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Assessing the economic value of a seagrass ecosystem in Southern Cebu, Philippines

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Department of Pure Sciences, Cebu Technological University. M. J. Cuenco Ave. cor. R. Palma St., Cebu 6000, Philippines. Tel.: +63-32-4024060, Fax.: +63-32-4166706, ♥email: anne.lorca@ctu.edu.ph

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Abstract. *Inocentes JAB, Escalante KD, Ginoo AI, Prado GT, Uy GML, Justol AE, Fernandez JL, Gacang JO, Lacorte CD, Cortes ST, Retubado ZAZ, Lorca AS, Almagro JJN. 2025. Assessing the economic value of a seagrass ecosystem in Southern Cebu, Philippines. Biodiversitas 26: 1898-1912.* Seagrass meadows are critical habitats that support marine biodiversity, enhance coastal protection, and serve as nurseries for various fish species, which are the foundation for local fisheries and tourism. By assigning a monetary value to these resources, we can better implement conservation efforts that safeguard and ensure their sustainability. In this regard, this study investigates the economic valuation of the seagrass ecosystem in Argao, Cebu, Philippines, a coastal municipality rich in marine biodiversity and dependent on fishing and ecotourism. We employ a mixed-methods approach, integrating surveys, interviews, and observations to collect data from stakeholders, including fishers, tourists, and local officials from ten coastal barangays. The economic assessment employs the Total Economic Value (TEV) framework, encompassing direct uses like fisheries and tourism, indirect benefits such as coastal protection and carbon sequestration, and non-use values, including bequest and existence values. Through a comprehensive assessment of the ecosystem services provided by seagrass beds, the findings highlight the critical role of Marine Protected Areas (MPAs) in Argao, which include ten key areas essential for marine life. The study reveals that the total economic value of the seagrass ecosystem is ₱56,299,100.61 (USD 960,080.16). The findings aim to offer a holistic understanding of the seagrass ecosystem's contribution to local livelihoods and global ecological services, thereby informing sustainable management and conservation strategies. The study also identifies key challenges, such as temporal data limitations and complexities in estimating non-market values, but it also underscores the potential for further research to address both ecological and social dimensions fully, offering hope for the future.

Keywords: Conservation, ecosystem services, economic valuation, seagrass ecosystem

INTRODUCTION

Tropical marine habitats, such as coral reefs, mangrove forests, and seagrass meadows, are among the most biologically diverse and productive ecosystems on Earth (Earp et al. 2018). Seagrass ecosystems, in particular, which thrive in the shallow coastal seas around the globe, are crucial for preserving ecological health and economic vitality (Sondak and Kaligis 2022). These underwater meadows, composed of flowering plants with long, thin leaves and robust rhizomes, anchor themselves securely to the seabed (Erniati et al. 2023). They play an indispensable role in sustaining marine biodiversity, maintaining coastlines, and supporting local economies through fisheries and tourism (Dunic et al. 2021). In the municipality of Argao, located in Southern Cebu, Philippines, seagrass beds flourish within ten designated Marine Protected Areas (MPAs): Poblacion, Langtad, Bogo, Tulic, Binlod, Bulasa, Casay, Talaga, Guiwanon, and Taloot. These areas are essential for supporting marine life and strengthening community resilience. Seagrasses make significant contributions to both environmental health and economic sustainability. By boosting fish production, stabilizing coastlines, and aiding in carbon sequestration (Dewsbury et al. 2016), these plants provide vital nursery sites for numerous marine species, directly benefiting fishing communities. Additionally, seagrass meadows attract tourists who engage in diving and snorkeling, thereby bolstering local tourism (Dunic et al. 2021). Barbier et al. (2011) highlighted the protective role of seagrasses, which act as natural barriers against coastal erosion by dispersing wave energy, thereby enhancing the economic resilience of coastal communities.

Despite their immense benefits, seagrass ecosystems face significant vulnerabilities. According to recent studies, seagrass meadows continue to decline globally at an alarming rate, with significant losses attributed to coastal development, climate change, and pollution (Dunic et al. 2021). Seagrass meadows are diminishing globally at an alarming rate of 7% per year (Waycott et al. 2009). In the Philippines, land reclamation and water pollution have a severe impact on these habitats, endangering both biodiversity and the economic activities that rely on them (Unsworth et al. 2018). These losses underscore the urgent need for effective conservation initiatives and sustainable management practices. In response to these concerns, various conservation programs have been established in the Philippines. These include the creation of Marine Protected Areas (MPAs), the implementation of community-based coastal resource management, numerous seagrass restoration programs, and even the valuation of seagrass (Fortes et al. 2018). Seagrass valuation, which assesses the economic and ecological benefits of these ecosystems, is a crucial tool for conservation efforts. This valuation underscores the significance of seagrass meadows and informs conservation planning by highlighting their economic contributions. For example, evaluating the economic impact of seagrasses in Argao involves assessing their benefits to fisheries, tourism, and coastal conservation. By analyzing these advantages, policymakers can make more informed decisions regarding resource allocation and conservation strategies (de Groot et al. 2018).

Understanding the economic importance of seagrass is vital for its effective protection and sustainable management (Amone-Mabuto et al. 2023). This research aims to provide a comprehensive economic evaluation of Argao's seagrass meadows, focusing on their ecological and economic significance. Although Argao boasts abundant seagrass resources, studies addressing their valuation are limited. This study seeks to bridge this gap by meticulously assessing the economic impacts of these ecosystems on the local community. In Argao, a coastal municipality in Cebu, the fishing sector is a primary livelihood source (National Statistics Office 2012). Despite the region's rich seagrass resources, an extensive valuation study has not yet been conducted. Although the municipality has established numerous MPAs, the valuation and assessment of seagrasses have not received adequate attention. This research aims to identify the current challenges faced in Argao, establish clear research objectives, and demonstrate how this study can promote the conservation of seagrass meadows. By providing valuable insights into the economic benefits of these ecosystems, this study intends to contribute to the sustainable management and protection of these vital habitats for future generations. The study also seeks to address the gaps in existing research by employing advanced methodologies to quantify the economic value of seagrass ecosystems, thereby providing a robust foundation for future conservation efforts. Furthermore, it aims to engage local communities in the conservation process, fostering a sense of ownership and responsibility towards these critical ecosystems. Through scientific research and community involvement, this study aspires to create a sustainable model for seagrass conservation that can be replicated in other regions facing similar challenges. Ultimately, the findings of this research will not only enhance our understanding of the economic and ecological value of seagrass ecosystems but also provide actionable insights for policymakers, conservationists, and local communities to ensure the long-term preservation of these vital marine habitats.

MATERIALS AND METHODS

Study area

The study was conducted at Argao, a coastal municipality located in the southern part of Cebu, Philippines (Figure 1). Argao covers a land area of 191.50 km^2 (73.94 square miles), which constitutes approximately 3.87% of Cebu's total area. Geographically, it is situated at 9.99326° N and 123.5504° E. According to the 2020 Census, Argao has a population of 78,187, representing approximately 2.35% of Cebu Province's total population and 0.97% of the Central Visayas Region's overall population. This results in a population density of 408 inhabitants per square kilometer (1,057 inhabitants per square mile) (PhilAtlas 2023). Argao is characterized by its rich marine biodiversity and extensive seagrass beds. The municipality is home to ten Marine Protected Areas (MPAs), which are crucial for conservation efforts (Isok and Isok 2023). Table 1 shows the 10 MPAs with their corresponding coordinates.

Table 1. Location of the marine protected areas in Argao, Cebu, Philippines

Marine protected area	Decription	Location
Poblacion	Near the town center, this MPA combines conservation with mild tourism and is used for environmental education.	9.8747°N, 123.6081°E
Langtad	It features coral-rich zones and seagrass beds that support diverse marine life, and community-based enforcement helps protect the area.	9.890618°N, 123.606331°E
Bogo	The area is known for its clear waters and healthy coral patches, and it is occasionally visited by dolphins and sea turtles.	9.858424°N, 123.573708°E
Tulic	The MPA focuses on protecting reef fish populations and is enforced by the local *Bantay Dagat*.	9.869062°N, 123.585554°E
Binlod	It is a small but thriving MPA with coral restoration projects and is popular among local researchers for biodiversity monitoring.	9.912535°N, 123.608094°E
Bulasa	Originally established to combat overfishing, it is now a model for community-led marine conservation.	9.93457°N, 123.619713°E
Casay	It is one of Argao's most scenic MPAs, featuring vibrant coral cover and offering tourist-friendly snorkeling opportunities.	9.823333°N, 123.563333°E
Talaga	The area features a mix of coral reefs and sandy habitats and is a key spot for local fishers due to fish spillover effects.	9.849138°N, 123.566868°E
Guiwanon	It is a well-managed MPA with mangrove rehabilitation efforts, serving both as a fish nursery and an ecotourism site.	9.961718°N, 123.619515°E
Taloot	It protects a mix of mangroves and coral reefs, acting as a buffer zone against coastal erosion.	9.953734°N 123.618875°E

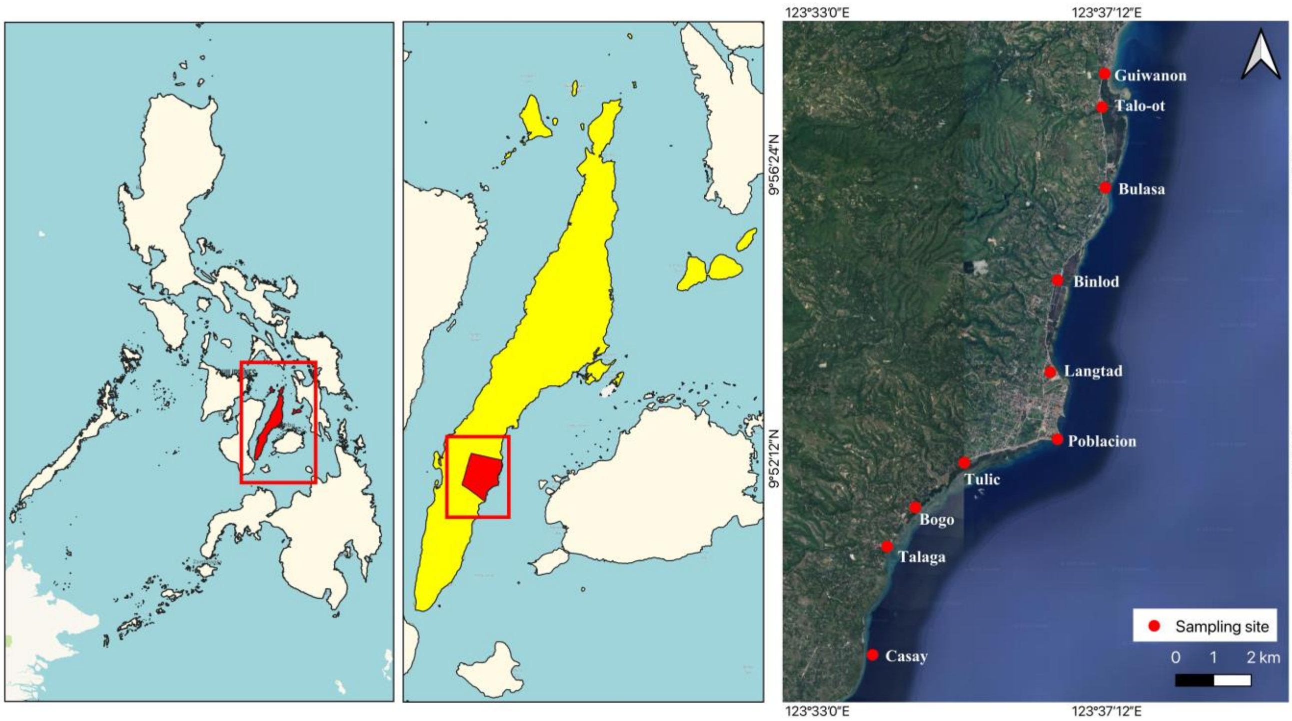

Figure 1. Map of Argao, Cebu, Philippines, the 10 coastal barangay sampling sites (Casay, Bogo, Talaga, Tulic, Poblacion, Langtad, Binlod, Bulasa, Talo-ot, and Guiwanon), and the estimated total area of seagrass bed

Figure 2. Seagrass bed in Argao, Cebu, Philippines

Data collection

The coastal area of Argao encompasses approximately 604 hectares of seagrass beds composed solely of *Enhalus acoroides* (Figure 2), which are vital to the local ecosystem. Updated information on resource users and operators of tourism-related businesses was obtained from the Municipal Local Government Units (MLGUs) and barangay offices. Key insights into the primary economic uses of seagrasses, along with associated environmental and socio-economic issues, were identified through interviews with key informants from various local government offices and provincial agencies. However, some data were limited due to incomplete records. Then, to ensure a representative sample, surveys were conducted using snowball sampling, targeting 451 respondents, to ensure representation across various community segments, including fishermen, gleaners, and tourism operators. This approach allowed us to capture a rich tapestry of diverse perspectives and experiences related to seagrass utilization, making this research truly inclusive. All respondents were randomly selected regardless of age, gender, place of origin, or fishing equipment (Wallner-Hahn et al. 2022). In addition to primary data collected from interviews lasting 10-15 minutes using a pre-tested survey questionnaire, secondary data were gathered from government reports and academic studies.

The area is vital for local communities that depend on fishing and tourism for their livelihoods. The seagrass ecosystem provides essential services, including habitat for juvenile fish, carbon storage, and shoreline stabilization. Therefore, assessing the economic value of these ecosystems is imperative for both environmental conservation and community sustainability.

Seagrass ecosystem valuation

The annual net benefits derived from the seagrass ecosystem encompass all net benefits from both use and non-use values (Figure 3). These annual net benefits were calculated using the Total Economic Value (TEV) framework as outlined by Spurgeon (1992). TEV, or total economic value, is a combined evaluation of the value that an ecosystem offers a local community based on its functions and represented by the formula:

$$TEV = Use\ Value + Non\ Use\ Value = (DUV + IUV + OV) + (XV + BV)$$

DUV stands for Direct Use Value, IUV represents Indirect Use Value, OV is the Option Value, XV denotes Existence Value, and BV signifies Bequest Value.

Direct uses

Direct use values of seagrass ecosystems encompass the tangible benefits that arise from their exploitation and interaction with human activities, primarily in fisheries and ecotourism. These values hold substantial economic significance in regions where seagrass is plentiful and are classified into two primary categories: extractive and non-extractive. Extractive values encompass the net revenues generated from fisheries, which are assessed using market valuation techniques that estimate earnings based on the market prices of products derived from the seagrass ecosystem (Praisankul and Nabangchang-Srisawalak 2017). In contrast, non-extractive values stem from tourism-related activities such as snorkeling, skimboarding, diving, and boating. The economic benefits associated with these non-consumptive activities accrue to business operators in the tourism sector. Additionally, values related to education and research are calculated based on expenditures for similar studies conducted in the field.

Seagrass ecosystems provide numerous direct benefits to humans, one of the most significant being their role as nursery grounds and feeding habitats for commercially important fish species. The economic value of this service can be estimated using techniques such as Catch Per Unit Effort (CPUE) and production function analysis, which link seagrass abundance to fish productivity and market value (Unsworth et al. 2019). Furthermore, seagrass species possess ethnobotanical value, being utilized in traditional medicines for their therapeutic properties. The economic value of this use can be assessed through replacement cost and market valuation methods, which estimate the cost of replacing seagrass-based remedies with synthetic alternatives or their market value (Unsworth et al. 2018).

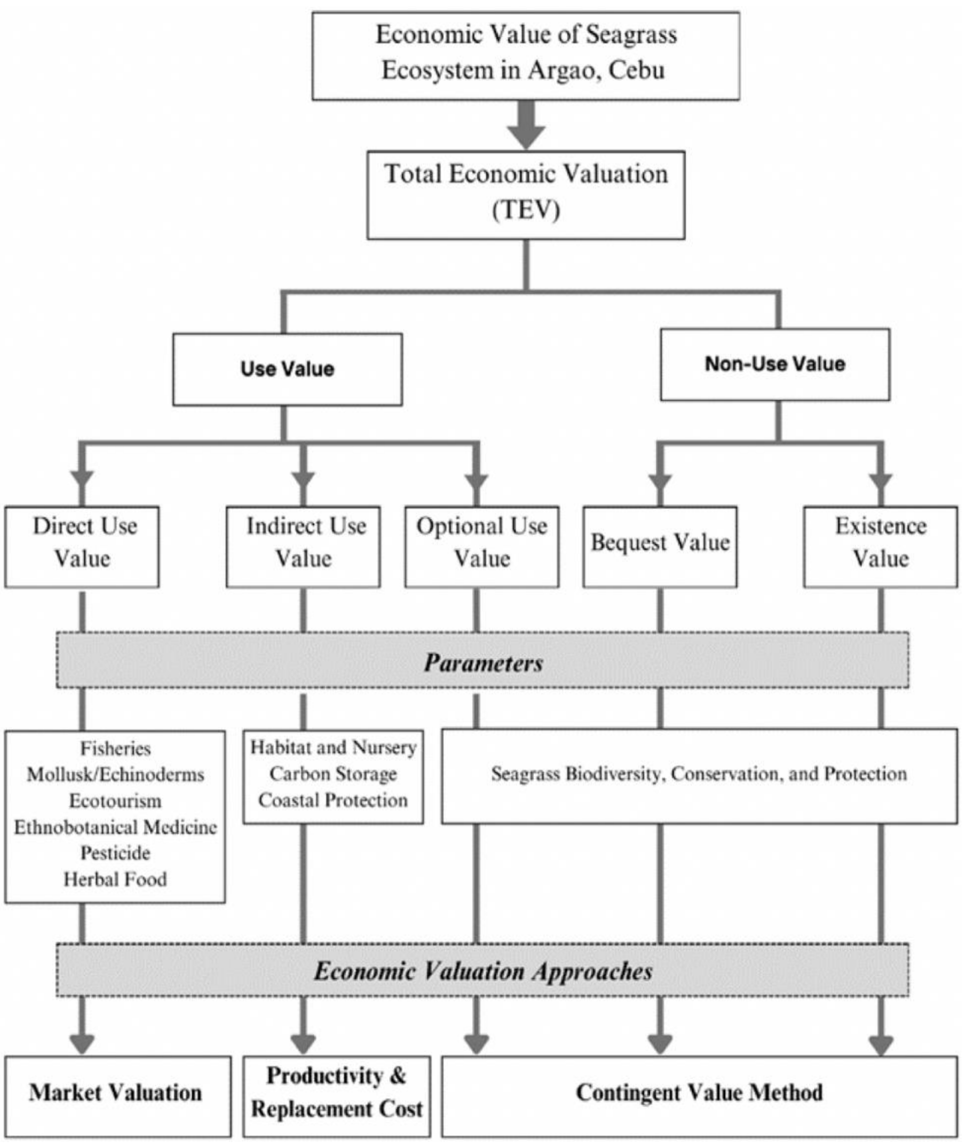

Figure 3. Total economic valuation framework of the seagrass ecosystem in Argao, Cebu, Philippines

In addition to these uses, seagrasses can be processed into insulating materials and bio-composite products. They are also harvested for use as mulch and organic fertilizer, which enhances agricultural productivity. This service can similarly be valued using replacement cost and market valuation methods to estimate the cost of replacing seagrass-based fertilizers with synthetic alternatives or their market price (Fourqurean et al. 2012). Seagrass meadows attract divers and snorkelers, making a significant contribution to ecotourism. The economic value of this service can be estimated using the Travel Cost Method (TCM) and the Contingent Valuation Method (CVM), which assesses visitors' willingness to pay for the opportunity to experience these ecosystems (Dunic et al. 2021). Data on costs and revenues were obtained through interviews with fishermen, gleaners, and tourism entrepreneurs, further contributing to the economic valuation of seagrass ecosystems.

The annual net benefits obtained from the seagrass ecosystem are computed from the following formulas. The Net Revenue (NR), Gross Revenue (GR), and Total production Cost (TC) are calculated, respectively:

$$NR = GR - TC$$
$$GR = QP$$
$$TC = VC + FC$$

Where, Q is the quantity produced, P is the price per unit, VC is the variable cost, and FC is the fixed cost.

Indirect uses

The Indirect use values of seagrass ecosystems encompass the essential ecological services they provide, such as habitats for marine life, nurseries, carbon storage, and coastal protection. In the Argao region, we assessed these indirect use values by examining their functional contributions, including nursery functions, coastal protection, and carbon sequestration. To estimate the net revenues derived from these services, two main approaches were employed: the productivity method and the replacement cost method. The Productivity Method evaluates the net value of seagrass ecosystems in providing coastal protection and nursery functions. According to Unsworth et al. (2014), the net value of seagrass areas as habitats and nurseries is typically calculated as 20% of the net landings from fisheries. Meanwhile, the Replacement Cost Method was utilized to estimate the monetary value of seagrasses' carbon storage and coastal protection functions. For instance, the value of seagrass carbon storage is determined by the market price of carbon, such as the cost per ton of CO_2. According to the IUCN report on blue carbon, seagrass biomass can store approximately 11 tons of CO_2 equivalent per hectare. In 2020, the price of carbon was around USD 15 per ton (Luckow et al. 2015). These methodologies highlight the significant economic contributions of seagrass ecosystems through their indirect use values, emphasizing their vital role in supporting marine biodiversity, mitigating climate change, and protecting coastal communities.

Non-use values

The Non-use values of ecosystems, including seagrass meadows, encompass option values, bequest values, and existence values, each capturing different aspects of the benefits derived from preserving these natural resources. The option value represents the potential for both direct and indirect future uses of ecosystems and their resources, underscoring their importance for future generations. This value is often tied to the public's Willingness to Pay (WTP) for preserving or utilizing these resources in the future, factoring in potential benefits from yet-to-be-discovered qualities, such as medicinal plants or marine organisms. Bequest value emphasizes the importance of conserving natural resources as a legacy for future generations, ensuring that these vital ecosystems remain intact and accessible. Existence value, also known as preservation value, reflects the intrinsic worth people place on knowing that a resource exists and is being protected. While it is sometimes categorized as a type of bequest or option value, existence value specifically pertains to the satisfaction derived from the continuous preservation of the resource (Palanca-Tan 2020).

Next, to evaluate the non-use value of the seagrass ecosystem in the municipality of Argao, the Contingent Valuation Method (CVM) was employed. This technique involves creating a hypothetical market where individuals can express their willingness to pay for the conservation or improvement of an ecosystem. The community was surveyed to determine their Willingness To Pay (WTP) for maintaining the seagrass ecosystem. The validity of these responses was assessed based on the socio-economic and demographic profiles of the respondents, as well as their annual willingness to pay for this purpose. A total of 435 respondents were selected from the fishermen and gleaners. They were presented with various monetary values (USD 0.34, USD 0.85, USD 1.70, USD 2.04, USD 2.56, or USD 3.41) and asked to choose their preferred amount. The WTP values indicated through these surveys were then used to estimate the average willingness to pay for the conservation of seagrass biodiversity, capturing its non-use values.

RESULTS AND DISCUSSION

Sociodemographic profile of the resource users and their perceived seagrass ecosystem services

A survey was conducted involving 451 resource users. Table 2 presents the distribution of resource users grouped by several sociodemographic profiles, comprising 280 fishermen, 155 gleaners, and 16 tourism and business operators who participated in the survey. The survey also reveals that resource users are typically in their forties to fifties, with many fishermen and gleaners having lived in their barangays for an average of 30 years, often from birth. The data indicates a gender divide in occupations, with 87% of those engaged in fishing being male, whereas 86% of gleaners are female.

Table 2. Socio-economic profile of the resource users in Argao, Cebu, Philippines

		Fishers N: 280	**Gleaners N: 155**	**Business operators N: 16**
Gender	Female	36	86	12
	Male	244	69	4
Age in years	% <10-20	5.04%	13.64%	0.00%
	% 20-40	35.71%	28.41%	12.50%
	% 40-60	48.74%	46.59%	75.00%
	% >60	10.50%	11.36%	12.50%
Civil status	% Single	26.89%	29.55%	12.50%
	% Married	39.92%	53.41%	56.25%
	% Living with partner	33.19%	17.05%	31.25%
Number of years living in the barangay	% <20-30	15.55%	40.91%	0.00%
	% 30-40	36.55%	30.68%	43.75%
	% 50-60	39.92%	25.00%	50.00%
	% >60	7.98%	3.41%	6.25%
Number of people living in the household	% 1-5	56.30%	67.05%	62.50%
	% 5-10	36.55%	30.68%	37.50%
	% >10	7.14%	2.27%	0.00%
Full-time occupation in marine-based activities	% Yes	7.56%	10.23%	87.50%
	% No	92.44	89.77%	12.50%
Member of an organization	% Yes	41.60%	2.58%	6.25%
	% No	58.40%	97.42%	93.75
Education	% Elementary level	41.60%	37.50%	12.50%
	% Secondary level	52.52%	42.05%	75.00%
	% Tertiary level	5.88%	20.45%	12.50%

The average household size among these resource users ranges from 1 to 5 members. Notably, a small percentage of fishermen (7%) and gleaners (8%) rely entirely on marine-based livelihoods. Moreover, almost half of the fishermen are affiliated with local organizations, in contrast to the majority of gleaners (97%) who do not participate in any community group. Generally, these resource users have attained a high school-level education at most. Additionally, some individuals supplement their income with land-based jobs such as carpentry, labor, farming, vending, and driving.

The data also reveals a pronounced gender distribution, with fishermen predominantly male (87.14%) and gleaners largely female (55.48%). This indicates a gendered division of labor, consistent with the results of interviews highlighting that men dominate the fishing industry due to its risky and physically demanding nature. This observation aligns with the research by Lein and Setiawina (2018), which found that men's labor primarily supports the fishing sector. According to recent studies, traditional gender roles in fishing communities persist, with men primarily engaged in fishing. At the same time, women focus on gleaning and post-harvest activities such as processing and marketing fish (Kleiber et al. 2017). Regarding age demographics, the table indicates that the majority of fishers (48.74%) and gleaners (46.59%) are aged 40-60, suggesting both considerable experience and potential challenges associated with aging. Notably, 75% of tourism operators also fall within this age bracket. Civil status data indicates that a significant proportion of fishers (39.92%) and gleaners (53.41%) are married, which can influence their economic decisions and resource management practices. According to Ghosh et al. (2015), married fishermen typically generate higher household incomes compared to their single counterparts, primarily due to the combined incomes of spouses and shared financial responsibilities. Furthermore, family stability and size impact their economic resilience, as larger families may experience more financial strain despite potentially higher combined incomes.

Experience in marine activities is substantial, with many individuals having over 20 years of involvement. However, the absence of gleaners with less than 10 years of experience suggests barriers to entry for younger individuals. Household size data indicate that most resource users reside in small households (1-5 members), while larger families often rely on multiple income sources. Employment patterns reveal that only 7.56% of fishers and 10.23% of gleaners are engaged full-time in marine-based activities, contrasting sharply with the 87.50% of tourism operators who work full-time in their sector. Membership in organizations is notable among fishers (41.60%), suggesting support and advocacy for their interests. In comparison, gleaners (2.58%) and tourism operators (6.25%) show low membership, indicating potential gaps in community organization and support networks. Fishermen affiliated with organizations benefit from enhanced support networks compared to those who operate independently. Organizational support significantly influences the adoption of best practices in aquaculture. Community-Supported Fisheries (CSFs) foster relationships between fishers and their communities, promoting sustainable practices and economic resilience (Yan et al. 2023). Finally, education levels reveal that most fishers (52.52%) and gleaners (42.05%) have completed secondary education, with fewer attaining tertiary education (5.88% for fishers and 20.45% for gleaners). In contrast, tourism operators exhibit higher rates of tertiary education (12.50%), correlating with the skills required for business management and customer service.

To provide insights regarding the uses of seagrass ecosystems from the perspective of the resource users, they reported both direct and indirect benefits (Table 3), highlighting their substantial economic and ecological importance to coastal communities. Among the direct uses are fishing, gleaning, ecotourism, ethnobotanical medicine, pesticides, and herbal food. In terms of indirect benefits, the resource users cited habitat and nursery value, carbon storage, and coastal protection.

Revenue from direct uses of the seagrass ecosystem

Fishers typically work three (3) to five (5) days each week. Data indicates that the peak fishing months are from March to May, while the lean months are from July to August. Fishermen from the ten (10) barangays in Argao identified and caught a total of seventy-six (76) fish species; however, only the thirteen (13) frequently caught fish (Figure 4) are reported in terms of their annual fish catch (kg) and the percentage contribution of each fish from the total catch. The most frequently caught fish in the seagrass areas (Table 4) were *Tulingan* (*Auxis rochei*), making up 20.07% of the total catch. *Tamarong* (*Atule mate*) was the second most common, comprising 17.77% of the catch, followed by *Burot-burot* (*Decapterus macarellus*) at 11.28%. *Bolinao* (*Stelophorus heterolobus*) and *Malapati* (*Decapterus tabl*) were also commonly caught, each constituting around 7% of the total catch. To help fishermen catch these fish species, they use several gears, including nets, lines, traps, and spearfishing. The average fish yield varies significantly throughout the year. During peak months of high fish abundance, fishers typically catch between 11.01 to 12.2 kg of fish per trip. In contrast, during lean months, the average catch per trip declines substantially, ranging from 7.08 to 8.03 kg. The total annual net revenue from fisheries within the seagrass ecosystem is calculated by multiplying the average annual net revenue per fisher by the total number of fishers in each municipality, resulting in a total annual net revenue of ₱18,658,220.61 (USD 318,182.48).

Meanwhile, gleaners typically work around one (1) to two (2) days each week. They recorded a total of eight (8) species of mollusks, three (3) species of echinoderms, and three (3) species of crustaceans (Table 5). According to the data, some of the most common species harvested by gleaners include *Aninikad* (*Strombus canarium*), accounting for 28.13% of the total catch. *Saang* (*Lambis lambis*) constitutes 17.77% of the catch, making it the second most common species. *Manok-manok* (*Euprotamus bulla*) and *Swaki* (*Tripneustes gratilla*) were also commonly caught (Figure 5), each representing approximately 7% to 9% of the total catch. The price of mollusks and echinoderms varies depending on the species, ranging from PhP 100.00 (USD 1.71) to PhP 150.00 (USD 2.56) per kg. Sea urchins (*Swaki*) are sold at a slightly higher price, ranging from PhP 150.00 (USD 2.56) to PhP 200.00 (USD 3.41) per kg. To estimate the total annual revenue generated by gleaning activities within the seagrass ecosystem, the average annual income of each gleaner in each municipality was multiplied by the total number of gleaners operating in that area. This calculation resulted in an estimated total annual net revenue of ₱3,037,390.00 (USD 51,797.24).

Table 3. Major uses of the seagrass ecosystem in Argao, Cebu, Philippines

Direct use	Indirect use
Fisheries	Habitat and Nursery
Mollusk/ Echinoderms	Carbon storage
Ecotourism	Coastal protection
Ethnobotanical medicine	
Pesticide	
Herbal food	

Table 4. Annual catch (kg) per fish species of fishermen (n: 280)

Common	Scientific names	Kg/annually	%- catch	Percentile
Tulingan	*Auxis rochei*	23,868	93.80%	20.07%
Tamarong	*Atule mate*	21,138	87.50%	17.77%
Burot-burot	*Decapterus macarellus*	13,416	81.30%	11.28%
Bolinao	*Stelophorus heterolobus*	9,464	75.00%	7.96%
Malapati	*Decapterus tabl*	9,152	68.80%	7.69%
Tuloy	*Sardinella longiceps*	7,046	56.30%	5.92%
Pagatpat	*Scarus prasiognathus*	5,824	50.00%	4.90%
Badlon	*Platycaranx malabaricus*	5,304	43.80%	4.46%
Balo	*Ablennes hians*	4,160	37.50%	3.50%
Danggit	*Siganus canaliculatus*	4,108	31.30%	3.45%
Pogapo	*Epinephelus fuscoguttatus*	2,340	25.00%	1.97%
Anduhaw	*Rastrelliger kanagurta*	2,158	18.80%	1.81%
Lapu-Lapu	*Epinephelus* spp.	1,846	6.30%	1.55%

Table 5. Annual harvest (kg) per mollusk/echinoderm/crustacean species of gleaners (n: 115)

Common	Scientific names	Kg/annually	%- catch	Percentile
[1]*Aninikad*	*Strombus canarium*	720	93.30%	28.69%
[1]*Saang*	*Lambis lambis*	560	86.70%	22.31%
[1]*Manok-manok*	*Euprotamus bulla*	250	80.00%	9.96%
[2]*Swaki*	*Tripneustes gratilla*	180	73.30%	7.17%
[1]*Litob*	*Antigona magnifica*	100	60.00%	3.98%
[2]*Sungkod-ungkod*	*Monetaria annulus*	100	60.00%	3.98%
[3]*Kasag*	*Thalamita crenata*	90	33.30%	3.59%
[3]*Lambay*	*Portunus* sp.	90	33.30%	3.59%
[3]*Pasayan*	*Penaeus* sp.	90	33.30%	3.59%
[2]*Tuyom*	*Diadema setosum*	90	33.30%	3.59%
[1]*Bungkawil*	*Laevistrombus canarium*	70	20.00%	2.79%
[1]*Tikod*	*Spondylus* sp.	70	20.00%	2.79%
[1]*Liswi*	*Conomurex luhuanus*	50	6.70%	1.99%
[1]*Malungpong*	*Cerastoderma* sp.	50	6.70%	1.99%

*** Note: [1]Mollusk; [2]Echinoderms; [3]Crustaceans

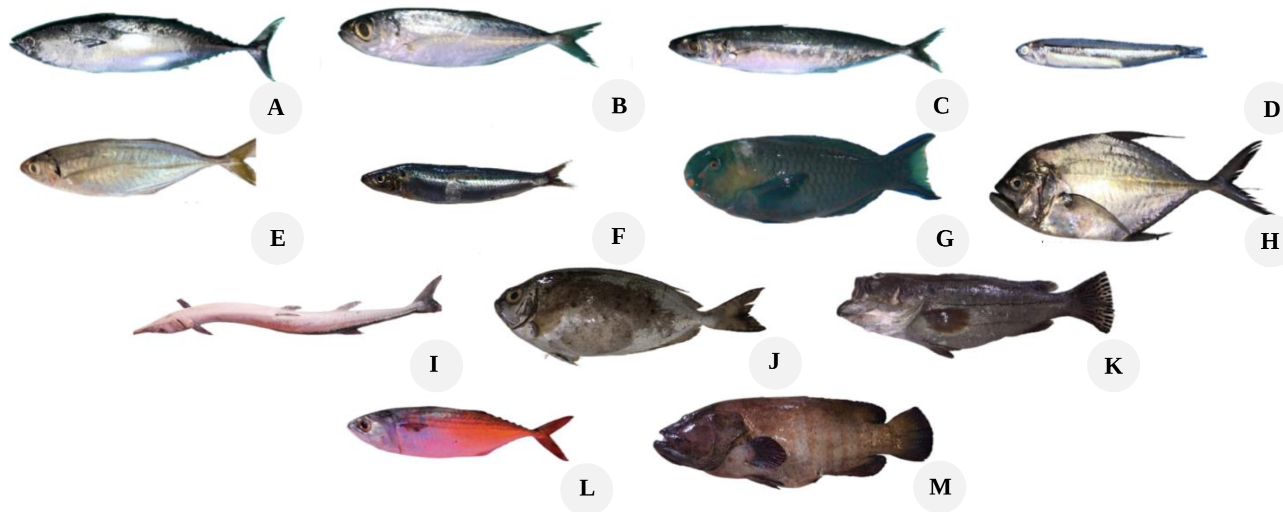

Figure 4. Frequently catch fish species in Argao, Cebu, Philippines. A. *Auxis rochei* (*Tulingan*); B. *Atule mate* (*Tamarong*); C. *Decapterus macarellus* (*Burot-burot*); D. *Stelophorus heterolobus* (*Bolinao*); E. *Decapterus tabl* (*Malapati*); F. *Sardinella longiceps* (*Tuloy*); G. *Scarus prasiognathus* (*Pagatpat*); H. *Platycaranx malabaricus* (*Badlon*); I. *Ablennes hians* (*Balo*); J. *Siganus canaliculatus* (*Danggit*); K. *Epinephelus fuscoguttatus* (*Pogapo*); L. *Rastrelliger kanagurta* (*Anduhaw*); M. *Epinephelus* spp. (*Lapu-lapu*)

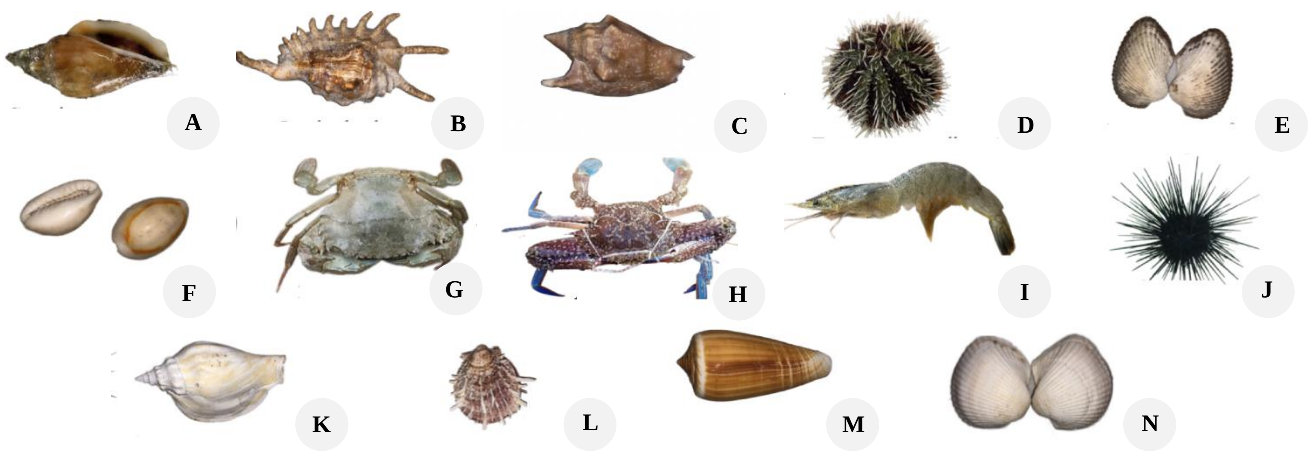

Figure 5. Frequently gleaned species in Argao, Cebu, Philippines. A. *Strombus canarium* (*Aninikad*); B. *Lambis lambis* (*Saang*); C. *Euprotamus bulla* (*Manok-manok*); D. *Tripneustes gratilla* (*Swaki*); E. *Antigona magnifica* (*Litob*); F. *Monetaria annulus* (*Sungkod-ungkod*); G. *Thalamita crenata* (*Kasag*); H. *Portunus* sp. (*Lambay*); I. *Penaeus* sp. (*Pasayan*); J. *Diadema setosum* (*Tuyom*); K. *Laevistrombus canarium* (*Bungkawil*); L. *Spondylus* sp. (*Tikod*); M. *Conomurex luhuanus* (*Liswi*); N. *Cerastoderma* sp. (*Malungpong*)

In terms of business operation, particularly in the areas of Poblacion and Tulic, operators thrive by catering to both tourists and residents, who rely on seagrass ecosystem services and eventually contribute significantly to the local economy. For example, the Tulic Reef is a hotspot for scuba divers due to its dense seagrass beds. While healthy seagrass beds ensure a sustainable supply of marine resources, which underpins fishing and gleaning activities, they also enhance the appeal of coastal areas for tourism. Consequently, scuba diving is a prominent tourism activity. These scuba divers rent equipment from local operators, providing a steady stream of revenue through rental fees and guided dive services. Meanwhile, Poblacion predominantly features cottage and house rentals, which attract tourists seeking accommodations near the beach to observe the rich marine life in reefs and seagrass meadows. These rentals generate income through nightly or weekly fees. Additionally, across these areas, fish vending is a common business activity. Vendors sell fresh or dried fish, contributing to the local economy and offering a staple food source for the community. This blend of tourism services and local trade creates a vibrant economic ecosystem that supports the livelihoods of many Argao residents. Table 5 shows the annual net revenue generated by business operators in Poblacion is exceptionally high, amounting to ₱9,801,200.00, largely driven by cottage and house rentals. Tulic contributes ₱984,000.00 annually, primarily from scuba diving equipment rentals and related services. Langtad plays a vital role in the fish vending business, with an annual net revenue of ₱312,000.00 from this activity. Other coastal barangays, like Casay, also stand out with significant revenue from business operators, reaching ₱4,000,000.00. These figures underscore the pivotal role of tourism-related services and local enterprises in propelling the coastal economy of Argao. By integrating data from fishing, gleaning, and fish vending activities, it becomes evident that the local economy benefits from a diverse range of sources. This combination of tourism, fishing, and trade sustains the region's financial health, ensuring sustainable livelihoods for its residents.

Locals in specific barangays also reported the use of ethnobotanical medicine, herbal food, and pesticides derived from seagrass. The economic valuation of each use in certain barangays is reflected in Table 6. The results highlight the relatively minor economic contributions of these specific functions within the seagrass ecosystem in Argao Coastal Area. Ethnobotanical medicine, with a total cost of ₱23,373.00 and a valuation of USD 398.58, represents only 0.04% of the overall ecosystem valuation. This suggests that the use of seagrass for medicinal purposes is minimal, likely due to the availability of alternative sources or limited knowledge of its potential. Meanwhile, seagrass contributes moderately to natural pest control, reflected in its valuation as a pesticide at USD 3,833.29 (₱224,784.00), accounting for approximately 0.40% of the total value. This underscores the ecosystem's role in maintaining ecological balance, which reduces the need for synthetic pesticides. On the other hand, the contribution of seagrass as a resource for herbal food is notably small, with a valuation of only USD 266.03 (₱15,600.00), comprising 0.03% of the total. This may indicate limited cultural or economic reliance on seagrass for food purposes. While these functions provide direct benefits, their combined economic impact is minimal compared to more prominent uses such as fisheries and ecotourism. However, their potential to support sustainable practices and community livelihoods remains an avenue for further exploration and development (Fortes et al. 2018; Unsworth et al. 2019; Dunic et al. 2021).

The abundant seagrass ecosystems of Argao, Cebu, are well-known and essential to the local economy. Fisheries, gleaning, and tourism provide the yearly net income from these ecosystems. Several barangays in Argao, including Guiwanon, Taloot, Bulasa, Binlod, Langtad, Poblacion, Tulic, Bogo, Casay, and Talaga, directly benefit economically from the seagrass habitat. The seagrass ecosystem in Argao, Cebu, offers a range of indirect and non-use values that are crucial for understanding its overall economic contribution to local communities and the environment. Indirect use values refer to the ecosystem services provided by seagrass that do not involve direct extraction or consumption. These services include habitat provision, carbon storage, and coastal protection. The total indirect use value of the seagrass ecosystem in Argao, Cebu, amounts to ₱19,242,533.00, representing a significant contribution to the Total Economic Value (TEV) of the ecosystem.

Among these, the habitat and nursery function are valued at ₱414,533.00, which gives insight into the important role of seagrass as a nursery ground for juvenile fish species essential for sustaining local fisheries. Although this value is relatively small, it underscores the importance of seagrass in maintaining fish populations that support local livelihoods. Seagrass beds are essential for supporting populations of commercially harvested fish and invertebrates by providing stable habitats, nursery areas for juveniles, feeding grounds, and protection from predators (James and Mwaluma 2022). Additionally, they contribute organic matter to coastal nutrient cycles, which enhances secondary production and supports fisheries, playing a critical role in maintaining marine biodiversity and ecosystem functioning (Duarte et al. 2020). The carbon storage service is valued at ₱4,983,000.00. Seagrass meadows are important in carbon sequestration, capturing CO_2 at rates significantly higher than tropical rainforests and storing up to 19.9 petagrams of organic carbon in sediments. Covering less than 0.2% of the ocean floor, they contribute 10-18% of oceanic carbon storage while also providing essential ecosystem services, such as habitat for marine life and coastal protection, making them crucial in combating climate change (Huxham et al. 2018).

The most significant indirect use value is associated with coastal protection, amounting to ₱13,500,000.00. Seagrass meadows play a crucial role in stabilizing shorelines, reducing erosion, and protecting coastal communities from storm surges, which is increasingly important in the context of climate-related threats to coastal areas (Tuya et al. 2014). While the value of seagrass biodiversity is not quantified in terms of total cost, it is essential to recognize that biodiversity contributes to the resilience of the ecosystem and supports various ecological functions. In addition to indirect use values, non-use values encompass the benefits derived from the existence of the seagrass ecosystem, even if individuals do not directly use its resources. These values include option value, bequest value, and existence value, reflecting the intrinsic worth of preserving natural resources for future generations (Cullen-Unsworth and Unsworth 2013). Effective conservation strategies that recognize and enhance these values are essential for sustaining both the environment and the livelihoods of local communities.

Economic value of indirect uses of seagrass ecosystem

The non-market values for seagrass ecosystems include (a) coastal protection, (b) habitat and nursery areas for fisheries, and (c) carbon storage. The Argao Coastal Area has a total area of 604 hectares of seagrass beds. Seagrass ecosystems play a crucial role in coastal protection by acting as natural barriers against storm surges and coastal erosion. They help stabilize the seabed, reduce wave energy, and protect shorelines from the impacts of extreme weather events (James et al. 2019). Additionally, seagrass meadows provide essential habitats for marine life, supporting biodiversity and fisheries (Tuya et al. 2014). Regarding the economic value, the revenue of ₱13,500,000 represents 23.98% of the total economic value of the coastal protection project. This value was derived from the replacement cost of the 22 km coastline, with a cost of 915 per meter for a Class C riprap. Meanwhile, the net value of seagrass areas as habitation, breeding sites, and nurseries is estimated at 20% of the net landings. Seagrass meadows provide essential nursery habitats for many commercially important fish and invertebrates, offering shelter and food for juvenile marine life and supporting biodiversity. The nursery habitat value of seagrass ecosystems in Argao has been estimated at ₱414,533, based on the replacement cost method. This approach compares the cost of artificial commercial fish nurseries and habitat values with the natural ecosystem services provided by seagrass meadows (Mascariñas and Otadoy 2023). Seagrass meadows are also among the biggest marine carbon sinks in the world (Duarte et al. 2020). While occupying less than 1% of the world's oceans on an area basis, an estimated 11 tons of CO_2 is estimated to be stored per hectare in the seagrass beds. Given that the seagrass beds in Argao are expected to cover 604 hectares, the provision's net revenue is ₱4,983,000.00. This is computed using the 2020 price of C02 at USD 15 per ton in US dollars (Murray et al. 2011).

Non-use value of seagrass ecosystem

Using the average WTP values of respondents, the seagrass biodiversity was calculated (Table 7). The WTP of 435 respondents, including fishers and gleaners, offers significant insights into the perceived value of a proposed product or service. The data indicates a marked decrease in the percentage of respondents willing to pay as bid prices rise. At the lowest bid of ₱20, an overwhelming 98% of respondents are willing to pay, highlighting high perceived value or affordability at this price point. However, as the price increases to 50.82% still express willingness to pay, reflecting a strong, though slightly diminished, preference for the service. The WTP drops more sharply at ₱100, with only 48% of respondents agreeing to this price, indicating heightened price sensitivity. At even higher price points, the WTP plummets drastically: only 4% are willing to pay ₱150, and none are willing to pay ₱200, suggesting these amounts surpass the perceived value of the product or service. The average WTP is ₱104 (approximately USD 1.77), suggesting that respondents are, on average, willing to pay slightly over ₱100. At the same time, the median WTP of ₱100 indicates that half of the respondents are willing to pay this amount or less. The standard deviation of ₱65.30 (USD 1.11) illustrates significant variation in WTP, with some respondents willing to pay much lower amounts and others higher amounts.

Table 6. Annual net revenue from the seagrass ecosystem of Argao, Cebu, Philippines

	Annual net revenue (PhP/Year)					
Coastal barangays	**Fishing**	**Gleaning**	**Business operators**	**Medicine**	**Pesticide**	**Herbal food**
Guiwanon	₱567,865.22	₱224,359.20	---	---	---	---
Taloot	₱3,717,385.35	₱188,037.00	---	---	---	---
Bulasa	₱915,317.00	₱171,761.20	---	---	---	---
Binlod	₱753,962.30	₱243,984.00	---	---	---	---
Langtad	₱4,452,243.64	₱161,772.00	₱312,000.00	---	---	---
Poblacion	₱3,658,846.88	₱236,912.00	₱9,801,200.00	---	---	---
Tulic	₱588,636.36	₱438,906.00	₱984,000.00	---	---	---
Bogo	₱1,657,599.06	₱803,556.00	---	---	---	---
Casay	₱1,154,768.42	₱248,846.00	₱4,000,000.00	₱20,655.00	₱224,784.00	₱15,600.00
Talaga	₱1,191,596.38	₱319,256.60	---	₱2,718.00	---	---
Total	₱18,658,220.61 (USD 318,182.48)	₱3,037,390.00 (USD 51,797.24)	₱15,097,200.00 (USD 257,455.66)	₱23,373.00 (USD 398.58)	₱224,784.00 (USD 3,833.29)	₱15,600.00 (USD 266.03)

***Note: *USD 1.00: ₱58.64 (2024); ---: No report obtained

Table 7. Bid values and percentage of respondents WTP the proposed bids

Bid prices	N: 435 (Gleaners and fisherman)
₱20 (USD 0.34)	98%
₱50 (USD 0.85)	82%
₱100 (USD 1.71)	48%
₱150 (USD 2.56)	4%
₱200 (USD 3.41)	0%
Average WTP (PhP)	₱104 (USD 1.77)
Standard deviation (PhP)	₱65.30 (USD 1.11)
Median (PhP)	₱100 (USD 1.71)

***Note: *USD 1.00: ₱58.64 (2024)

This data highlights a price-sensitive market, where most respondents are comfortable paying lower to mid-range prices; however, prices above ₱100 significantly reduce the number of potential customers. Hence, setting a price between ₱50 and ₱100 would likely attract the highest number of respondents while balancing affordability with perceived value. The net revenue for seagrass biodiversity was calculated based on the municipality's resource consumers. The yearly net benefits from indirect and non-use value in the Argao Coastal Area is PhP 49,880,900.61 (USD 850,629.27) (Table 8).

Total economic value of seagrass ecosystem in Argao, Cebu, Philippines

The economic valuation of the seagrass ecosystem in the Argao Coastal Area has been estimated at ₱56.2 million, equivalent to approximately USD 960,000 (Table 8). The total direct use value stands at ₱37 million (USD 6.3 million), with fisheries identified as the principal economic sector contributing ₱18.6 million. This is followed by ecotourism, which generates ₱15 million, and the exploitation of mollusks and echinoderms, which adds ₱3 million to the economy. Additionally, ethnobotanical medicine, pesticide, and herbal food contribute ₱23,373, ₱224,784, and ₱15,600, respectively. In contrast, the indirect and non-use values collectively amount to ₱18.89 million (USD 3.2 million). These non-market values are primarily derived from coastal protection (₱13.5 million), carbon storage (₱4.9 million), and habitat and nursery functions (₱414,533). Seagrass biodiversity also contributes ₱345,000. On a per-hectare basis, the economic value of the seagrass ecosystem is calculated at ₱93,210 or USD 1,589. The total production cost is ₱6,418,200 (USD 109,450.39), leading to a net Total Economic Value (TEV) of ₱49,880,900.61 (USD 850,629.27). The monetary valuation of seagrass meadows highlights their significant ecological and economic contributions. According to Short et al. (2011), the value of seagrass ecosystems can reach up to USD 19,000 per hectare per year, underscoring their importance in carbon sequestration, coastal protection, and supporting marine biodiversity. The study by de Groot et al. (2012) further supports these findings, emphasizing the critical role of seagrass meadows in providing ecosystem services that benefit both the environment and local economies.

The production cost in the Table 8 reflects the monthly expenses for fishing, gleaning, and business operations, gathered through surveys. These costs, such as maintenance, equipment, fuel, and labor, vary by location and sector. Costs vary by location and activity type: northern barangays like Taloot, with a cost of ₱822,000.00, focus on commercial fishing, while southern areas like Bogo, with a cost of ₱365,400.00, primarily engage in subsistence fishing. This distinction highlights the differing economic scales, with commercial operations incurring higher expenses compared to smaller-scale, sustenance-focused activities. The total production cost across all areas is ₱6,418,200.00, providing insight into the financial requirements and sustainability of these operations.

Table 8. Benefits from direct, indirect, and non-use values of seagrass ecosystem in Argao, Cebu, Philippines

Ecological function		Total cost	Valuation USD
Direct use (66%)	Fisheries (33.14%)	18,658,220.61	USD 318,182.48
	Mollusks/Echinoderms (5.40%)	3,037,390.00	USD 51,797.24
	Ecotourism (26.82%)	15,097,200.00	USD 257,455.66
	Ethnobotanical medicine (0.04%)	23,373.00	USD 398.58
	Pesticide (0.40%)	224,784.00	USD 3,833.29
	Herbal food (0.03%)	15,600.00	USD 266.03
Direct Use Subtotal		₱37,056,567.61	USD 6,319,933.28
Indirect use (33.57%)	Habitat and nursery (0.74%)	414,533.00	USD 7,069.12
	Carbon storage (8.85%)	4,983,000.00	USD 84,976.13
	Coastal protection (23.98%)	13,500,000.00	USD 230,218.28
Indirect Use Subtotal		₱18,897,533	USD 3,281.146.88
Non-use (0.61%)	Seagrass biodiversity conservation and protection (0.61%)	345,000.00	USD 5,883.36
Non-use Subtotal		₱345,000.00	USD 5,883.36
Gross Total Economic Value (TEV_{Gross})		₱56,299,100.61	USD 960,080.16
TEV per ha per year		₱93,210.00	USD 1,589.53
Total production cost		₱6,418,200.00	USD 109,450.89
Net Total Economic Value (TEV_{Net})		₱49,880,900.61	USD 850,629.27

***Note: *USD 1.00: ₱58.64 (2024)

The economic valuation of the seagrass ecosystem in Maribojoc Bay, Philippines, reveals significant annual net revenue from various resource uses (Table 9). Fisheries production yields an annual net revenue of USD 268 per hectare, surpassing the USD 118 per hectare reported by Wawo et al. (2014) in Indonesia. This higher value could be attributed to improved resource management or more abundant fish stocks in Maribojoc Bay (Mascariñas and Otadoy 2023). Mollusks and echinoderms contribute USD 47 per hectare annually, reflecting their importance to the local economy and their potential for sustainable growth (Mascariñas and Otadoy 2023). Ecotourism in Maribojoc Bay generates a notable USD 426 per hectare annually, underscoring its economic impact and the area's appeal as a tourist destination. Habitat and nursery functions provide an annual net revenue of USD 117 per hectare, emphasizing their critical role in sustaining marine biodiversity and ecosystem health (Mascariñas and Otadoy 2023). Carbon storage contributes USD 140 per hectare, aligning with values reported by Lavery et al. (2013) in Australia and underlining the global importance of seagrass ecosystems in climate change mitigation. Coastal protection services in Maribojoc Bay yield USD 281 per hectare annually, emphasizing their vital role in reducing coastal erosion and providing natural barriers against storms (Mascariñas and Otadoy 2023). Similarly, in Nueva Valencia, Guimaras, Philippines, coastal protection services generated USD 768 per hectare annually, showcasing the higher protective benefits in that area due to potential variations in coastline features or ecosystem services delivery (Bundal et al. 2018). Other ecosystem services, including ethnobotanical medicine, pesticides, herbal food, and biodiversity conservation, while less quantified in monetary terms, contribute to the overall valuation of seagrass ecosystems. These findings strongly advocate for the conservation and sustainable management of seagrass meadows to maintain their substantial economic and ecological benefits.

Threats and proposed solutions towards seagrass conservation

The seagrass ecosystem in the coastal areas of Argao faces significant pressures, as identified during interviews with local resource users (Table 10). Key issues included: (i) increase in competition among fishermen/gleaners; (ii) expansion of commercial fishing activities; (iii) illegal fishing; (iv) overharvesting due to unrestricted access (influx of fishers and gleaners from other municipalities); (v) environmental degradation of marine habitats; (vi) rapid changes in weather patterns. The table depicts the statistical responses that were collated to determine the decrease in catch yields of the resource users despite the increase in fishing efforts. The primary issue was due to an increase in competition among fishermen and gleaners. According to the interviewed local fishermen and gleaners, the increased numbers of fishermen and gleaners resulted in lower catch yields. This is common, particularly for those who live near the coast, due to increased demand for commercial fishing to meet the basic needs of life (Anticamara and Go 2016). Individual fishermen may invest in new vessels, profitable equipment, or technology and, in some cases, engage in illicit fishing practices to increase their earnings, particularly in response to declining fish stocks and economic pressures (Belhabib et al. 2019). For small-scale fisheries, whose members heavily rely on resource extraction for livelihood support and food security, illegal fishing can be particularly devastating (Hauck 2008; Worm et al. 2009). Illegal fishing frequently takes place in disadvantaged communities; fishermen break the law to provide for their families' basic needs (de la Torre-Castro 2006). This also includes entering the 'no-take' zone in Marine Protected Areas (MPAs). According to recent studies, illegal fishing activities continue to occur at varying levels in these areas, undermining conservation efforts (Bergseth et al. 2018).

Illegal fishing leads to unsustainable fishing practices, which have a negative impact on the environment, increase the risks to global food security, and cause large economic losses (Hasan et al. 2021). Barbier (2023) stated that a significant portion of our coastal waterways suffer from pollution, eutrophication, oxygen depletion, and rising temperatures, and at least one-third of fish stocks are overfished. Competition between fishermen and between fishing operation levels rises as a result of the ensuing increased fishing pressure, which causes further declines in fishery populations (Cinner et al. 2018; Hasan and Islam 2020). Nearly every ocean fishery operates under 'open-access' conditions, allowing both small-scale and large-scale fishermen to fish extensively without significant restrictions, which often leads to overexploitation and resource depletion (Costello et al. 2016). Overfishing is one of the main causes of illegal fishing because overfished traditional fishing grounds encourage fishermen to supplement their catch in other waters, which increases competition and conflict (Belhabib et al. 2019; Hasan and Widodo 2020). Competing fishermen frequently put short-term financial gain ahead of long-term sustainability, which feeds the cycle of overexploitation (Mullon and Mullon 2016). Further, rapid changes in weather patterns influence the decline in catch rates among fishers and gleaners. Fishermen's livelihoods rely heavily on natural resources, the productivity and distribution of which are known to be impacted by climate dynamics (Barange et al. 2018). While variations in fishery production and other natural resources can affect the livelihood strategies and outcomes of fishing communities, recent studies highlight the adaptive strategies employed by these communities to cope with environmental and economic changes (Cinner et al. 2018), extreme weather events can also interfere with fishing operations (Westlund 2007). Injuries and maritime safety are frequently linked to natural catastrophes associated with climate stressors, like hurricanes and floods, which limit fishermen's physical capacity to pursue their marine-based livelihood (Lam et al. 2020). The economic consequences on fisheries due to climate change are variations in the cost of fishing, the price and value of catches, and the earnings of fishermen. The price of fish rises when the supply is reduced by climate change, and this increase could be significant enough to offset the loss of gross revenues from fewer catches (Sumaila et al. 2011).

Table 9. Comparison of annual net revenue from the seagrass ecosystem in Maribojoc Bay, Philippines, with other studies

Resource use	This study annual net revenue (USD /ha/yr)	Other studies annual net revenue (USD /ha/yr)	Valuation method	Author/ location
Fisheries	526	268	Market valuation	Mascariñas and Otadoy (2023), Bohol, Philippines
		118	Market valuation	Wawo et al. (2014), Indonesia
Mollusk/ Echinoderms	85	47	Market valuation	Mascariñas and Otadoy (2023), Bohol, Philippines
Ecotourism	426	357	Market valuation	Mascariñas and Otadoy (2023), Bohol, Philippines
Ethnobotanical medicine	0.66	(none)	---	---
Pesticide	6	(none)	---	---
Herbal food	0.44	(none)	---	---
Habitat and nursery	11	117	Market valuation	Mascariñas and Otadoy (2023), Bohol, Philippines
Carbon storage	140	140	Carbon storage calculation	Mascariñas and Otadoy (2023), Bohol, Philippines
		313	Carbon storage calculation	Lavery et al. (2013), Australia
Coastal protection	381	(none)	---	---
Seagrass biodiversity	9	3		Mascariñas and Otadoy (2023), Bohol, Philippines
		768		Bundal et al. (2018), Nueva Valencia, Guimaras, Philippines

***Note: *For comparison from other studies, the annual net revenue in Philippines Peso (PhP) was converted to USD. USD 1.00: ₱58.64 (2024), ---: No available studies reporting these direct uses

Table 10. Threats and proposed solutions given by the resource users to conserve seagrass beds

Issues and problems	Fishers N: 280	Gleaners N: 155	Solutions	Fishers N: 280	Gleaners N: 155
Increase in competition among fishermen/gleaners	32.14%	36.13%	Establish community-managed fishing areas to ensure equitable access and sustainable practices.	9.27%	9.03%
			Provide training and support for alternative income sources like aquaculture, seaweed farming, or ecotourism.	13.57%	13.55%
			Encourage fishers to form cooperatives to share resources and negotiate fair market prices collectively.	13.22%	11.61%
Expansion of commercial fishing activities	21.43%	10.32%	Strengthen enforcement of fishing quotas and allowable catch limits for commercial fishers.	27.86%	11.61%
Illegal fishing	4.64%	1.94%	Raise awareness about the long-term impacts of illegal fishing on marine ecosystems and livelihoods.	6.43%	5.81%
Overharvesting due to unrestricted access (influx of fishers/gleaners from other municipalities)	16.07%	1.94%	Introduce closed seasons to allow fish stocks to replenish.	2.86%	3.87%
			Coordinate with neighboring municipalities to enforce restrictions and prevent overharvesting.	2.5%	4.52%
Environmental degradation of marine habitats	7.14%	30.32%	Regulate and reduce coastal pollution through proper waste disposal systems.	7.5%	23.87%
Rapid changes in weather patterns	18.57%	10.36%	Develop weather-resilient facilities like stronger boats and safer fishing ports.	16.76%	17.42%

In light of the identified threats to seagrass ecosystems in Argao by the resource users, they have also proposed several mitigation measures or conservation efforts. Among the most recommended are strengthening enforcement of fishing quotas and allowable catch limits for commercial fishers (39.47%), developing weather-resilient facilities like stronger boats and safer fishing ports (34.18%), regulate and reduce coastal pollution through proper waste disposal systems (31.37%), provide training and support for alternative income sources like aquaculture, seaweed farming, or ecotourism (27.12%), and encourage fishers to form cooperatives to share resources and negotiate fair market prices collectively (24.83%).

In conclusion, the seagrass ecosystem in Argao is a vital pillar of the local economy, supporting fisheries, ecotourism, and the extraction of mollusks and echinoderms across ten coastal barangays. However, it faces significant threats from population growth and commercial activities. This study emphasizes the urgent need for conservation and sustainable management, highlighting the opportunity costs of seagrass utilization through monetary valuation to inform effective policy-making and ensure the ecosystem's long-term resilience. Yet, challenges such as temporal data limitations and difficulties in estimating non-market values hinder a comprehensive economic assessment. To address these, we propose a long-term monitoring program. This program, integrating remote sensing and in-situ observations alongside innovative valuation techniques like contingent valuation and choice modeling, offers a beacon of hope; it will capture stakeholder preferences for non-market services. Collaborative efforts with interdisciplinary experts are also recommended to enhance the accuracy and reliability of economic assessments, ultimately securing the ecosystem's sustainability and improving the livelihoods of coastal communities.

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