related to mangrove management; (iii) awareness of the presence of legal instruments governing mangrove conservation; and (iv) knowledge about the existence of any body, any level, or institution responsible for monitoring and evaluating mangrove resources.

The perception of mangrove managers was gauged by identifying the institutions or agencies responsible for mangrove management within their locality. Additionally, perception of threats to mangroves if existing was elicited through an open-ended question, allowing respondents to freely list events or factors that are impacting the ecosystem in their area, according to them. This structured approach aimed to capture a comprehensive understanding of community awareness, management perceptions, and perceived threats to mangroves in the study area.

2.2.2. Design of the Governance Study

To identify the type of governance present, interviews were conducted involving specialists from each of the three protected areas: MCOA, SAM, and HAT. These experts play active roles in the development and management planning of their respective areas. An unstructured instrument with open-ended questions was used during interview sessions. Key topics explored included: (i) the degree of consultation of communities during the preparation of management plans; (ii) the extent of community involvement in identifying issues, conflicts, and solutions; (iii) the role of communities solely as recipients of management plan actions or as actively involved; (iv) features of management, distinguishing top-down, bottom-up, or co-management systems, with diverse perspectives analysed regarding the specific governance system applied in each study area. The focus group surveys were aimed to gather insights into the governance structures and processes within each protected area, highlighting perspectives from various stakeholders involved in mangrove management.

In addition, we used the interviews to examine the following six variables crucial for understanding mangrove management and decision-making in the study region: (i) *Transparency*: assessing the accessibility and clarity of information related to decision-making processes; (ii) *Knowledge of the Legal Framework*: understanding of the legal provisions concerning mangrove protection and their implementation; (iii) *Accountability*: inquiry into stakeholders' awareness of their responsibility to demonstrate actions related to mangrove management and their ability to assess the consequences of these actions; (iv) *Citizen Participation*: evaluating the extent to which citizens can engage in mangrove decision-making processes and influence public policies; (v) *Equity*: analysis of the distribution of resources and opportunities related to mangrove management; (vi) *Inclusion*: examining the participation of all social groups in mangrove decision-making processes.

To gauge the stakeholders' level of influence and interest, we utilised an influence-interest matrix, more specifically the Mendelow Stakeholder Matrix [66]. This matrix helps to categorise stakeholders based on their level of influence over mangrove management decisions and their level of interest in the outcomes. The interviews and the matrix analysis are intended to provide insights into the dynamics of mangrove governance, stakeholder engagement, and decision-making processes within the study area.

2.2.3. Integrated Matrix Analysis

Finally, to qualitatively assess the impacts of social–ecological and governance interactions, we constructed a matrix incorporating anthropic activities reported by respondents, mangrove ecosystem services, technical reports, public information, and reports from protected area management plans. Each component was evaluated to determine its influence on the overall state of SES. This qualitative weighting or evaluation process involves assessing how the development of specific activities, uses, or ecosystem services affect the SES comprehensively.

- ↑ High impact: an extensive social–ecological interaction that causes major changes in the SES, thereby affecting its balanced functioning. These are typically very pervasive activities or uses defining the prevalent state of the SES.
- → Medium impact: a strong social–ecological relationship, however, without causing irreversible changes.
- ↓ Low impact: a weak social–ecological relationship that does not cause irreversible changes. These are typically isolated activities, uses, or services that do not affect the functioning of the mangrove in the SES.

2.3. Sampling

The study baseline was established through a review of the 2021–2025 management plans for the following protected areas: Monte Cabaniguán/Ojo de Agua Wildlife Refuge (MCOA), San Miguel de Parada Wildlife Refuge (SAM), and the Hatibonico Ecological Reserve (HAT). Guamá is a multiple-use area not subject to any official management regime; information was gathered from public population statistics data [67]. Additionally, six specialists from SNAP were interviewed to contrast the information obtained from the above review.

The sample size was determined based on the total population of coastal communities adjacent to each mangrove site. The number of respondents was calculated to ensure a representative sample for each location. A 95% confidence level was chosen with a margin of error of 10% (see Table 1 for details), corresponding to the final number of questionnaires administered per mangrove site. Individuals within these communities were selectively approached, ensuring all participants were over 18 years old. Prior to participation, all individuals were informed of the study's objectives and were requested to provide their consent for involvement.

Social–Demographic Profile of Respondents

Participants from all sites were aged between 18 and 80 years, with a median age of 43 years. The gender balance was nearly equal, with 53.8% male and 46.2% female respondents overall (Table 2).

Regarding the reported occupational backgrounds, the largest proportion of participants was employed in the public sector: 20.5% in MCOA, 41.3% in GUM, 51.4% in SAM, and 60.9% in HAT. These backgrounds included forest rangers, specialists from the Flora and Fauna Company, teachers, and tourism sector workers. Approximately 14.1% of respondents were engaged in the private sector, and an equal percentage (14.1%) were farmers conducting agricultural activities in coastal areas. About 20% identified as housewives, and 8.4% were retired (Table 2).

Table 1. Mangrove SES localities: status, extent, mangrove type, resp. communities, population size, and general appraisal of pollution status.

Mangrove Site	Management Classification (SNAP)	Administration	Extension (ha)	Mangrove Typology [68]	Population (Number of Respondents)
MCOA	Wildlife Refuge	Enterprise for Flora and Faunal Protection Las Tunas	3929.18	Deltaic	596 (83)
GUAM	Multiple use area	No management regime	162	Bay Open coast estuary	1525 (92)
SAM	Wildlife Refuge	Enterprise for Flora and Faunal Protection, Santiago de Cuba	55	Bay	267 (72)
HAT	Ecological Reserve	Ministry of Science Technology and Environment (CITMA)	64	Open coast	1003 (87)
Number of questionnaires 334					

Table 2. Distribution of the demographic profile of participants (in percentage, n = 334).

Indicators	Percentage			
	MCOA	GUAM	SAM	HAT
Age groups	15.7	20.7	30.6	14.9
18–30				
31–40	28.9	19.6	16.7	25.3
41–50	24.1	18.5	16.7	25.3
51–60	16.9	23.9	16.7	20.7
61–70	7.2	10.9	15.3	6.9
71–80	7.2	6.5	4.2	6.9
Total	100	100	100	100
Gender				
Male	50.6	53.3	54.2	56.3
Female	49.4	46.7	45.8	43.7
Total	100	100	100	100
Occupation *				
Housewife	24.2	20.7	20.8	14.9
State sector 1	-	30.4	44.4	43.7
State sector 2	-	9.8	5.6	13.8
Private Sector	33.7	14.1	16.7	14.9
Farmer	34.9	15.2	-	1.1
Retired	7.2	9.8	12.5	8.2
Student	-	-	-	3.4
Total	100	100	100	100

Note: * State sector 1—nonrelated to conservation, state sector 2—related to conservation.

2.4. Statistical Analysis

The creation of the database and analysis of the frequency tables were conducted using IBM SPSS Statistics for Windows, version 27.0, developed by IBM Corp. in Armonk, NY, USA. This facilitated the identification of patterns and highlighted the notable variable characteristics assessed in the communities for each mangrove site. The participants' profiles, together with the frequency of use and level of awareness of ecosystem services, were tabulated and summarised using frequency distributions and percentages [19].

When dealing with survey data on mangrove management and ecosystem services perceptions, non-parametric tests such as Kruskal–Wallis and Spearman's rank correlation are essential tools. These tests do not assume normal distribution of data, making them robust and reliable for analysing ordinal data and non-normally distributed continuous data, ensuring that the insights drawn are both accurate and meaningful. A Spearman correlation coefficient analysis was conducted to examine the relationship between occupation and frequency of mangrove ecosystem use [19]. Additionally, a Kruskal–Wallis test was employed to compare the frequency of mangrove uses and the perception of ecosystem services among the studied localities [32].

3. Results

3.1. Community Awareness of the Use of Mangrove Ecosystem Resources

The Kruskal–Wallis test revealed significant differences in the frequency of resource consumption as a food source. The results for fish consumption indicated H(3) = 51.9, $p < 0.001$. The post-hoc analysis, conducted using the Games–Howell test, demonstrated that the frequency of fish consumption in GUAM (Mdn = 3) was statistically significantly higher as compared to MCOA (Mdn = 2, $p < 0.001$, 95% CI [0.30, 0.83]), SAM (Mdn = 2, $p < 0.001$, 95% CI [0.60, 1.16]), and HAT (Mdn = 2, $p < 0.001$, 95% CI [0.26, 0.88]) (Table 3).

Table 3. Comparison of the frequency of mangrove uses between the study areas with Mdn—mean, Kruskal–Wallis H—test, *p*—*p* value. Site acronyms given in Section 2.1.

Use of Mangrove Resources	MCOA Mdn (Range)	GUAM Mdn (Range)	SAM Mdn (Range)	HAT Mdn (Range)	H	*p*
Food source (Fish)	2 (2)	3 (2)	2 (2)	2 (2)	51.9	0.001
Food source (Molluscs)	1 (2)	2 (2)	1 (2)	2 (2)	44.0	0.001
Food source (Crustaceans)	1 (2)	2 (2)	1 (2)	2 (2)	44.7	0.001
Traditional medicine	1 (2)	2 (2)	1 (2)	2 (2)	30.2	0.001
Wildlife watching	1 (2)	1 (2)	1 (2)	1 (2)	13.7	0.03
Recreational use	2 (2)	2 (2)	1 (2)	1 (2)	26.1	0.001
Education/Research	1 (2)	1 (2)	1 (2)	1 (2)	9.7	0.021
Spiritual/Religious practices	1 (2)	1 (2)	1 (10)	1 (2)	17.4	0.001

Note: 95% Confidence Interval.

The results of the test for the frequency of mollusc consumption among the localities showed H(3) = 44.0, $p < 0.001$. In GUAM, the consumption of this resource is significantly higher (Mdn = 2) compared to MCOA (Mdn = 1, $p < 0.001$, 95% CI [0.41, 1.05]) and SAM (Mdn = 1, $p < 0.001$, 95% CI [0.44, 1.00]). Differences in crustacean consumption were also examined, resulting in H(3) = 44.7, $p < 0.001$. The analysis indicates that in GUAM, consumption is higher (Mdn = 2) than in MCOA (Mdn = 1, $p < 0.001$, 95% CI [0.41, 1.04]) and SAM (Mdn = 2, $p < 0.001$, 95% CI [0.47, 1.03]), as shown in Table 3. Statistically significant values were also found for traditional medicine use, with H(3) = 30.2, $p < 0.001$. The result was significant for the GUAM locality (Mdn = 2) compared to MCOA (Mdn = 1, $p < 0.001$, 95% CI [0.19, 0.65]), SAM (Mdn = 1, $p < 0.001$, 95% CI [0.27, 0.75]), and HAT (Mdn = 1, $p < 0.001$, 95% CI [0.02, 0.54]). Moreover, significant differences were identified in the use of mangroves for recreation and education, with H(3) = 42.2, $p < 0.001$. This service does not appear to be important for members of the HAT community (Mdn = 1) compared to the communities of MCOA (Mdn = 3, $p < 0.001$, 95% CI [0.36, 0.97]), GUAM (Mdn = 3, $p < 0.001$, 95% CI [0.28, 0.85]), and SAM (Mdn = 3, $p < 0.001$, 95% CI [0.01, 0.61]).

Correlation Analysis of Occupations and Frequency of Mangrove Resource Use in the Study Localities

The Spearman rank correlation analysis (Rho) between demographic variables and mangrove uses in the studied localities indicates generally low to very low correlations (Table S3). In MCOA, age showed significant correlations with fish consumption ($rho_{(81)} = 0.310$, $p = 0.004$) and mollusc consumption, $rho_{(81)} = 0.218$, $p = 0.047$. In HAT, a correlation was found between religious use, $rho_{(85)} = 0.238$, $p = 0.26$) as well as with medicinal use ($rho_{(85)} = 0.229$, $p = 0.33$). In SAM, age correlated with wildlife watching, $rho_{(70)} = 0.340$, $p = 0.004$, and research/education use, $rho_{(70)} = 0.250$, $p = 0.35$. Additionally, in GUAM, age correlated with medicinal use, $rho_{(90)} = 0.281$, $p = 0.007$. In MCOA, length of residence in the community correlated with fish consumption, $rho_{(81)} = 0.354$, $p = 0.001$, mollusc consumption, $rho_{(81)} = 0.704$, $p = 0.001$, and crustacean consumption, $rho_{(81)} = 0.411$, $p = 0.001$. In HAT, time of residence correlated with medicinal use, $rho_{(85)} = 0.229$, $p = 0.33$, and religious practices, $rho_{(85)} = 0.238$, $p = 0.26$.

The rho correlation was also used to identify whether occupation influences the frequency of mangrove use (Table S3). In MCOA, housewives exhibited significant negative correlations with fish consumption, $rho_{(81)} = 0.356$, $p = 0.001$, mollusc consumption, $rho_{(81)} = 0.319$, $p = 0.003$, and crustacean consumption, $rho_{(81)} = 0.279$, $p = 0.011$. This suggests that this occupation relies less on these resources compared to other occupations. In GUAM, both positive and negative correlations were observed, highlighting the influence of housewives and farmers on the utilisation of specific resources. Housewives showed a significant positive correlation with the following uses: fish consumption, $rho_{(90)} = 0.265$, $p = 0.011$), medicinal use, $rho_{(90)} = 0.234$, $p = 0.025$, and dye production, $rho_{(90)} = 0.248$, $p = 0.017$. Farmers correlated significantly with fish consumption, $rho_{(90)} = 0.225$, $p = 0.031$, mollusc consumption, $rho_{(90)} = 0.262$, $p = 0.012$, and medicinal use, $rho_{(90)} = 0.227$, $p = 0.030$.

In SAM, housewives had a significant positive correlation with spiritual use or religious practices, $rho_{(70)} = 0.532$, $p = 0.001$, related to mangroves. The government sector 2 (linked to conservation) correlated with educational practices, $rho_{(70)} = 0.345$, $p = 0.003$. In HAT, housewives exhibited a significant negative correlation with the use of mangroves as a source of molluscs, $rho_{(85)} = 0.236$, $p = 0.028$. Government sector 2 correlated significantly with the consumption of species for food.

3.2. Community Perception of Mangrove Ecosystem Services

Respondents recognised the presence of red mangrove (*Rhizophora mangle*, locally called mangle rojo) and black mangrove (*Avicennia germinans*, locally called mangle prieto) in their area, followed by white mangrove (*Laguncularia racemosa* (L.) C.F. Gaertn, locally called patabán). The least identified (Figure 6) is the button mangrove (*Conocarpus erectus* L., locally called yana). In HAT, between 2.4% and 7.8% of respondents lacked knowledge of any mangrove species.

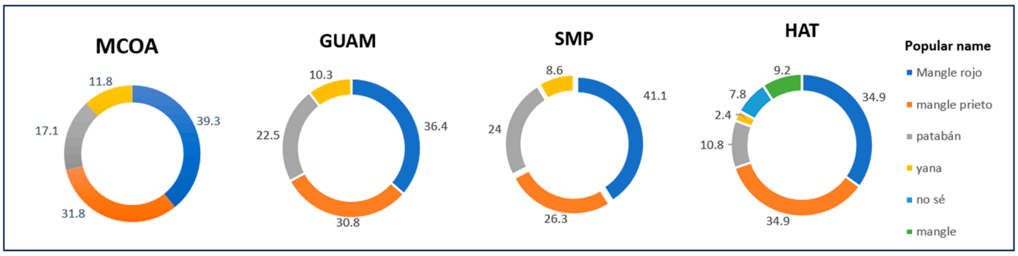

Figure 6. Distribution of responses (in percentage) regarding the knowledge of popular mangrove names across four sites: MCOA, GUAM, SMP, and HAT. The categories include red mangrove, black mangrove, patabán, yana, "I don't know", and mangrove.

Local people were inquired about the importance of ecosystem services provided by mangroves (Table S2, Figure S1). Overall, the perception of ecosystem services was very high in all mangrove communities. Between 43.7% and 100% of participants confirmed that mangroves provide an important supporting function for fauna, including juveniles (nursery function).

Significant differences (p-value < 0.05) were found in perceptions of ecosystem services in mangrove localities (Table 4). The result of the Kruskal–Wallis test for juvenile refuge (nursery) among the localities was $H(3) = 66.9$, $p < 0.001$. The communities in GUAM indicated the highest perception for this service (Mdn = 3) compared to MCOA (Mdn = 3, $p < 0.001$, 95% CI [0.001, 0.26]), SAM (Mdn = 3, $p < 0.001$, 95% CI [0.17, 0.56]), and HAT (Mdn = 2, $p < 0.001$, 95% CI [0.48, 0.97]). Conversely, HAT participants provided the lowest perception compared to the other localities, as shown in Table 4.

Table 4. Comparison of the perception of mangrove ecosystem services between localities studied. Mdn—mean, Krusskal-Wallis H—test, *p*—*p* value.

Ecosystem Services	MCOA Mdn (Range)	GUAM Mdn (Range)	SAM Mdn (Range)	HAT Mdn (Range)	H	*p*
1. Nursery	3 (2)	3 (1)	3 (2)	2 (2)	66.9	0.001
2. Wildlife habitat	3 (0)	3 (0)	3 (2)	2 (2)	97.4	0.001
3. Food source	3 (2)	3 (2)	2 (2)	2 (2)	89.2	0.001
4. Coastal protection	3 (2)	3 (2)	1 (2)	1 (2)	78.0	0.03
5. Water quality	3 (2)	3 (2)	3 (2)	1 (2)	45.5	0.001
6. Recreation/Education	3 (2)	1 (2)	2 (2)	2 (2)	42.2	0.001

Note: 95% Confidence Interval.

In addition, MCOA (Mdn = 3) and GUAM (Mdn = 3) communities identified food sources to be very important as provisioning services. The SAM (Mdn = 2) and HAT (Mdn = 2) communities reported this less frequently as important. We defined three different levels of importance for mangrove regulating services. Coastal protection is considered very important, with between 65.2% and 95.7% of respondents indicating that mangroves help to protect against the high waves and strong winds associated with extreme hydrometeorological events. Significant results were found regarding this service, with H(3) = 78.0. In GUAM, the perception of this service was considered very important (Mdn = 3) compared to MCOA (Mdn = 3, $p < 0.001$, 95% CI [0.7, 0.45]), SAM (Mdn = 1, $p < 0.001$, 95% CI [0.14, 0.56]), and HAT (Mdn = 1, $p < 0.001$, 95% CI [0.66, 1.17]). In HAT, there is less recognition of this service compared to the other localities (Table 4).

Regarding the perception of water quality maintenance, the Kruskal–Wallis test indicated H(3) = 45.5, $p < 0.001$. In HAT, the perception of this service is significantly lower (Mdn = 1) compared to MCOA (Mdn = 3, $p < 0.001$, 95% CI [0.43, 1.00]), GUAM (Mdn = 3, $p < 0.001$, 95% CI [0.29, 0.86]), and SAM (Mdn = 3, $p < 0.001$, 95% CI [0.08, 0.72]).

The role of mangroves in climate change mitigation through carbon sequestration was perceived to be minimal by the participants, with 45.8% in MCOA, 40.2% in GUAM, 41% in SAM, and 43.7% in HAT (See Table S2). The Kruskal–Wallis test indicated no significant differences in the distribution of perception values among localities. This suggests that perceptions of mangroves were similar across the four studied areas.

3.3. Community Perceptions of Mangrove Management Framework

We asked the participants per site if they were aware of the existence of any management activity (Figure 7A). Respondents indicated they were fully aware of the existence of the protected area and management activities in MCOA (61.4%) and SAM (44.4%). In GUAM, between 23.9% and 29.3% were, respectively, aware and fully aware that there was no management plan. However, they referred to the activities of the rangers and the government to protect the mangrove forest (Figure 7D). In HAT, 50.6% of the villagers were moderately aware of management activities.

In the study sites, a significant percentage of respondents in MCOA (63.9%) and SAM (40.3%) indicated that they were very aware of ongoing management training activities, such as seminars, workshops, and training sessions (Figure 7B). In GUAM, where mangroves are not designated as a protected area, perceptions of management activities were linked to the implementation of the COSTASURESTE project, which was concluded in 2012 and is no longer operational. Conversely, in HAT, local awareness of mangrove management activities was reported as moderate percentages.

Across all sites, the communities displayed moderate to high levels of awareness regarding the existence of laws regulating mangrove use, penalties for non-compliance, and the governmental authorities responsible for enforcement (Figure 7C,D).

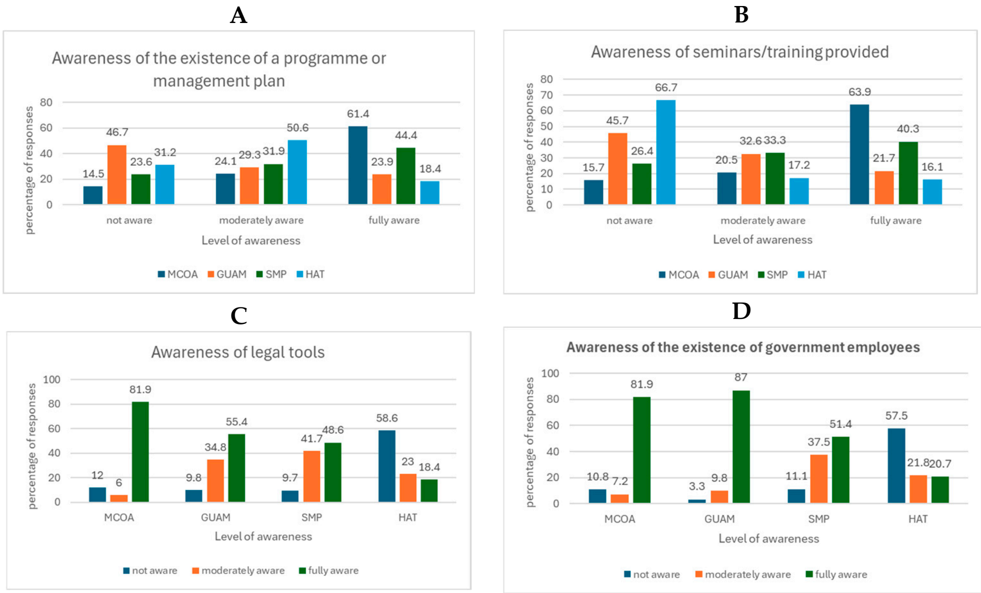

Figure 7. (**A**)—Awareness of mangrove management in the study sites. Perception of management plan existence, (**B**)—awareness of management training activities, (**C**)—awareness of the existence of legal tools regarding mangrove management, and (**D**)—awareness of any body, any level, or institution responsible for monitoring and evaluating mangrove resources in the various areas.

3.4. Community Perception of Potential Threats to Mangroves

During the survey, villagers identified and ranked 15 natural and anthropogenic threats affecting their localities (Table 5). Climate change and drought emerged as the natural threats that raise the most concern across all areas. The villagers of GUAM (16.1%) and SAM (9.0%) also identified tropical cyclones as significant threats. Salinisation was also noted as a relevant concern in MCOA (4.2%), GUAM (12.5%), and SAM (4.2%).

Table 5. Threats to the mangrove perceived in the sites studied (ordered alphabetically).

	Answers (%)			
Mangrove Threats/Localities	**MCOA**	**GUAM**	**SAM**	**HAT**
Agriculture	-	5.1	-	-
Bark and roots removal	-	6.8	-	-
Climate change	24.6	18.5	19.6	31.9
Drought	16.3	5.5	20.1	39.3
Exotic species	5.3	4.1	-	4.3
Fires	14.4	-	-	24.5
Grazing	-	4.5	-	-
Industries	-	-	18.0	-
Logging	24.2	24.7	12.7	-
Pollution/waste dumping	6.4	9.9	11.6	-
Rising sea level	-	1.4	0.5	-
River damming	3.0	-	4.2	-
Road construction	4.8	4.8	-	-
Salinisation	4.2	12.5	4.2	-
Tropical cyclones	-	16.1	9.0	-

Locally, forest fires were seen as a threat by respondents in MCOA (14.4%) and HAT (24.5%). Among direct anthropogenic threats, logging was prominently mentioned in MCOA (24.2%), GUAM (24.7%), and SAM (12.7%). Industries were specifically noted in SAM (18.0%) as contributing to environmental risks.

Road construction was reported as impacting mangroves in MCOA (4.8%) and GUAM (4.8%). Damming of rivers was cited in MCOA (3.0%) and SAM (4.2%). Agricultural expansion was mentioned in GUAM (5.1%) as a replacement of mangrove areas with crops, while 4.5% reported this conversion was into pastures.

Local communities also expressed their concern regarding the extraction of mangrove bark and roots for various purposes. Moreover, the presence and spread of exotic species were identified as hazards in MCOA (5.3%), GUAM (4.1%), and HAT (4.3%) but were not considered hazards in SAM.

We also queried local residents regarding their perceptions of changes and the current state of mangroves near their communities (Figure 8). To conduct this part of the study, we surveyed local communities to assess their awareness and perception of the impact of mangrove degradation on their communities (Figure 8A). In MCOA, 54.2% of respondents acknowledged the severe impact of mangrove degradation, while in GUAM, this figure was notably higher at 77.1%. Conversely, in SAM, 34.7% of respondents perceived mangrove degradation as having minimal or moderate negative consequences. In HAT, most respondents (67.8%) believed that mangrove degradation would either be harmless or would only have a moderate negative impact on their communities.

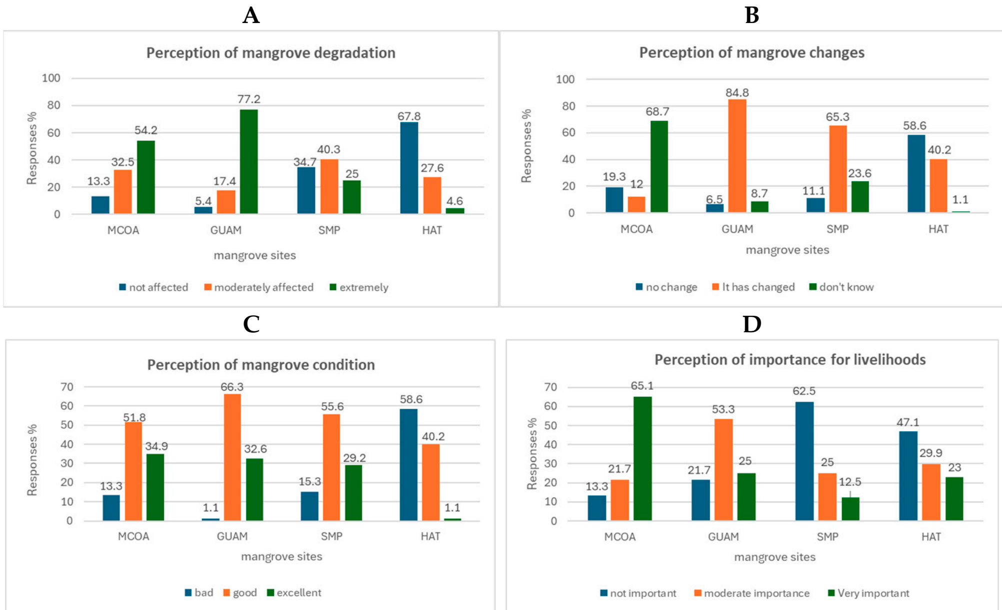

Figure 8. Perception of the studied communities regarding degradation, condition, changes in the mangroves, and importance for their livelihood. (**A**)—Perception of mangrove degradation impact on the community, (**B**)—perception of mangroves changes as a landscape, (**C**)—perception of mangrove condition, (**D**)—perception of the importance of the mangrove for the livelihood of the local people.

Within the same inquiry, the participants of MCOA (68.7%) indicated that they perceived no significant changes in the mangrove landscape, while 51.8% felt that mangroves were in good condition (Figure 8C). Additionally, 65.1% of the MCOA respondents emphasised that mangroves are really important to their livelihoods (Figure 8D). In GUAM, a notable 84.8% of the participating community felt that there were changes in local mangroves; however, 66.3% of them are convinced that these ecosystems are in good condition (Figure 8B). About 53.3% of this community acknowledges that their livelihoods moderately depend on these mangroves, primarily as a food source (Figure 8D). In SAM, 55.6% of participants observed an increase in mangrove areas within the wetland area, and an equal part of the community considered that their mangroves were in good shape. Surprisingly, 62.5% of them stated that they do not depend on mangroves for their livelihoods (Figure 8D). In HAT, 58.6% of respondents reported no noticeable changes in mangroves (Figure 8B), and 40.2% of them assessed the mangroves as being in a healthy state (Figure 8C). Similar to the SAM community, the majority (64.4%) of HAT participants expressed that mangroves are not crucial for their livelihoods (Figure 8D).

3.5. Results of the Governance Analysis

Based on insights gathered from both interviews and management plans, distinct approaches to mangrove management and community involvement were observed across the different sites.

In MCOA, mangrove management plans are formulated exclusively by area specialists without direct community participation or voting rights. The community's role is limited to providing information during stakeholder workshops, where only one community representative is invited.

In SAM, workshops serve as platforms to reconcile diverse interests, gathering inputs from various experts within the protected area. However, community participation here is also restricted to providing information rather than influencing decision-making directly.

HAT employs a more inclusive approach where workshops precede plan development or updates. These sessions involve community participation in defining tasks and reporting on previous plans. Decision-makers and community representatives are integral to these workshops, held locally with support from government entities such as the Ministry of the Revolutionary Armed Forces (MINFAR) and civil defence. Economic challenges sometimes hinder plan implementation, especially for continuity plans, which often rely solely on data updates.

In GUAM, there is no programme or framework for mangrove management, but activities for preservation fall under the responsibility of the Integral Forestal Guamá Enterprise and the State Forestry Service of the Ministry of Agriculture (MINAG), with involvement from the municipal government and the Ministry of Science Technology and Environment (CITMA) in decision-making. However, there is a recognised need that other local institutions and community members should be involved in the future.

The analysis of stakeholder relationships identified that key public entities such as the Cuban State, CITMA, MINAG, provincial governments, and municipal councils have significant influence and interest in mangrove management (Figure S2). In contrast, entities such as the National Hydraulic Institute (INRH) and the Ministry of Food Industry (MINAL) currently exhibit lower influence and interest, resulting in minimal involvement in the management framework.

Local communities and the Ministry of Tourism (MINTUR) are identified as stakeholders who have high levels of interest but low influence in shaping outcomes within the mangrove social–ecological system. This suggests that they are highly affected by the results of actions taken that impact mangroves, yet their ability to influence these outcomes through management decisions is rather limited. Conversely, stakeholders such as MINFAR and the Ministry of the Interior (MININT) possess high influence but exhibit low interest in mangrove-related activities.

3.6. Description of the Observed Social–Ecological Relationships

Our analysis emphasises how human activities (social, economic, and cultural) affect the mangrove ecosystem in each locality analysed. The matrix (Figure 9) synthesises the social–ecological relationships observed, revealing three distinct interaction types: urban/industrial, rural/agricultural, and rural/agricultural/tourist.

In MCOA, significant interaction occurs with the agricultural sector and expanding livestock farming. Probably due to the size of the local mangroves, these activities have minimal impact on the ecosystem. The mangroves primarily provide supporting services, crucial for justifying conservation efforts, with provisioning services playing a secondary role, according to the participants.

GUAM exhibits a high level of interaction between tourism and agriculture activities. Agricultural expansion poses the greatest threat to mangrove areas through land use changes. Tourism, while not directly impacting the mangrove ecosystem, focuses on exploiting the scenic and cultural values of the local forest, thereby fostering strong social relations based on goods supply and cultural services.

SAM is characterised by intense urban–industrial interaction, situated within the industrial zone of Santiago de Cuba's bay. Here, mangroves face significant challenges from pollution and land use changes driven by industrial growth, compromising ecosystem services. Supporting services, particularly the mangrove's role in sheltering migratory birds, dominate despite these pressures.

HAT experiences minimal interaction. The interaction that is happening is primarily centred on agricultural activities and non-productive forestry endeavours. Social interactions thrive without adverse effects on mangroves. This area exhibits low ecological impact, with supporting services being most pronounced and provisioning services playing a moderate role.

Mangrove sites	**Anthropic activities**				**Ecosystem services**			
	1	2	3	4	S	A	R	C
MCOA	↑	↓	↓	↑	↑	→	↓	↓
GUAM	↑	↑	↓	↓	↑	↑	↑	↑
SMP	→	↓	↑	↑	↑	↓	→	→
HAT	↑	↓	↑	↑	↑	→	↓	↓

Legend: 1 Agriculture, 2. Industry, 3. Tourism, 4, Conservation, S. Support service, A. Supply service, R. Regulation service, C. Cultural service. Degree of influence:

↓ *High influence*	→ *Average influence*	↑ *Low influence*

Figure 9. Evaluation matrix of social–ecological interactions in the study sites.

4. Discussion

Our study underscores that knowledge of and exploitation of mangroves are deeply intertwined in the daily lives and cultural practices of southeastern Cuban communities, consistent with studies from elsewhere [7,18,32]. The increased awareness by local communities of ecosystem services and threats such as climate change likely stems from environmental education initiatives integrated into Cuba's Environmental Strategy implementation [69].

Cuba, situated in the West Atlantic–East Pacific mangrove region, naturally exhibits a relatively low mangrove species richness as compared to the Indo-West Pacific and the global number of approximately 70 species. Mangroves in Cuba comprise primarily *Rhizophora mangle* (red mangrove), *Avicennia germinans* (black mangrove), and further *Laguncularia racemosa* (white mangrove), and *Conocarpus erectus* (button mangrove). These species, particularly red and black mangroves, also dominate the mangrove forests across the study sites in southeastern Cuba [20,58], whereby coastal communities mostly recognised red mangroves, in particular [20,58]. Yet, in terms of areal extent, Cuba ranks 10th worldwide [40] and its mangrove SESs are important.

The identification of mangrove species appears, on the one hand, to be influenced by the distribution and composition of the local ecosystem. Due to the environmental conditions of the study area, the presence of *C. erectus* is minimal compared to the other species. On the other hand, the duration of time a participant has resided in the locality also appears to affect their ability to identify the species. Further research should be conducted in this regard.

In this study, we provide descriptive data for the mangrove social–ecological systems of southeastern Cuba in support of a better understanding of issues related to good management and conservation.

4.1. Use of Mangrove Resources by Communities

Fishing and the exploitation of forest products, whether for commercial or subsistence purposes, have historically been primary livelihoods for coastal communities near mangroves [4,6,65]. However, our study indicates a shift in southeastern Cuba where local livelihoods are increasingly diversifying towards inland (terrestrial) activities [55,56] in industrial employment [67] and job opportunities in emerging agricultural and livestock sectors [59,68]. Despite these changes, the use of mangrove resources for food purposes remains prominent, alongside medicinal and recreational uses such as bathing areas. Notably, while mangrove wood is valued elsewhere for fuel and construction [4,64], in this study, participants perceived its use as illegal, which reflects Cuba's stringent regulations against mangrove logging [70]. Studies on mangroves in Mexico, Brazil, Bangladesh, and Madagascar highlight uses such as recreation, tourism, and cultural preservation tied to mangroves [7,71–73]. In southeastern Cuba, local communities also utilise red mangroves for traditional medicine, including treatments for kidney infections and skin diseases. Despite the high scenic value of mangroves, which presents opportunities for nature and ecotourism, such as wildlife observation within protected areas, their use is not widespread in this region. Sustainable practices for these activities remain underdeveloped.

Comparing local occupations with mangrove resource use revealed interesting patterns showing how residents' jobs affect both the frequency and type of mangrove resource utilisation (Supplementary Table S3). The governmental sector is mostly associated with its conservation and research/educational efforts towards the mangrove ecosystem. In SAM, housewives use the mangroves mainly for medicine and religious practices. More research needs to be conducted to understand the significance of this small percentage of religiosity, probably of African origin.

When combining occupation with perceptions of mangrove ecosystem services the respondents' occupation and residency play an important role (Table 5). The social context on the valuation of ecosystem services, management, and conservation activities should take these differences into account.

To better understand the causality behind these observed differences in perception, further research is needed. However, it is crucial to consider these differences when designing conservation and management policies for mangroves, ensuring all community sectors are involved.

4.2. Perception of Ecosystem Services in Communities

Communities near mangroves in southeastern Cuba demonstrate a robust understanding of the ecosystem goods and services provided by mangroves, similar to knowledge found globally, such as in Mauritius [6]. The communities widely recognise their habitat support for fauna, especially juveniles, and the provisioning services such as food and medicine [7,22,74]. In GUAM and MCOA, mangroves play a crucial role in supporting local fisheries, underscoring their significant economic importance [51]. This dependency is more closely related to community livelihood strategies than to demographic factors, unlike other studies [7,74,75]. In GUAM, the proximity of communities to mangroves may contribute to the frequent use of mangrove resources, a pattern also observed in Tanzania [31]. Perception of the regulatory function of climate mitigation services depends on the population's awareness of the protective role of mangroves against extreme hydrometeorological events. This awareness extends beyond the experience of the respondents with national environmental policies [24], which emphasise this ecosystem service [4,32].

While there is a general awareness of mangroves' regulatory role in climate mitigation, understanding of their carbon sequestration capacity remains limited, possibly due to the abstract nature of this service in local contexts [76,77]. This highlights the need for improved environmental education and capacity building to enhance local knowledge and leverage it for future blue carbon initiatives, especially in light of Cuba's position in the world rankings of mangrove areas.

In brief, this study's findings reveal that respondents' occupations in mangrove areas affect their views on the ecosystem services provided by these environments. In several localities, such as GUAM, SAM, and HAT, there were noticeable links between government roles, conservation efforts, and the perception of specific services. Conversely, in MCOA, housewives showed a lower appreciation for services like nursery function, erosion protection, and CO_2 assimilation and carbon retention, while retirees in HAT had a reduced perception of nursery services, erosion protection, consumption and sale, and salinity protection. These variations highlight how different occupational groups perceive the utility and benefits of mangroves differently (Table 5). Overall, these findings underscore the strong impact of occupation on the management and conservation practices related to mangroves.

Additionally, this study reveals that respondents in the four areas studied are unaware of the role of mangroves in carbon sequestration (Table S4). This lack of awareness limits local communities' abilities to value and support this ecosystem's conservation. Mangroves are effective carbon sinks, with a carbon sequestration capacity that surpasses that of tropical forests. Yet this benefit is not widely recognised among local stakeholders and cannot be used as an argument for conservation yet, let alone the establishment of carbon credit programmes. There is an urgent need to enhance awareness and environmental education programmes about the critical role of mangroves in carbon sequestration and climate change adaptation. It is recommended that mangrove management initiatives include these efforts aimed at highlighting the multiple benefits of mangroves. Some examples are integrating relevant information into school curricula, conducting public communication campaigns, and developing materials for key stakeholders such as farmers, fishers, and policymakers. Enhancing this awareness has the potential to foster greater support for mangrove conservation and restoration, thereby maximizing both the benefits for local communities and the environment.

4.2.1. Perception of Mangrove Ecosystem Threats and Management Framework

Coastal residents are usually well aware of ongoing mangrove conservation efforts and the regulatory frameworks governing their use in Cuba. However, clarity on responsible management entities remains a concern despite established legal structures [24]. Apparently involving local governments is essential for successful management programmes [32,48]. Management plans often prioritise charismatic faunal species over entire mangrove ecosystems, reflecting funding biases. In GUAM, initiatives like the COSTASURESTE project [78] have bolstered local environmental awareness, albeit without specific protected area designations or integrated coastal zone management (ICZM) programmes. Though concluded in 2012, the awareness lingers on.

Governance types around the world could be divided roughly into bottom-up, top-down, and co-management [79], amongst others. In Cuba, the top-down management system is still prevailing [39,80]. Moving forward, embracing bottom-up or co-management models could enhance local participation and governance efficacy, aligning with international best practices and ensuring sustainable mangrove management [79]. Such governance also allows two-directional information flows, a sense of property and belonging and acceptance of constraining measures.

4.2.2. Potential Threats to Mangroves

Mangroves face varied threats, categorised as natural (e.g., drought, cyclones) and anthropogenic (e.g., logging, agricultural expansion, pollution) hazards, each posing different levels of risk [16,81]. Natural forces have caused significant mangrove loss [23]. Climate change has natural and anthropogenic roots, but locals identified it as a natural threat. Climate change and drought are perceived as the most significant natural threats in southeastern Cuba, exacerbated by local climatic conditions and regional forecasts [82].

Cyclones are a major threat, causing area loss and damage, though mangroves can recover [23,83]. Salinisation and forest fires are other concerns expressed, while sea level rise is less perceived due to the elevated eastern coast.

Anthropogenic threats such as logging and agricultural expansion are significant concerns, driven by economic activities that alter land use and hydrology, impacting mangrove ecosystems [16,84–86]. Effective governance and community involvement are crucial for mitigating these threats, aligning policies with local realities and sustainable practices [16,79,80].

4.2.3. New Perspective for Governance and Management of Mangroves in Eastern of Cuba

While Cuba has established institutional mechanisms for environmental governance, their effectiveness in incorporating community voices and ensuring equitable, accountable management of mangroves remains a challenge. Enhancing stakeholder engagement and fostering inclusive governance models could bridge existing gaps, facilitating more sustainable mangrove conservation practices and increasing awareness [38,39]. The proposed model (Figure 10) outlines actionable steps for integrating local knowledge and fostering collaborative management approaches, building on Cuba's existing legal frameworks [24]. The existing legal framework in Cuba supports the development of a scheme (Figure 10) for identifying key stakeholders and their responsibilities towards potential conservation efforts. This provides a solid foundation for improving mangrove governance even though the prevailing approach predominantly follows a top-down model.

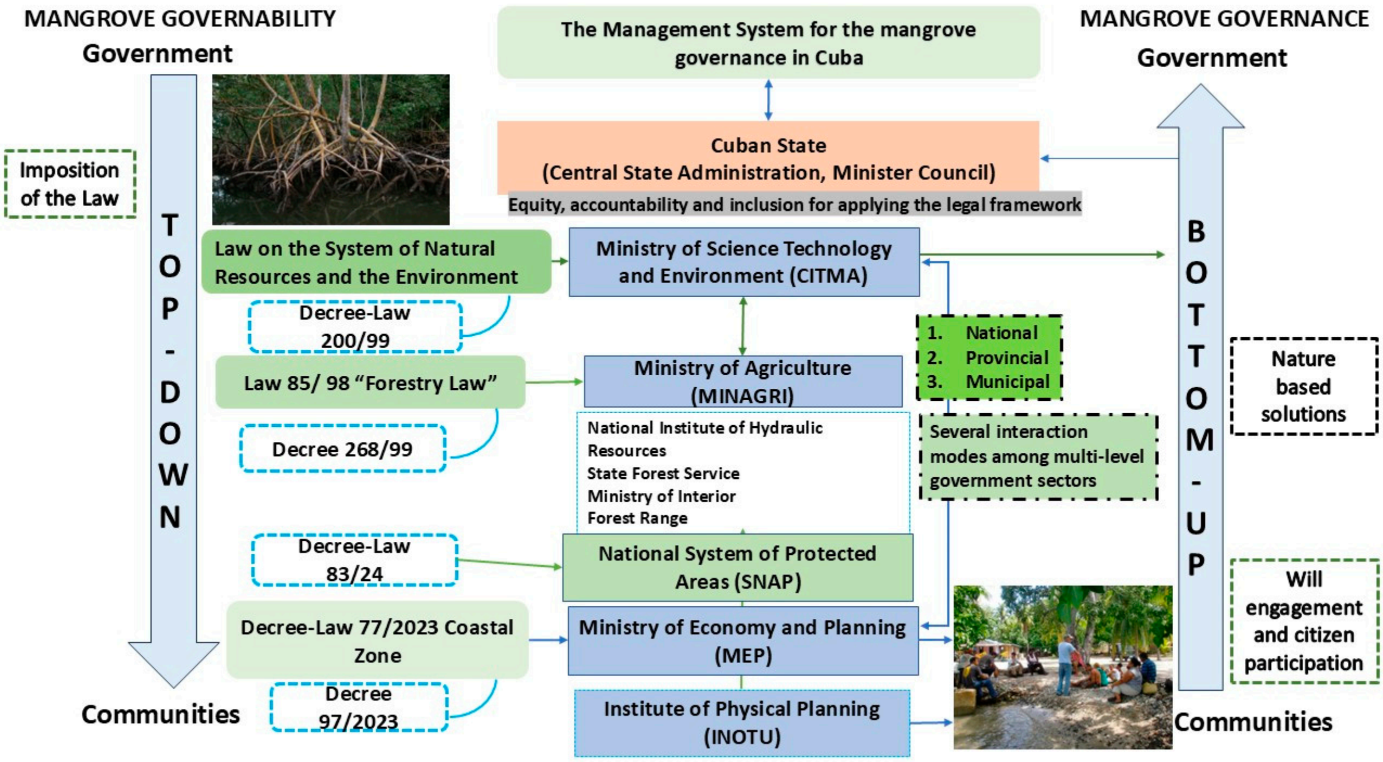

Figure 10. The management system proposed for mangrove governance in Cuba, particularly in southeastern Cuba. Photos credit Nico Koedam ((**top left**), *R. mangle* in MCOA) and Yanet Cruz Portorreal ((**bottom right**), meeting with residents of GUAM).

4.2.4. Analysis of the Observed Social–Ecological Relationships

We conducted a preliminary qualitative and descriptive analysis by integrating the survey results with a structured documentary review. For future research, we recommend incorporating indicators and measurable variables to better analyse these social–environmental interactions. Our study suggests that management programmes for protected areas should align with integrated coastal zone management principles. This alignment will facilitate the development of social–ecological system approaches and increase governance efficacy.

We found gaps in local knowledge on the role of mangrove ecosystems in carbon sequestration. There is a need for training and identifying opportunities for implementing local development projects. Emphasising capacity building could address market issues for ecosystem services, including carbon sequestration, and raise awareness of this intangible service. Understanding the complex international carbon market assessments and realising the ecosystem's potential for this service in Cuba is crucial.

Our study concludes that communities have different social–environmental relationships based on the rural, urban, and coastal characteristics of these settlements. There are also different manifestations of anthropic activities depending on the dominant sector of economic development and its impact on mangrove functioning. There is unexploited potential for understanding and engagement in mangrove SESs of southeastern Cuba if considering the level of public knowledge and awareness. There is a need when summing the contributions of mangrove goods and services to the local economy or subsistence livelihoods, even though these are not similar in each community.

5. Conclusions

This study explored the knowledge, usage patterns, interdependencies, and social-cultural aspects related to social–ecological dynamics between four southeastern Cuban communities and coastal mangrove ecosystems. The four communities and mangroves have different settings and legal frameworks. The expected diversity in human–mangrove relations has been confirmed, with several recurrent features. Understanding these relationships offers valuable insights for decision-makers to promote conservation and highlights gaps in existing management programmes, including the need for community-specific training programmes for local public and private stakeholders.

Our findings emphasise the necessity of a comprehensive approach to mangrove management and conservation, with implications that extend beyond Cuba. Policymakers should recognise NbS as an opportunity for inclusive solutions and forge partnerships for effective mangrove management in southeastern Cuba, even where they have not been called NbS yet in the region. Bridging the gap between NbS and formal governance, addressing diverse opinions, and providing continuous support for community participation is essential. Developing NbS capacities based on regional contexts is crucial for effective management.

The variations in mangrove use frequency and occupational roles highlight the importance of considering the interests of different stakeholder groups in management activities. This also indicates that certain groups may be more susceptible to understanding and remediating mangrove degradation. This should be considered in mangrove restoration practices currently proliferating in the country.

The positive links between the government sector and conservation along with certain educational and research uses underscore the key role of the government in fostering sustainable use. Perceptions of ecosystem services differ by occupation and locality, illustrating the importance of the social and geographical context in the valuation of mangroves.

Overall, the analysis reveals key opportunities and challenges for effective governance by clarifying the complex relationships between human communities and mangrove ecosystems. This research provided valuable scientific information on community perceptions of use, management, and threats to the mangrove ecosystem valid for effective governance of this socio-ecosystem. Upon implementation, decision-makers could promote community participation, identify threats, and develop effective policies that enhance the value placed on these resources. They could better valorise the awareness and knowledge baselines in the communities to the benefit of local economies, livelihoods, and securing coastal safety under environmental threats.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/w16172495/s1, Table S1: Questionnaire; Table S2: Percentage distribution of respondents at each level of importance of mangrove ecosystem services, Table S3: Correlations between the occupation and frequency of resource utilization; Table S4. Correlations between the occupation and awareness of ecosystem services. Figure S1: Frequency of mangrove resource use in the sites studied, Figure S2: Level of specific stakeholders in the management system for the mangrove governance in Cuba (Mendelow's Stakeholder Matrix).

Author Contributions: Conceptualisation, Y.C.P., N.K., C.B.M., F.D.-G., and O.P.M.; methodology, Y.C.P., N.K., C.B.M., F.D.-G., and O.P.M. software, Y.C.P.; validation, Y.C.P., C.B.M., and O.P.M.; formal analysis, Y.C.P., N.K., N.B., O.J.R.D., C.B.M., and O.P.M.; investigation, Y.C.P.; writing—original draft preparation, Y.C.P.; writing—review and editing, Y.C.P., N.K., N.B., O.J.R.D., C.B.M., F.D.-G., and O.P.M.; visualisation, Y.C.P. and C.B.M.; supervision, N.K., N.B., O.J.R.D., and O.P.M.; funding acquisition, Y.C.P., N.K., N.B., O.J.R.D., and O.P.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Flemish Development Cooperation through the Flemish Interuniversity Council-University Cooperation for Development (VLIR-UOS) as part of an Institutional University Cooperation programme with Universidad de Oriente in Santiago de Cuba, Cuba. YC received a grant from Global Minds, Hasselt University, Belgium. Moreover, we received support from the Science, Technology, and Innovation research project: Adaptive Governance to Climate Change in Coastal Municipalities of Cuba, PN211LH012-018, Associated with the National Local Development Programme in Cuba.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors thank Agustin Garzón for valuable discussions and insights, also Yusneida Alarcón Jorge, Yairén Alonso Jiménez, Ing. Yuri Debros Trutié, Hayler M. Pérez Trejo for assistance with field trips and questionnaire implementation. The fifth author thanks Universidad del Magdalena, Colombia, COIBA-AIP, Panama, and ESPOCH, Ecuador, for supporting her post-doctoral project entitled "Anthropogenic pressures in the Galapagos Islands: pluralistic regulations to mitigate anthropogenic pressures and promote sustainable development." The methodology used in this article is a pivot for qualitatively assessing the influence of social–ecological relationships and governance of mangroves in Galapagos Island.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Chapin, F.S.; Kofinas, G.P.; Folke, C. *Principles of Ecosystem Stewardship Resilience-Based Natural Resource Management in a Changing World*; Springer Science+Business Media: New York, NY, USA, 2009; p. 402.
2. Dahdouh-Guebas, F.; Hug, J.; Abuchahla, G.M.O.; Cannicci, S.; Jayatissa, L.P.; Kairo, J.G.; Kodikara, S.; Koedam, N.; Mafaziya, T.W.G.F.; Mukherjee, N.; et al. Coastal and Shelf Science Reconciling nature, people and policy in the mangrove social-ecological system through the adaptive cycle heuristic. *Estuar. Coast. Shelf Sci.* **2021**, *248*, 1–29. [CrossRef]
3. SARAS Institute. Key Concepts: Socio-Ecological Systems. South American Institute for Resilience and Sustainability Studies 2019; p. 2. Available online: https://saras-institute.org/social-ecological-systems/ (accessed on 5 February 2020).
4. Walters, B.B.; Rönnbäckb, P.; Kovacsc, J.M.; Cronab, B.; Hussain, S.A.; Badola, R.; Primavera, J.H.; Barbier, E.B.; Dahdouh-Guebas, F. Ethnobiology, socio-economics and management of mangrove forests: A review. *Aquat. Bot.* **2008**, *89*, 220–236. [CrossRef]
5. Nagendra, H. Reforestation and regrowth in the human-dominated landscapes of South Asia. In *Reforesting Landscapes*; Springer: Berlin/Heidelberg, Germany, 2009; pp. 149–174.
6. Abib, S. Local people and mangroves: Ecosystem perception and valuation on the southwest coast of Mauritius. *West. Indian Ocean. J. Mar. Sci.* **2021**, *20*, 11–19. [CrossRef]
7. Merven, R.; Appadoo, C.; Florens, V.; Iranah, P. Dependency on mangrove ecosystem services is modulated by socioeconomic drivers and socio-ecological changes–insights from an insular biodiversity hotspot. *Res. Sq.* **2023**, 1–18. [CrossRef]
8. MEA (Millennium Ecosystem Assessment). *Ecosystems and Human Well-Being: Biodiversity Synthesis 2005*; World Resources Institute: Washington, DC, USA, 2005.
9. Mitra, A.; Mitra, A. Ecosystem services of mangroves: An overview. In *Mangrove Forests in India: Exploring Ecosystem Services*; Springer: Berlin/Heidelberg, Germany, 2020; pp. 1–32.
10. Nellemann, C.; Corcoran, E.; Duarte, C.M.; Valdés, L.; De Young, C.; Fonseca, L.; Grimsditch, G. *Blue Carbon: A Rapid Response Assessment, Blue Carbon*; United Nations Environment Programme, GRID-Arendal: Arendal, Norway, 2009; Volume 80.

11. Kauffman, J.B.; Adame, M.F.; Arifanti, V.B.; Schile-Beers, L.M.; Bernardino, A.F.; Bhomia, R.K.; Donato, D.C.; Feller, I.C.; Ferreira, T.O.; Garcia, M.C.J.; et al. Total ecosystem carbon stocks of mangroves across broad global environmental and physical gradients. *Ecol. Monogr.* **2020**, *90*, e01405. [CrossRef]
12. Macreadie, P.I.; Anton, A.; Raven, J.A.; Beaumont, N.; Connolly, R.M.; Friess, D.A.; Kelleway, J.J.; Kennedy, H.; Kuwae, T.; Lavery, P.S.; et al. The future of Blue Carbon science. *Nat. Commun.* **2019**, *10*, 3998. [CrossRef] [PubMed]
13. Cummings, A.R.; Shah, M. Mangroves in the global climate and environmental mix. *Geogr. Compass* **2017**, *12*, e12353. [CrossRef]
14. Bouillon, E. Carbon cycle: Storage beneath mangroves. *Nat. Geosci.* **2011**, *4*, 282–283. [CrossRef]
15. Das, S.C.; Das, S.; Tah, J. Mangrove Forests and People's Livelihoods. In *Mangroves: Biodiversity, Livelihoods and Conservation*; Das, S.C., Pullaiah, T., Ashton, E.C., Eds.; Springer Nature: Singapore, 2022; pp. 153–173.
16. Akram, H.; Hussain, S.; Mazumdar, P.; Chua, K.O.; Butt, T.E.; Harikrishna, J.A. Mangrove Health: A Review of Functions, Threats, and Challenges Associated with Mangrove Management Practices. *Forests* **2023**, *14*, 1698. [CrossRef]
17. Friess, D.A.; Yando, E.S.; Alemu, J.B.; Wong, L.W.; Soto, S.D. Ecosystem services and disservices of mangrove forests and salt marshes. In *Oceanography and Marine Biology*; CRC Press: Boca Raton, FL, USA, 2020.
18. Come, J.; Peer, N.; Nhamussua, J.L.; Miranda, N.A.; Macamo, C.C.; Cabral, A.S.; Madivadua, H.; Zacarias, D.; Narciso, J.; Snow, B. A socio-ecological survey in Inhambane Bay mangrove ecosystems: Biodiversity, livelihoods, and conservation. *Ocean Coast. Manag.* **2023**, *244*, 106813. [CrossRef]
19. Gomez, R.G.; Baldago, R.M. Peoples' Resource Utilization of Mangroves and Their Awareness to Its Environmental Importance. *J. Educ. Khon Kaen Univ.* **2016**, *39*, 35–45.
20. Portorreal, Y.C.; Montero, O.P. Evaluación de impactos a la salud del manglar en el municipio Guamá, Santiago de Cuba, Cuba. *Madera Bosques* **2017**, *23*, 27–41. [CrossRef]
21. Alati, V.M.; Olunga, J.; Olendo, M.; Daudi, L.N.; Osuka, K.; Odoli, C.; Tuda, P.; Nordlund, L.M. Mollusc shell fisheries in coastal Kenya: Local ecological knowledge reveals overfishing. *Ocean Coast. Manag.* **2020**, *195*, 17. [CrossRef]
22. Zu Ermgassen, P.S.; Mukherjee, N.; Worthington, T.A.; Acosta, A.; da Rocha Araujo, A.R.; Beitl, C.M.; Castellanos-Galindo, G.A.; Cunha-Lignon, M.; Dahdouh-Guebas, F.; Diele, K.; et al. Fishers who rely on mangroves: Modelling and mapping the global intensity of mangrove-associated fisheries. *Estuar. Coast. Shelf Sci.* **2021**, *248*, 106975. [CrossRef]
23. Goldberg, L.; Lagomasino, D.; Thomas, N.; Fatoyinbo, T. Global declines in human-driven mangrove loss. *Glob. Change Biol.* **2020**, *26*, 5844–5855. [CrossRef]
24. Portorreal, Y.C.; Dominguez, O.J.R.; Cuker, B.; Milanes, C.B.; Montero, O.P. Environmental policy and regulatory framework for managing mangroves as a carbon sink in Cuba. *Water* **2022**, *14*, 3903. [CrossRef]
25. RMunang, T.; Thiaw, I.; Rivington, M. Ecosystem management: Tomorrow's approach to enhancing food security under a changing climate. *Sustainability* **2011**, *3*, 937–954. [CrossRef]
26. Polidoro, B.A.; Carpenter, K.E.; Collins, L.; Duke, N.C.; Ellison, A.M.; Ellison, J.C.; Farnsworth, E.J.; Fernando, E.S.; Kathiresan, K.; Koedam, N.E.; et al. The Loss of Species: Mangrove Extinction Risk and Geographic Areas of Global Concern. *PLoS ONE* **2010**, *5*, 10. [CrossRef] [PubMed]
27. Satyanarayana, B.; Bhanderi, P.; Debry, M.; Maniatis, D.; Foré, F.; Badgie, D.; Jammeh, K.; Vanwing, T.; Farcy, C.; Koedam, N.; et al. A Socio-Ecological Assessment Aiming at Improved Forest Resource Management and Sustainable Ecotourism Development in the Mangroves of Tanbi Wetland National Park, The Gambia, West Africa. *Ambio* **2012**, *41*, 513–526. [CrossRef]
28. Friess, D.A.; Yando, E.S.; Abuchahla, G.M.O.; Adams, J.B.; Cannicci, S.; Canty, S.W.J.; Cavanaugh, K.C.; Connolly, R.M.; Cormier, N.; Diele, K.; et al. Conservation optimism, for now. *Curr. Biol.* **2020**, *30*, R153–R154. [CrossRef] [PubMed]
29. Dahdouh-Guebas, F.; Ajonina, G.N.; Amir, A.A.; Andradi-Brown, D.A.; Aziz, I.; Balke, T.; Barbier, E.B.; Cannicci, S.; Cragg, S.M.; Cunha-Lignon, M.; et al. Public Perceptions of Mangrove Forests Matter for Their Conservation. *Front. Mar. Sci.* **2020**, *7*, 603651. [CrossRef]
30. Nguyen, H.; Harper, R.J.; Dell, B. Examining local community understanding of mangrove carbon mitigation: A case study from Ca Mau province, Mekong River Delta, Vietnam. *Mar. Policy* **2023**, *148*, 10. [CrossRef]
31. Nyangoko, B.P.; Berg, H.; Mangora, M.M.; Gullström, M.; Shalli, M.S. Community Perceptions of Mangrove Ecosystem Services and Their Determinants in the Rufiji Delta, Tanzania. *Sustainability* **2021**, *13*, 63. [CrossRef]
32. Quevedo, J.M.D.; Uchiyama, Y.; Kohsaka, R. Perceptions of local communities on mangrove forests, their services and management: Implications for Eco-DRR and blue carbon management for Eastern Samar, Philippines. *J. For. Res.* **2020**, *25*, 12. [CrossRef]
33. Martín-López, B.; Iniesta-Arandia, I.; García-Llorente, M.; Palomo, I.; Casado-Arzuaga, I.; Amo, D.G.; Gómez-Baggethun, E.; Oteros-Rozas, E.; Palacios-Agundez, I.; Willaarts, B.; et al. Uncovering Ecosystem Service Bundles through Social Preferences. *PLoS ONE* **2012**, *7*, e38970. [CrossRef] [PubMed]
34. Bimrah, K.; Dasgupta, R.; Hashimoto, S.; Saizen, I.; Dhyani, S. Ecosystem Services of Mangroves: A Systematic Review and Synthesis of Contemporary Scientific Literature. *Sustainability* **2022**, *14*, 12051. [CrossRef]
35. Turschwell, M.P.; Tulloch, V.J.D.; Sievers, M.; Pearson, R.M.; Andradi-brown, D.A.; Ahmadia, G.N.; Connolly, R.M.; Bryan-Brown, D.; Lopez-Marcano, S.; Adame, M.F.; et al. Multi-scale estimation of the effects of pressures and drivers on mangrove forest loss globally. *Biol. Conserv.* **2020**, *247*, 11. [CrossRef]
36. Rodríguez-Crespo, G.C.; Domínguez-Junco, O. Servicios ecosistémicos en manglares: Beneficios a: Resiliencia del ecosistema ante cambios climáticos, la comunidad y su desarrollo local. *Rev. Transdiscipl. Estud. Soc. Tecnol.* **2022**, *2*, 5–10. [CrossRef]

37. Mahardika SM, A.; Yulianda, F.; Adrianto, L. Interactive Governance for Mangrove Social-Ecological System in Tangerang Regency: A DPSIR Approach. *Int. J. Adv. Sci. Eng. Inf. Technol.* **2023**, *13*, 1249–1257. [CrossRef]
38. Gayo, L. Local community perception on the State Governance of mangroves in Western Indian coast of Kinondoni and Bagamoyo, Tanzania. *Glob. Ecol. Conserv.* **2022**, *39*, 11. [CrossRef]
39. Ahmed, J.; Kathambi, B.; Kibugi, R. Policy perspective on governance standards setting using community participation for sustainable mangrove management in Lamu Kenya. *Int. J. Conserv. Sci.* **2023**, *14*, 315–326. [CrossRef]
40. Bunting, P.; Rosenqvist, A.; Hilarides, L.; Lucas, R.M.; Thomas, N.; Tadono, T.; Worthington, T.A.; Spalding, M.; Murray, N.J.; Rebelo, L.-M. Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. *Remote Sens.* **2022**, *14*, 3657. [CrossRef]
41. Valderrama, S.P.; Ávila, A.H.; Méndez, J.G.; Martínez, O.M.; Rojas, D.C.; Azcona, H.F.; Hernández, E.M.; Aragón, H.C.; Alcolado, P.M.; Pina-Amargós, F.; et al. Marine protected areas in Cuba. *Bull. Mar. Sci.* **2018**, *94*, 423–442. [CrossRef]
42. García, M.A.V.; González, B.A. Manglar vivo en cuba: Costos y beneficios de las acciones basadas en ecosistemas. Análisis económico-ecológico en las provincias Sur Artemisa y Mayabeque. *Rev. Iberoam. Econ. Ecol.* **2021**, *34*, 86–110.
43. Ferro-Azcona, H.; Espinoza-Tenorio, A.; Calderón-Contreras, R.; Ramenzoni, V.; País, M.G.; Mesa-Jurado, M. Adaptive capacity and social-ecological resilience of coastal areas: A systematic review. *Ocean Coast. Manag.* **2019**, *173*, 36–51. [CrossRef]
44. Perera-Valderrama, S.; Hernández-Ávila, A.; Ferro-Azcona, H.; Cobián-Rojas, D.; González-Méndez, J.; Caballero-Aragón, H.; de la Guardia-Llansó, E.; Ramón-Puebla, A.; Hernández-González, Z.; Espinosa-Pantoja, L.; et al. Increasing marine ecosystems conservation linking marine protected areas and integrated coastal management in southern Cuba. *Ocean. Coast. Manag.* **2020**, *196*, 11. [CrossRef]
45. CITMA. *Estrategia Ambiental Nacional 2021–2025*; CITMA: La Habana, Cuba, 2021; p. 44.
46. Spalding, M.D.; Fox, H.E.; Allen, G.R.; Davidson, N.; Ferdaña, Z.A.; Finlayson, M.; Halpern, B.S.; Jorge, M.A.; Al Lombana, S.A.L.; Martin, K.D.; et al. Marine Ecoregions of the World: A Bioregionalization of Coastal and Shelf Areas. *BioScience* **2007**, *57*, 573–583. [CrossRef]
47. Menéndez, L. The Mangrove Ecosystem in the Cuban Archipelago: Bases for Its Management. Ph.D. Thesis, University of Alicante, San Vicente del Raspeig, Spain, 2013.
48. Martínez Quesada, E. Relación entre morfología foliar de antófitos y factores abióticos en las principales pluvisilvas de la Región Oriental cubana. *Rev. Biol. Trop.* **2009**, *57*, 235–256. [CrossRef]
49. Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B. World map of the Köppen-Geiger climate classification. *Meteorologische Zeitschrift* **2006**, *15*, 59–263. [CrossRef] [PubMed]
50. Reyes, O.J.; Acosta-Cantillo, F. Principales fitocenosis en el humedal del delta del río Cauto, Cuba Oriental. I. Vegetación lacustre y herbazal de humedal. *For. Veracruzana* **2007**, *9*, 15–22.
51. Alonso-Tabet, M.; López-Salcedo, M.; Olano-Labrada, R.; Alarcón Jorge, Y.; Gil Rivero, A.; Alonso Jiménez, Y.; Egard Tamayo, D.; Rodríguez González, O.; Borrero Nieves, Y. *Plan de Manejo 2021–2025 Refugio de Fauna Ojo de Agua-Monte Cabaniguán*; Empresa Flora y Fauna Las Tunas: Las Tunas, Cuba, 2021; Unpublished work.
52. González-Rivera, D.; Manet-Bombú, I.; Aroche-Rodríguez, M.; Frómeta-Barrera, A.; Rodriguez-Munivel, I.; Leiva Cueto, A. *Management Plan 2021–2025 Hatibonico Ecological Reserve*; Unidad de Medio Ambiente-CITMA-Guantánamo: Guantánamo, Cuba, 2021; Unpublished work.
53. Fernández-Rodríguez, I.L.; Hechavarria, S.L.; Mestril Cosme, K.; Bouza Alonso, J.A.; Debros Trutié, Y. *Plan de Manejo Refugio de Fauna San Miguel de Parada 2021–2025*; Empresa Flora y Fauna Santiago de Cuba: Santiago de Cuba, Cuba, 2021; Unpublished work.
54. Cabrera-Díaz, J.P.; Naranjo-Peña, L.A. Estudio de vulnerabilidad de paisajes para la gestión ambiental del área protegida Reserva Ecológica Monte Cabaniguán-Ojo del Agua del municipio Jobabo, Las Tunas. *Estud. Desarro. Soc. Cuba. Am. Lat.* **2019**, *7*, 172–181.
55. Ferrera Bergues, W.V.; Pérez Montero, O.; Soler Nariño, O. Población y vulnerabilidad social ante los efectos del cambio climático en el municipio costero de Guamá. *Noved. Población* **2020**, *16*, 190–217. Available online: http://www.novpob.uh.cu (accessed on 10 February 2024).
56. Pérez, O.; Carbonero, M.A.; Poveda, I.; Gómez, M.; Oliver, M.A. Cuando la mujer migra. Una mirada a las migraciones internas, desde la perspectiva del desarrollo sostenible, en el municipio costero de Guamá, Santiago de Cuba. *Noved. Población* **2018**, *28*, 1–9.
57. Lara, S.C.; Núñez, E.G. Reflexiones desde la relación población-vulnerabilidad en el municipio Guamá, Santiago de Cuba Reflections on the relationship population-vulnerability in the Municipality Guamá, Santiago de Cuba. *Noved. Población* **2020**, *16*, 31–44.
58. Milanés, B.C.; Pérez, M.O. Ordenamiento y Manejo Integrado de la Zona Costera Frente a los Riesgos del Cambio Climático en la Región Suroriental de Cuba. Available online: http://www.revistaccuba.cu/index.php/revacc/article/view/572 (accessed on 10 February 2024).
59. González Rivera, D. Conservación de *Leptocereus nudiflorus* en la Reserva Ecológica Hatibonico, Guantánamo. *Bissea* **2023**, *15*, 1.
60. Manet-Bombus, I.; Barroso-Frometa, L.; González-Rivera, D.; Pérez-Trejo, H.M.; Begué-Quiala, G. Caracterización de la biodiversidad de especies florísticas en la Reserva Ecológica Hatibonico. *Hombre Ciencia y Tecnología* **2020**, *24*, 31–39.
61. RSampieri, H.; Collado, C.F.; Lucio, M.D.P.B. *Metodología de la Investigación*; Mcgraw-Hill: Mexico City, Mexico, 2014; p. 634. ISBN 978-1-4562-2396-0.
62. Quevedo, J.M.D.; Uchiyama, Y.; Kohsaka, R. Local perceptions of blue carbon ecosystem infrastructures in Panay Island, Philippines. *Coast. Eng. J.* **2021**, *63*, 227–247. [CrossRef]

63. Dahdouh-Guebas, F.; Collin, S.; Lo Seen, D.; Rönnbäck, P.; Depommier, D.; Ravishankar, T. Analysing ethnobotanical and fishery-related importance of mangroves of the East-Godavari Delta (Andhra Pradesh, India) for conservation and management purposes. *J. Ethnobiol. Ethnomed.* **2006**, *2*, 24. [CrossRef] [PubMed]
64. Mohamed, M.K.; Adam, E.; Jackson, C. MAssessing the Perception and Contribution of Mangrove Ecosystem Services to the Well-Being of Coastal Communities of Chwaka and Menai Bays, Zanzibar. *Resources* **2024**, *13*, 23. [CrossRef]
65. Asante, F.; Huge, J.; Asare, N.K.; Dahdouh-Guebas, F. Does mangrove vegetation structure reflect human utilisation of ecosystem goods and services? *iScience* **2023**, *26*, 6. [CrossRef]
66. Krkač, K. Stakeholder Mapping. In *Encyclopedia of Sustainable Management*; Idowu, S., Schmidpeter, R., Capaldi, N., Zu, L., Del Baldo, M., Abreu, R., Eds.; Springer: Cham, Switzerland, 2022. [CrossRef]
67. Oficina Nacional de Estadísticas e Información (ONEI). *Anuario Estadístico de Cuba. Capítulo 1: Territorio*; Oficina Nacional de Estadísticas e información República de Cuba: La Habana, Cuba, 2021; p. 15.
68. Worthington, A.; Ermgassen, P.S.E.; Friess, D.A.; Krauss, K.W.; Lovelock, C.E.; Thorley, J.; Tingey, R.; Woodroffe, C.D.; Bunting, P.; Cormier, N.; et al. A global biophysical typology of mangroves and its relevance for ecosystem structure and deforestation. *Sci. Rep.* **2020**, *10*, 14652. [CrossRef] [PubMed]
69. Soto, H. *Priorización de los ODS en Cuba: Articulación de la Agenda 2030 con el Plan Nacional de Desarrollo e Identificación de prioridades de Desarrollo sostenible. Sede Subregional de la CEPAL en México (Estudios e Investigaciones) 49071*; Ciudad de México, México, 2023; 164p.
70. Ley 85 "Ley Forestal". Gaceta Oficial de la República de Cuba. Edición Ordinaria Número No. 46: 773. 1998. Available online: https://www.gacetaoficial.gob.cu/ (accessed on 21 January 2024).
71. Uddin, M.S.; Shah, M.A.R.; Khanom, S.; Nesha, M.K. Climate change impacts on the Sundarbans mangrove ecosystem services and dependent livelihoods in Bangladesh. *Asian J. Conserv. Biol.* **2013**, *2*, 152–156.
72. Souza, L.D.; Rossi, S.; Calvet-Mir, L.; Ruiz-Mallén, I.; García-Betorz, S.; Salvà-prat, J.; Jeovah, A.; Meireles, D.A. Neglected ecosystem services: Highlighting the socio-cultural perception of mangroves in decision-making processes. *Ecosyst. Serv.* **2017**, *26*, 137–145.
73. Reyes-Arroyo, N.; Camacho-Valdez, V.; Saenz-Arroyo, A. Socio-cultural analysis of ecosystem services provided by mangroves in La Encrucijada Biosphere Reserve, southeastern Mexico. *Local Environ.* **2021**, *26*, 86–109. [CrossRef]
74. Afonso, F.; Félix, P.M.; Chainho, P.; Heumüller, J.A.; de Lima, R.F.; Ribeiro, F. Community perceptions about mangrove ecosystem services and threats. *Reg. Stud. Mar. Sci.* **2022**, *49*, 102114. [CrossRef]
75. Mallick, B.; Priodarshini, R.; Kimengsi, J.N.; Biswas, B.; Hausmann, A.E.; Islam, S.; Huq, S.; Vogt, J. Livelihoods dependence on mangrove ecosystems: Empirical evidence from the Sundarbans. *Curr. Res. Environ. Sustain.* **2021**, *3*, 100077. [CrossRef]
76. Warren-Rhodes, K.; Schwarz, A.-M.; Boyle, L.N.; Albert, J.; Agalo, S.S.; Warren, R.; Bana, A.; Paul, C.; Kodosiku, R.; Bosma, W. Mangrove ecosystem services and the potential for carbon revenue programs in the Solomon Islands. *Environ. Conserv.* **2011**, *38*, 485–496. [CrossRef]
77. Song, A.M.; Dressler, W.H.; Satizábal, P.; Fabinyi, M. From conversion to conservation to carbon: The changing policy discourse on mangrove governance and use in the Philippines. *J. Rural. Stud.* **2021**, *82*, 184–195. [CrossRef]
78. Chircop, A. Local Integrated Coastal Zone Management in Cuba (COSTASURESTE Project); S06499; Report to the Department of Foreign Affairs. 2015. Available online: https://ssrn.com/abstract=2757073 (accessed on 10 February 2024).
79. Golebie, E.J.; Aczel, M.; Bukoski, J.J.; Chau, S.; Ramirez-Bullon, N.; Gong, M.; Teller, N. A qualitative systematic review of governance principles for mangrove conservation. *Conserv. Biol.* **2021**, *36*, e13850. [CrossRef]
80. Walker, J.E.; Ankersen, T.; Barchiesi, S.; Meyer, C.K.; Altieri, A.H.; Osborne, T.Z.; Angelini, C. Governance and the mangrove commons: Advancing the cross-scale, nested framework for the global conservation and wise use of mangroves. *J. Environ. Manag.* **2022**, *312*, 114823. [CrossRef] [PubMed]
81. Alongi, D.M. Responses of mangrove ecosystems to climate change in the Anthropocene. In *Mangroves: Ecology, Biodiversity and Management*; Rastogi, R.P., Phulwaria, M., Gupta, D.K., Eds.; Springer: Berlin/Heidelberg, Germany, 2021; pp. 201–224.
82. Iturralde-Vinent, M.; Méndez, H.S. *Peligros y Vulnerabilidades de la Zona Marino-Costera de Cuba: Estado Actual y Perspectivas ante el Cambio Climático Hasta el 2100*; Editorial Academia: La Habana, Cuba, 2015; p. 86. ISBN 978-959-270-338-4.
83. Krauss, K.W.; Osland, M.J. Tropical cyclones and the organization of mangrove forests: A review. *Ann. Bot.* **2020**, *125*, 213–234. [CrossRef] [PubMed]
84. Kissinger, G.; Herold, M.; De Sy, V. *Drivers of Deforestation and Forest Degradation: A Synthesis Report for EDD+ Policymakers*; Lexeme Consulting: Vancouver, BC, Canada, 2012.
85. Madhav, S.; Nazneen, S.; Singh, P. *Coastal Ecosystems Environmental Importance, Current Challenges, and Conservation Measures*; Springer Nature AG: Cham, Switzerland, 2022; p. 392.
86. Friess, D.A.; Adame, M.F.; Adams, J.B.; Lovelock, C.E. Mangrove Forests under Climate Change in a 2 °C World. *Wiley Interdiscip. Rev. Clim. Change* **2022**, *13*, e792. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.