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Economic valuation of a protected mangrove forest 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.
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Abstract. *Rosales RJC, Libranza LR, Roble JFZ, Jucdong FMB, Jumawan MC, Empeño S, Flores CM, Dumdum J, Cortes ST, Retubado ZAZ, Lorca AS, Almagro JJN. 2025. Economic valuation of a protected mangrove forest in Southern Cebu, Philippines. Biodiversitas 26: 2448-2459.* Mangroves are important ecosystems due to their roles in coastal protection, nurseries, carbon sequestration, and other services. However, climate change, habitat destruction, and aquaculture expansions threaten these ecosystems in the Philippines. Thus, this study investigates the Total Economic Value (TEV) of mangroves in Argao, Cebu, Philippines, which is a coastal municipality with a mangrove ecosystem spanning over 130.52 hectares across eight coastal *barangays*, to contribute to their conservation efforts. Argao has a wide cover of mangroves and most of the locals depend on the mangrove's ecosystem services and resources. Through an in-depth semi-structured interview survey using snowball sampling, data was gathered from 406 direct users. Use values, classified into direct (such as fishing, gleaning, etc.), indirect (such as coastal protection, carbon sequestration, etc.), and optional (such as ecotourism, goat feed, etc.) benefits, were assessed in addition to non-use values which include existence and bequest values. The economic valuation strategies and analysis involved a combination of market valuation, replacement cost, travel cost, benefit transfer method, and contingent valuation. The calculated TEV of mangroves was Php 307,487,030.00 or USD 5,227,279.51 annually, with use values dominating at 98.9%. This significant economic value underscores the importance of mangroves to the local economy. While non-use values at 1.01%, it also reveals the importance of mangroves to biodiversity preservation, landscape appreciation, research, and others. The study also reports the factors affecting mangrove conservation in the area, namely coastal development, aquaculture expansion, climate change, community livelihood dependency, and insufficient local awareness. Some conservation strategies are relative to these limiting factors. The study concludes that mangroves in the area provide ecological and economic benefits, thus urging the local government units and resource users to implement conservation strategies to achieve long-term sustainability and prosperity for the local environment and the community.

Keywords: Conservation, economic valuation, ecosystem services, mangrove forests

INTRODUCTION

The Philippines has abundant mangrove forests due to its tropical climate and close proximity to the Pacific Ocean. Mangrove ecosystems are important coastal regions in the country made up of plants and shrubs that can withstand salt and thrive in brackish water (Garcia et al. 2013). There are 39 authentic mangrove species identified, hence, among the wealthiest nations ranking 16th globally (Primavera 2004). As the first line of defense, these shrubs serve as natural barriers against a range of environmental threats, such as waves, storms, tsunamis, and coastal erosion (Asari et al. 2021). In addition, it acts as a nursery for a variety of marine animals, including fish, crabs, and shellfish (Dahlgren et al. 2006). Due to their ability to absorb and hold onto large amounts of CO_2, these ecosystems also greatly aid the carbon sequestration process, which mitigates the effects of climate change (Hui et al. 2016). Other ways that investments in mangrove areas improve are livelihoods and food security, and offer long-term economic opportunities including ecotourism, aquaculture, and small-scale fishing (Ahmad and Suratman 2021). Fisheries, fuel wood, medicine, carbon storage, coast protection, tourism, and recreation are all supported by mangroves, and these activities have a significant economic impact on the local communities (Aye et al. 2019; Cortes et al. 2024).

In the Philippines, mangrove habitats are under serious threat from urbanization and the expansion of aquaculture, which weakens coastal defenses and reduces biodiversity (Primavera 2006). Climate change, especially sea level rise and stronger storm surges, exacerbates these concerns by changing and weakening the mangrove ecosystem (Alongi 2008). Unsustainable practices such as overharvesting for fuelwood and coastal recovery projects also exacerbate the degradation of these crucial habitats (Primavera and Esteban 2008). In this regard, community-based mangrove management and replanting initiatives are two conservation initiatives that have been initiated to repair damaged mangrove areas and maintain ecological services (Datta et al. 2012). These programs emphasize the significance of integrating civic engagement into climate adaptation plans to ensure the long-term sustainability of the nation's mangrove ecosystem. Sustainable management of mangrove ecosystems depends on evaluating their economic worth in relation to the advantages they provide to both people and the environment. This process, known as economic valuation, assigns a monetary value to natural resources, products, and services derived from the environment, thereby driving conservation for the benefit it provides to humans. In other words, it's a way of quantifying the importance of these resources in a language that policymakers and stakeholders can understand (Tegenie 2015).

Although recognized as one of the largest countries with rich mangrove ecosystems and the importance of evaluating the economic value of these habitats, studies on the economic valuation of mangrove regions in various coastal areas of the Philippines remain limited. As of current research, published studies accounting for the total economic valuation of the mangrove ecosystems are limited, especially in the province of Cebu, Philippines. Mangrove ecosystems in Banacon, Bohol, Kamuning, Palawan, Tawi-Tawi Islands, and Zamboanga City have so far been studied, estimating and reporting their economic values. The municipality of Argao in Cebu has ten coastal *barangays*, of which eight of it has mangrove areas. These serve mainly as coastal protection from strong waves, especially during typhoons, as well as a nursery or habitat of marine organisms (e.g. fish, mollusks, crabs, etc.), which have become a source of food and income for the locals. The objective of this study is to estimate and provide a thorough valuation of the total economic value of the mangroves in Argao, Cebu. The importance of mangroves to the local communities and general welfare has been underscored through the calculation of the use and non-use economic benefits these ecosystems provide. Hence, this study specifically reports the ecosystem services valuation from fishery resources, ecotourism, coastal protection, carbon sequestration, biodiversity, etc. Furthermore, this research explores factors limiting mangrove conservation to contribute further important data that can be used to advocate stronger conservation efforts and policy-making and guide the officials to ensure that these ecosystems are conserved and protected, promoting a more sustainable future resource.

MATERIALS AND METHODS

Study area and Sampling

Argao is located in southeastern Cebu, about 66 km from the provincial capital, Cebu City, Philippines (Rios 2022). It is considered a first-class municipality composed of 45 rural *barangays*, 35 of which are upland and 10 coastal *barangays*. Of the ten coastal *barangays*, 8 have mangrove forests, namely: Guiwanon (9.961718°N, 123.619515°E), Taloot (9.953734°N, 123.618875°E), Bulasa (9.934570°N, 123.619713°E), Binlod (9.912535°N, 123.608094°E), Langtad (9.890618°N, 123.606331°E), Tulic (9.869062°N, 123.585554°E), Bogo (9.858424°N, 123.573708°E), and Talaga (9.849138°N, 123.566868°E) (Figure 1). The total mangrove area in all 8 *barangays* is 130.52 ha.

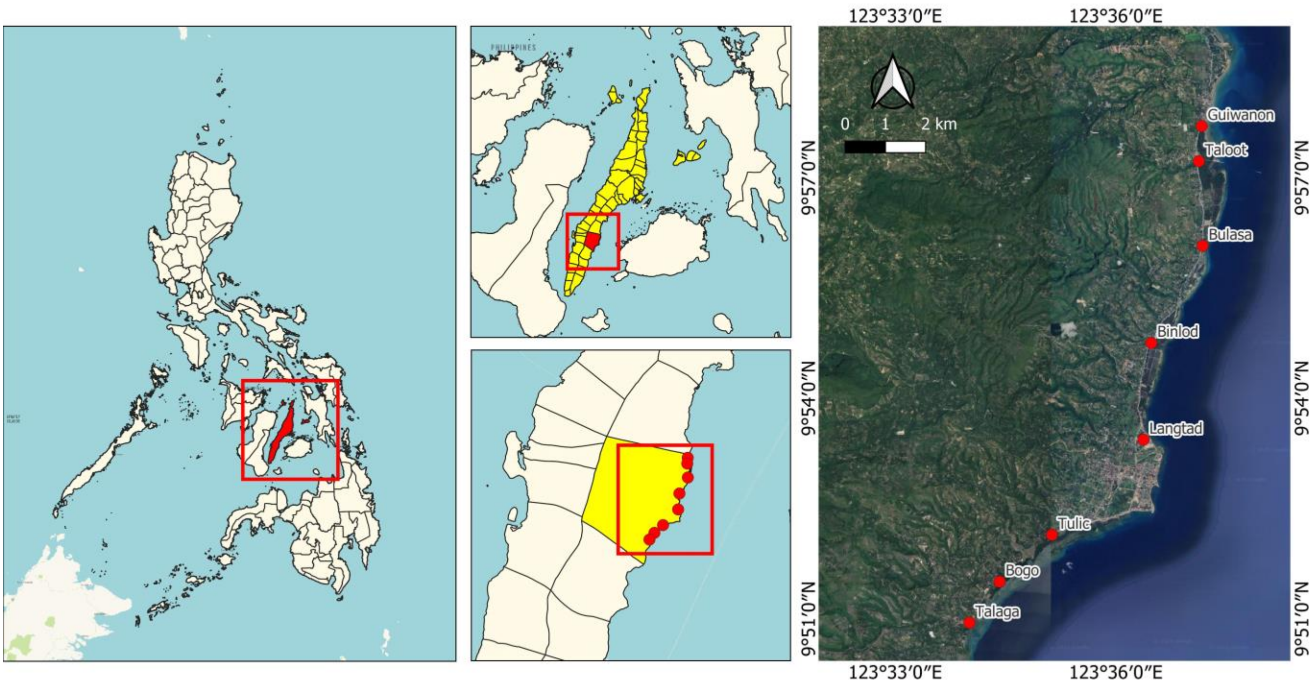

Figure 1. Map of Argao, Cebu City, Philippines with its *barangays*, coastal habitats, and the estimated total area of mangrove forest

Data collection

A personal interview with a semi-structured survey was conducted to collect socio-demographic information (e.g. gender, age, occupation, etc.) in addition to data on both the use and non-use value of the Argao mangrove ecosystem in Cebu. The semi-structured survey questionnaire is designed to specifically collect quantitative data about the value of use, including mangrove fisheries and forestry products and services (e.g. fish, firewood, ecotourism, etc.), and values of non-use (e.g. existence, recreation, biodiversity, etc.) by willingness to pay to determine the Total Economic Value (TEV) of the mangrove ecosystem. In addition, resource users were interviewed regarding the challenges they have experienced, which pose limitations toward mangrove conservation. Eventually, a literature review was conducted to suggest mangrove conservation strategies relative to limiting factors affecting its conservation. Finally, snowball sampling was used since the municipality has no existing records regarding the mangrove resource users. Moreover, it ensures systematic, cost-effective, and efficient access to 406 direct users across the different *barangays* from September to November 2024. This approach ensured that the valuation reflected both the tangible benefits and intrinsic values placed on mangroves by the local community.

Economic valuation

Total Economic Valuation (TEV) entails the use and non-use values in calculating the annual net benefits generated from the mangrove forest. Figure 2 shows the economic valuation framework of mangrove forests in Argao, Cebu. Next, to calculate TEV, this study follows the formula presented below (Sondak et al. 2019).

Use value

A use value is defined in terms of ecosystem benefits or the goods and services of use to the human population. Hence, it is construed to mean the provision of fishery products, carbon sequestration, nursery/habitat, coastal protection, and employment (Friess et al. 2019). It is subdivided into three categories, namely direct use, indirect use, and optional (Table 1). Direct use describes the economic value derived from the direct consumption and usage of services and products provided by the mangroves (Harini et al. 2019). This includes tangible products such as food and raw materials to be directly consumed or utilized (Mahlatini et al. 2020). The Market Price (MP) was used to determine the value of these direct-use goods because market prices exist for the majority of the mangrove goods, and the use of direct market value provides a realistic estimate. It is computed by taking the quantity of a good harvested and multiplying it by the market price (Mahlatini et al. 2020). Meanwhile, the indirect use value is the benefits that people get from mangroves that are used indirectly to support other economic activities such as carbon sequestration, nursery or habitat, coastal protection, and employment (Huxham et al. 2015; Malik et al. 2015; Salmon 2023; Zhang et al. 2024).

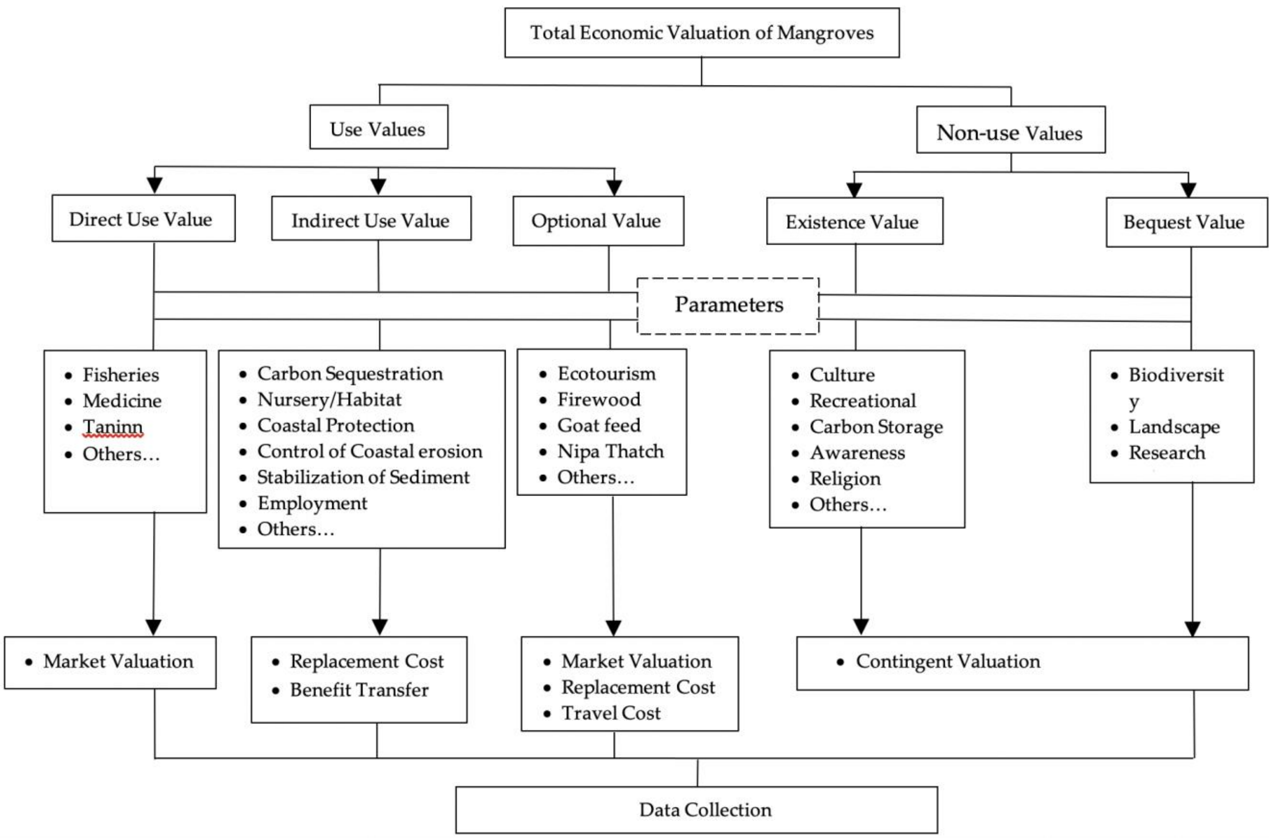

Figure 2. Economic valuation framework of mangrove ecosystem in Argao, Cebu, Philippines

Table 1. Formulas used to calculate direct, indirect, and optional values under use values

Category of uses	Specific uses	Formula	Reference	Valuation technique
Direct use	Fish, mollusks and shells, crabs, and shrimp capture value	FV; MSV; CV; SV = Production (kg/y) × Price (Php/kg)- Production cost (Php)	Alvarez and Otadoy (2023)	Market price
Indirect use	Carbon sequestration	SV = CSR × ∑(a) × V Where, CSV: Carbon Sequestration Value; CSR: Carbon Sequestration Rate; ∑(a): Total area of mangrove; V: Price of carbon market	Malik et al. (2015)	Benefit transfer Market price
	Nursery/Habitat	NV/HV = Production (kg/y) × Price (Php/kg) × ∑(a) − Production cost Where, NV/HV: Nursery/Habitat Value; ∑(a): Total area of mangrove	Malik et al. (2015)	Replacement cost
	Coastal protection	$V = A (P_i) (Q_i)$ Where, CPV: Coastal Prevention Value; m: Coastal length; C(X): Cost of breakwater construction	Zhang et al. (2024)	Replacement cost
	Employment	EV = Total number of employees × Average monthly pay × Number of months per year	Salmon (2023)	Replacement cost
Optional	Ecotourism	$V = (R_n) (R_e)$ Where, V: Total economic value of the activity; R_n: Number of tourists per year; R_e: Total expenditure per tourist	Zhang et al. (2024)	Travel cost
	Firewood, goat feed, nipa thatch	FwV; GfV; NtV: Wood/Branch collection (bundle/year) × Price (USD/bundle) − Production cost (USD) (1 bundle: 50 stems with a length of 1 m and a diameter of 4 to 8 cm)	Malik et al. (2015)	Market price

Carbon sequestration service was calculated by multiplying the carbon sequestration rate by the total mangrove area and the price of carbon in the market, which involves the benefit transfer method that utilizes values from similar studies, adjusting for site-specific differences, specifically the carbon sequestration rate of mangroves in the Philippines and market price for the price of carbon in the current market (Abino et al. 2014; Malik et al. 2015; World Bank Group 2024). The nursery or habitat, coastal protection, and employment used a replacement cost method to estimate each indirect value of mangrove services provided in the local community (Malik et al. 2015; Salmon 2023; Zhang et al. 2024). Finally, the optional value refers to the economic worth derived from preserving mangrove ecosystems for potential use or services, especially in uncertain conditions (Amiri et al. 2015). Specifically, it can be linked to the use of mangroves for firewood, goat feed, nipa thatching, and in preserving the ecosystem for purposes like ecotourism (Dang et al. 2022). Valuation techniques comprise market prices, which are used to analyze the value of forestry products by taking the number of bundles harvested and multiplying it by the market price. The travel cost method was used in order to estimate the value of recreational and tourism activities done within the mangrove ecosystem (Carandang et al. 2013).

Non-use value

Non-use value refers to the value that people place on a good or service, even if they never intend to use it directly. It is the benefits humans derive from knowing that an environmental good or service exists or is available for use for future generations (Randall and Stoll 1980). The non-use value of mangroves focuses on existence and bequest value (Table 2). The existence value is the satisfaction an individual derives from knowing that mangroves continue to exist to serve their many functions but are not necessarily planning to use them. It encompasses the awareness of existence, preservation of cultural significance, carbon storage, recreation, and religion (Hamilton and Casey 2016). These values are commonly assessed using the Contingent Valuation (CV), which estimates individuals' willingness to pay by summation of all Willingness To Pay (WTP) values for the satisfaction of goods and services provided (Huxham et al. 2015; Buncag 2022). Bequest value, on the other hand, is the value people place on preserving environmental resources for future generations. The bequest value indicates the community's willingness to preserve the mangrove ecosystems for its landscape aesthetics, biodiversity, and research purposes. It's satisfying to know that children and grandchildren will have the chance to experience nature's beauty and benefit from its resources (Johari et al. 2023). Then, to measure this value, contingent valuation is used to get the average willingness-to-pay among all the respondents' WTP and multiply it by the total number of households (Gagarin and Eslava 2022; Roldan 2022).

Table 2. Formulas used to calculate existence and bequest values under non-use values

Category of uses	Specific uses	Formula	Reference	Valuation technique
Existence	Culture, Recreation, Carbon storage, Awareness, Religion	$EV = \sum_{i=1n}^{n} (EVi)$ Where, EV: Existence Value; n: number of respondents taken; EVi: existence value of respondent-i	Novizantara et al. (2022)	Contingent Valuation
Bequest	Landscape, Biodiversity, Research	$BV = OWTP \times \Sigma(N)$ $OWTP = \frac{\Sigma(WTP \times P)}{n}$ Where, BV: Bequest Value; OWTP: average willingness-to-pay; WTP: the amount individuals are willing to pay; P: probability of agreeing to pay; n: number of households; n: total number of respondents	Roldan (2022)	

RESULTS AND DISCUSSION

This section provides valuable insights into the economic valuation of the mangrove forest ecosystem in Argao, Cebu. The socio-demographic description and categories of use and non-use values are further discussed along with the quantification of the use and non-use values leading to the total economic valuation of mangroves. Lastly, a comparison of the total economic valuation by other studies and this study also explores the limiting factors toward mangrove conservation.

Socio-demographic profile

Table 3 provides a detailed overview of the demographic, socioeconomic, and occupational characteristics of the surveyed resource users, shedding light on the community's structure, livelihoods, and income levels. The research indicated that a significant demographic among the respondents is male, making up 75.86% (n: 308.00) of the total surveyed resource users, while females represent 24.14% (n: 98.00). This gender difference may reflect traditional roles in coastal and resource-focused activities, where men frequently participate directly in mangrove-related livelihoods like fishing or gleaning. The respondents are mainly found within the age range of 25 to 50 years, representing 56.40% (n: 229.00) of the total. This working-age group may include individuals actively involved in mangrove-related economic activities. A smaller percentage is over 50 years old (31.28%, n: 127.00), representing long-term residents with extensive experience or dependency on mangroves. Meanwhile, only 12.32% (n: 50.00) are under 25 years old, indicating limited engagement by younger people.

A large portion of respondents have a high school education (46.55%, n: 189.00), closely followed by those with an elementary education (44.58%, n: 181.00). Only a small percentage (8.87%, n: 36.00) have achieved a college education. This limited educational background may affect their job opportunities, further stressing the importance of mangroves as a crucial livelihood source. The data shows that (47.32%, n: 274.00) of the respondents, who are direct mangrove users in Argao, Cebu, participate in fishing as their main occupation. Gleaning (38.00%, n: 220.00) follows, which involves harvesting shellfish, mollusks, and other marine products from the mangrove ecosystem. Other jobs like crab and shrimp collecting, aquaculture farming, and weaving are notably less common. The majority of respondents (97.78%) have a monthly income below PHP 10,957.00. This suggests that most of the direct mangrove users depend on the mangrove ecosystem for their income, and their earnings are relatively low.

Table 3. Socio-demographic profile of mangrove resource users in Argao, Cebu, Philippines (n: 406)

Category	Profile	n	%
Sex	Male	308.00	75.86
	Female	98.00	24.14
Age	<25 years old	50.00	12.32
	25-50 years old	229.00	56.40
	>50 years old	127.00	31.28
Length of residency	<5 years	15.00	3.69
	5-10 years	41.00	10.10
	>10 years	350.00	86.21
Number of dependents	0	76.00	18.72
	1-3	177.00	43.60
	4-6	105.00	25.86
	7-above	48.00	11.82
Education	Elementary Level	181.00	44.58
	Highschool Level	189.00	46.55
	College Level	36.00	8.87
Occupation	Fisherman	274.00	47.32
	Gleaner	220.00	38.00
	Crab and Shrimp Seeker	75.00	12.95
	Aquaculture Farmer	2.00	0.35
	Fish Warden	2.00	0.35
	Judge	1.00	0.17
	Weaver	3.00	0.52
	Tricycle Driver	1.00	0.17
	Government Official	1.00	0.17
Monthly Income	Php <10,957.00-21,914.00	397.00	97.78
	Php 21,914.00-131, 484.00	8.00	1.97
	Php 131,484.00-219, 140.00	0.00	0.00
	Php 219, 140.00-Up	1.00	0.25

Categories of use and non-use values

Table 4 indicates the use and non-use values of mangroves as reported by the resource users in Argao, Cebu. For use values, direct, indirect, and optional uses are expressed. Direct use, which refers to the tangible resources obtained from mangroves for commercial or subsistence purposes (Harini et al. 2019), allows the locals to catch fish and harvest mollusks and shells, crabs, and shrimps. Mangroves also provide essential ecosystem services that support both human activities and environmental health, known as indirect use values. One of the most important of these is carbon sequestration; mangroves absorb and store large quantities of carbon, which is important in order to prevent climate change (Hui et al. 2016). They also function as nurseries, providing breeding and sheltering grounds for fish, mollusks, and crustaceans, thereby supporting fisheries and promoting biodiversity (Malik et al. 2015). Additionally, they offer coastal protection; the intricate root systems of mangroves act as natural barriers, safeguarding communities from storm surges and coastal erosion during typhoons and tsunamis (Huxham et al. 2015). Furthermore, the realization of the significant role of mangroves paved the way for job orders in protecting and preserving them by the local government unit (Quevedo et al. 2019). The Local Government Unit of Argao reported to have budget allocations for these ecological, economic, and employment functions, leading this research to report them as indirect uses of mangroves and eventually assign economic values. Finally, under-use values, mangroves also yield a variety of alternative uses according to the locals. They obtain benefits from them in terms of ecotourism, firewood, goat feed, and nipa thatch. In literature, ecotourism is an important feature, with people drawn to mangrove ecosystems for activities such as boat tours, nature walks, and birding (Ahmad and Suratman 2021). Moreover, mangrove wood is frequently used as an alternative fuel source, being gathered for heating and cooking and collected for firewood in some regions (Malik et al. 2015). Mangroves also provide nipa thatch for traditional roofing and goat fodder, emphasizing their cultural and practical importance (Dang et al. 2022). Hence, this study assigns economic values to domains of use values (i.e. direct, indirect, and optional).

The intrinsic and bequest values of mangroves under non-use values are also documented in the study area. Hence, this study assigns economic values to both non-use values using the resource users' willingness to pay. The intrinsic and bequest values are important for both present and future generations, even if they do not directly relate to resource extraction or immediate economic gains. The inherent importance of mangroves to the environment and local communities adds to their existence value (Hamilton and Casey 2016). In many coastal communities, mangroves are deeply connected to cultural identities. They offer recreational spaces and serve an important function in carbon storage, helping to regulate the global climate by sequestering carbon throughout time (Novizantara et al. 2022). Additionally, awareness that mangroves exist and provide both tangible and intangible benefits to the local community and spiritual value contributes to a better understanding and appreciation of these ecosystems (Pulhin et al. 2017). Meanwhile, the bequest value focuses on the importance of protecting mangroves for future generations. Maintaining mangrove habitats provides peaceful natural environments that society appreciates and protects biodiversity and the important functions they perform in our natural environments (Johari et al. 2023). The diverse life found in mangroves is essential for the ecological system and gives opportunities for future scientific research (Roldan 2022).

Use values

Table 5 presents the economic valuation of mangrove use values in Argao, Cebu, covering a total area of 130.52 hectares. It describes the economic and environmental benefits of mangrove ecosystems and divides the use values into three categories: direct use, indirect use, and optional values.

It is indicated that the highest benefit of use value is in the direct use value (52.77%), which was obtained from fish capture, amounting to Php 134,847,210.00 or USD 2,292,402.57 (44.30%). Most of the direct users of mangroves are fishermen, they mostly capture 71 different species of fish in the area and the most prominent captured fish species is danggit (*Siganus vermiculatus*) (n: 126.00) while the least captured are labayan (*Halichoeres margaritaceus*), mamsa (*Carangoides orthogrammus*), grouper (*Epinephelus* spp.), etc. (n: 1.00). Fishing livelihood is the main source of income for resource users as they sell their catch at the market, while the rest serves as their daily food consumption. Mollusk and shell capture amount to Php 22,187,025.00 or USD 377,179.425 (7.29%). Another coastal livelihood in Argao is gleaning, in which the gleaners mostly capture 18 different species of mollusks and shells in the area. The most prominent captured mollusks or shell species is aninikad (*Strombus urceus*) (n: 164.00), while the least captured are liswe (*Ruditapes philippinarum*), pugita (*Cistopus* sp.), sisi (*Saccostrea cucullata*), etc. (n: 1.00). Similar to fishing, gleaning serves as one of the livelihoods of the direct users as well as one of the ways to acquire food for consumption. The same as reported by Nabua and Roxas (2023), other coastal communities with close proximity to mangroves have fishing as their main livelihood, while some are gleaning. Aside from fish, mollusks, and shellfish products, crab and shrimp capture also contribute to the direct use value, which is Php 3,928,590.00 or USD 66,786.03 (1.29%) and Php 2,696,320.00 or USD 45,837.44 (0.89%) respectively.

Table 4. Use and non-use values of mangrove resource users in Argao, Cebu, Philippines

Use values			Non-use values	
Direct use	**Indirect use**	**Optional**	**Existence**	**Bequest**
Fish	Carbon sequestration	Ecotourism	Culture	Landscape
Mollusks and shells	Nursery/habitat	Firewood	Recreation	Biodiversity
Crab	Coastal protection	Goat feed	Carbon storage	Research
Shrimp	Employment	Nipa thatch	Awareness	
			Religion	

Table 5. Use values of mangroves in Argao, Cebu, Philippines (ha: 130.52)

Category	Use values	Economic value	Total production cost	Net value	%
Direct use	Fish	143,067,210.00	8,220,000.00	134,847,210.00	44.30
	Mollusks and shells	24,387,025.00	2,200,000.00	22,187,025.00	7.29
	Crab	4,165,590.00	237,000.00	3,928,590.00	1.29
	Shrimp	2,816,320.00	120,000.00	2,696,320.00	0.89
Indirect use	Carbon sequestration	876,114.00	-	876,114.00	0.29
	Nursery/habitat	166,413,000.00	39,156,000.00	127,257,000.00	41.80
	Coastal protection	11,420,000.00	-	11,420,000.00	3.75
	Employment	504,000.00	-	504,000.00	0.17
Optional	Ecotourism	1,299,000.00	649,500.00	649,500.00	0.21
	Firewood	440.00	220.00	220.00	0.007
	Goat feed	12,720.00	6,360.00	6,360.00	0.002
	Nipa thatch	3,600.00	1,800.00	1,800.00	0.001
	Total:	354,965,019.00	50,590,880.00	304,374,139.00	100.00

In the indirect use value (46.01%), the mangroves are natural carbon sinks with high capacities to store carbon, which helps reduce the increasing amount of carbon dioxide in the atmosphere, mostly generated from human activities. Mangroves need to be conserved, preserved and improved to help reduce the effects of climate change caused by human activities, in addition to keeping the air clean (Choudhary et al. 2024). The carbon sequestration value of mangroves is Php 876,114.00 or USD 14,893.938 (0.29%). This value was calculated based on the carbon sequestration rate of 188.5-ton C/ha and the total hectares, using the market price of carbon, which is Php 35.61/tCO_2 (USD 0.61 t/CO_2) (Abino et al. 2014; World Bank Group, 2024). Mangroves also function as a nursery or habitat for many marine organisms as they provide food and shelter (Cuenca et al. 2015). The nursery or habitat value of the mangrove of Argao amounts to Php 127,257,000.00 or USD 2,163,639.00 (41.80%). This value was acquired from the calculation of the production and cost of production of aquaculture farms established in the municipality. Furthermore, the mangroves act as a natural protection for the coastline and the communities near them from natural disasters such as typhoons and tsunamis. The same as reported by Asari et al. (2021) in other mangrove areas, they also reduce the impact of damage caused by these disasters that affect the livelihoods and properties in the municipality, which the resource users also state. This benefit amounts to Php 11,420,000.00 or USD 194,140.00 (3.75%) and was acquired from the calculation using the budget of some established coastal protection projects (riprap, seawall) done in the area. Since it is evident how beneficial and important the mangrove ecosystems are, the Local Government Unit (LGU) has established laws and management plans to conserve and preserve them (Quevedo et al. 2019). In the same manner, government officials in Argao recognize the importance of mangroves. Thus, they assigned fish wardens to safeguard the area and were given a monthly salary of Php 2,500.00 or USD 42.73 for the job. Sometimes, when there are mangrove-related activities held by the LGU, a small amount is given to workers as a token of appreciation. The employment value derived from mangrove is Php 504,000.00 or USD 8,568.00 (0.17%).

In the optional value (0.22%), the mangroves are also used for other purposes, such as ecotourism due to the beauty of the landscape it provides through clean seawater, the green canopies, and the marine organisms it houses (Akram et al. 2023). The ecotourism value of mangroves is Php 649,500.00 or USD 11,041.50 (0.21%); this was acquired from the calculation of the total annual service rates of ecotourism operators in Barangay Guiwanon and Bulasa. Moreover, mangroves are also used as firewood, goat feed, and in making of nipa thatch for animal shelter roofs. However, harvesting and pruning of any parts of the mangroves are prohibited by Philippine law and even in other parts of the world (Hossain 2015; Cano et al. 2021). Some resource users utilize these alternative uses of mangroves for their own use and are not intended for selling to the market, which amounts to Php 220.00 or USD 3.74 for firewood, Php 6,360.00 or USD 108.12 for goat feed, and Php 1,800.00 or USD 30.60 for nipa thatch. All of which make up 0.01% of the overall use values. These values are acquired through the calculation of how frequently and how many they harvest, along with the market price of each product used.

Non-use values

Table 6 shows the non-use values in the municipality of Argao, Cebu. Outlining the intrinsic and non-material benefits of several categories, including existence, awareness, and bequest, which add up to Php 3,112,891.00 or USD 52,919.147 in total. As depicted in this table, the economic worth of mangroves tends to embrace various facets of their value, with the most significant contribution coming from bequest values (92.93%). The high valuation of the landscape (Php 979,509.00 or USD 16,651.65) itself stresses the importance of these mangrove ecosystems as viable pathways for coastal protection against erosion or storm surges and enhancing aesthetic and recreational opportunities. The biodiversity value (Php 976,123.00 or USD 16,594.09), on the other hand, extols the ecological significance of mangroves as nurseries and habitats for various marine species, which are vital for ecosystem balance and supporting fisheries. At the same time, the research value (Php 944,359.00 or USD 16,054.10) emphasizes the importance of these mangroves scientifically, with a big potential for climate resilience studies and environmental restoration.

Meanwhile, existence values (7.07%) account for a lesser value among overall non-use values because the benefits it provides are intangible, like the simple knowledge about mangroves' being here, which does not translate to direct benefits immediately relevant to the community (Pulhin et al. 2017), cultural value is merely at Php 53,000.00 or USD 901.00 (1.51%) as it indicates how mangroves give a sense of importance about culture but perhaps not widespread in the community or truly reflected in daily life (Primavera 2006). Recreational value is low at Php 52,500.00 or USD 892.50 (1.59%) because the ecotourism infrastructure is underdeveloped, and there is little promotion of mangroves as recreational destinations, resulting in fewer opportunities for economic and social benefits from recreational activities. The carbon storage value is also low at Php 52,400.00 or USD 890.80 (1.51%). Although mangroves play a vital role in global climate regulation, the economic value of carbon sequestration is often undervalued in local contexts where its direct benefits are not immediately apparent (Donato et al. 2011). Correspondingly, the awareness value, at Php 52,100.00 (1.46%), is moderate because the understanding within the community of mangroves' ecological values is also low. It can be increased through education and advocacy activities (Pulhin et al. 2017). Lastly, the religious value, at Php 2,900.00 (1.00%), is the least in all categories, suggesting that the spiritual value of mangroves is not commonly acknowledged or deeply inculcated in religious practices in the locality. Lower values of non-utilitarian values reflect the need for community engagement, education programs, and infrastructure development so as to understand better and appreciate the various non-utilitarian benefits mangroves offer.

The contrast of highest and lowest values brings into evidence the diverse roles of mangroves. The premier values in terms of landscape, biodiversity, and research are manifestations of environmental and long-term socioeconomic benefits. Meanwhile, lowly-ranked values such as religion call for a comprehensive conservation approach and integration of both tangible and intangible benefits to promote a greater awareness level and involve the public and community in mangrove conservation efforts more deeply. This ensures proper management and sustainable systems of mangrove ecosystems for future generations (Madid 2017; Pulhin et al. 2017; Garcia et al. 2019).

Total economic valuation

Table 7 quantifies the annual Total Economic Value (TEV) of mangroves in Argao, Cebu. Covering a total area of 130.52 hectares. These coastal ecosystems contribute Php 307,487,030.00 or USD 5,227,279.51 to the local economy each year. The resulting TEV was derived from both use values as direct, indirect, and optional use of the mangrove ecosystem (e.g. fishing, gleaning, goat feeding, etc.) and non-use values as intangible benefits (e.g. recreation, carbon storage, biodiversity conservation, etc.) as recommended by Sondak et al. (2019). The economic value of mangroves in Argao, Cebu, is substantial, with the use values dominating the total valuation. This signifies the importance of the mangrove ecosystem for local livelihoods. The non-use values, though smaller in percentage, accentuate the vast ecological and societal benefits of mangroves.

Comparison of the total economic value

Table 8 compares the total economic value of the different mangrove ecosystems in the Philippines, specifically Banacon in Bohol, Kamuning in Palawan, Zamboanga City, Tawi-Tawi Islands, and Argao in Cebu. Limited studies quantify the total economic value of mangrove ecosystems in the Philippines.

Table 6. Non-use values of mangroves in Argao, Cebu, Philippines (n: 406; N: 7513)

Category	Non-use values	Economic value	%
Existence	Culture	53,000.00	1.51
	Recreation	52,500.00	1.59
	Carbon storage	52,400.00	1.51
	Awareness	52,100.00	1.46
	Religion	2,900.00	1.00
Bequest	Landscape	979,509.00	31.40
	Biodiversity	976,123.00	31.29
	Research	944,359.00	30.24
Total		3,112,891.00	100.00

Table 7. Total economic valuation of mangroves in Argao, Cebu, Philippines (ha: 130.52)

Category	Annual economic value	%
Use Values	304,374,139.00	98.9
Non-Use Values	3,112,891.00	1.01
Total Economic Valuation	307,487,030.00	100.00

Table 8. Comparison of the total economic value by other studies in the Philippines

Title of the study	Total mangrove area (ha)	Total economic value (USD/year)	References
Economic valuation of mangroves in Tawi-Tawi Islands, Southern Philippines: A market price and contingent valuation approach	11,272 ha	36,255,856.00-53,353,223.00	Roldan (2022)
Economic valuation for sustainable mangrove ecosystems management in Bohol and Palawan, Philippines	836 ha-Kamuning, Palawan 470 ha-Banacon, Bohol	469,777.38 400,037.57	Carandang et al. (2013)
Economic valuation of mangrove forest ecosystem in Zamboanga City in the Philippines	503 ha	1,559,918.88	Alvarez and Otadoy (2023)
Economic valuation of a protected mangrove forest in Southern Cebu, Philippines	130.52 ha	5,227,279.51	*This study*

Tawi-Tawi Islands, with 11,272 ha of mangroves, the largest mangrove area coverage of study among the four locations excluding the study site of this research, has the highest total economic value, which ranges from 36,255,856.00-53,353,223.00 USD/yr. This means a total of the same hectares or area of this study (130.52 ha) would result in a total economic value of USD 615,322.834 yearly in Tawi-Tawi Islands. Its parameters of values include fish and seaweed value: timber, charcoal, nipa palm crafts, tanbarks, coastline protection, seawater intrusion prevention, nursery grounds, carbon sequestration, medicine, and biodiversity. It had taken all account of direct and indirect uses of mangroves from locals that depend greatly on them as well as optional uses such as medicine and the significance of preserving the mangroves for their function and future generations.

Meanwhile, the mangrove economic valuation of Banacon, Bohol, and Kamuning, Palawan, focused on fishery values, biodiversity, and recreational values. Despite Kamuning, Palawan having the second largest coverage of mangrove area, its total economic value of mangroves amounts to USD 469,777.38/yr which is lower than Zamboanga City. It could be inferred that the study fails to consider other benefits that may be used for quantifying its total value such as coastal protection and others.

Zamboanga City has 503 ha, which gained USD 1,559,918.88/yr, which comprises fishery resources, fish value obtained from the potential of mangroves as nursery, feeding and breeding grounds, carbon sequestration value, coastal protection value, willingness-to-pay for mangrove conservation program, and willingness to work for mangrove parameters. The study considered a lot of factors and benefits that can be derived from using the mangrove goods and services it provided. Still, it failed to consider quantifying forestry products due to the prohibition of the law in cutting or harvesting mangroves. On the other hand, this study, which estimates the mangrove ecosystem of Argao, Cebu, with 130.52 hectares amounts to USD 5,224,440.02/yr. The parameters quantified in this study are fishery products (e.g. fish, mollusks and shells, crabs, and shrimps), carbon sequestration, nursery or habitat, coastal protection, employment, ecotourism, forestry products (e.g. firewood, goat feed, and nipa thatch), preservation of the cultural significance, recreation, carbon storage, awareness of existence, religion, landscape, biodiversity, and research. It takes account of the tangible and intrinsic values the mangrove ecosystem offers for human use. All of the studies have different estimations of the total economic value of mangroves, fit for the mangrove area and the goods and services humans set a price on. Thus, this study concludes that when conducting an economic valuation study, the outcome of the total economic value is influenced by a variety of factors, including the quantity and type of values being measured, the current state or condition of the mangrove area, and the extent of the mangrove area under study.

Limiting factors toward mangrove conservation

Mangroves in Argao, Cebu, encompass vital ecosystem services such as coastal protections, carbon storage, and supporting marine biodiversity. However, these face myriad conservation challenges from anthropogenic activities, global changes, and the purview of locals. Such constraining factors, along with their consequences, could be important in creating sustainable strategies for conservation practices. Table 9 shows the factors hindering mangrove conservation in Argao, summarized along with their impacts and possible solutions.

Some limiting factors characterize mangrove conservation in Argao to render restoration and protection efforts ineffective. Several threats, include unsustainable aquaculture practices, deforestation, and climate change, pose a serious threat to mangrove ecosystems in the region. These not only threaten the ecological health of the mangroves but also compromise their vital services to local communities, such as carbon sequestration, biodiversity, and coastal protection. However, there is an increasing recognition of the need to complement restoration programs with community-based conservation strategies, sustainable management, and climate adaptation efforts. These constraints would require a joint effort of local communities and governmental agencies with the environmental organizations in mobilizing relatively increased investments in research and public awareness campaigns into a future pristine mangrove ecosystem.

Table 9. Limiting factors to mangrove conservation in Argao, Cebu, Philippines

Limiting factors	Implications to health of mangroves	Suggested mangrove conservation efforts
Coastal development	Infrastructure projects and urban expansion lead to mangrove deforestation and habitat fragmentation	Zoning and regulating land use to prevent mangrove clearing for developments; Implementing local government ordinances to protect mangrove ecosystems (Primavera et al. 2018)
Aquaculture expansion	Fishpond conversions result in mangrove loss, soil degradation, and reduced ecological services	Restoring abandoned aquaculture sites and enforcing stricter policies against illegal fishpond expansion to reclaim mangrove habitats (Alongi 2015)
Climate change	Rising sea levels and increased storm surges cause erosion and submersion of mangrove areas, reducing survival rates	Planting mangroves in areas with natural tidal processes and promoting resilient mangrove species to withstand changing climatic conditions (Osland et al. 2019)
Community livelihood dependency	Overharvesting for wood, fuel, and other products degrades mangrove ecosystems and slow regeneration	Providing alternative livelihoods, such as ecotourism and sustainable aquaculture, to reduce dependency on mangrove resources (Friess et al. 2019)
Insufficient local awareness	Limited understanding of the ecological importance of mangroves has resulted in unsustainable practices and weak conservation efforts	Conducting educational campaigns and workshops, community extension projects, and integrating mangrove conservation topics into local school curricula to raise awareness (Pandisamy et al. 2020)

In conclusion, mangrove ecosystems in Argao, Cebu, spanning 130.52 hectares, are essential for economic, environmental, and cultural sustainability, with a total annual economic value of Php 307,487,030.00 or USD 5,227,279.51.00/yr. Use values encompass direct use, indirect use, and optional values, highlighting their critical role in supporting livelihoods, carbon sequestration, and coastal protection, which underscore their importance in combating climate change and mitigating natural disasters, and alternative uses that have not been realized. Non-use values include the intrinsic benefit it provides in the present and future through existence and bequest value, which underscore the satisfaction of users to its goods and services. However, threats like urbanization, aquaculture expansion, and unsustainable practices call for urgent conservation efforts. The study underscores the need to protect mangroves for future generations through effective conservation efforts that will safeguard not only Argao's mangroves but also the broader environmental and economic stability they support. Then, to achieve this, the study recommends enhancing the legal framework by passing or revising legislation to provide stronger protection for mangroves, ensuring precise guidelines for their preservation, restoration, and sustainable use in Argao, Cebu. This is a task that requires the collaboration of all stakeholders, including local government officials, environmental organizations, and community leaders. Implementing evaluation and monitoring programs to regularly monitor the survival and growth of planted mangroves, along with biodiversity changes, water quality, and sediment accretion, to evaluate planting initiatives and adjust management plans accordingly, promoting ecotourism and awareness by developing community-based ecotourism initiatives, such as birdwatching and educational tours, to generate income while fostering conservation awareness and highlighting the ecological importance of mangroves; enforce sustainable harvesting practice by establishing strict regulations for sustainable resource collection, ensuring the prevention of overharvesting of mud crabs, mollusks, and other mangrove-associated species to protect ecosystem balance; and conduct cost-benefit analyses to compare the economic value of mangrove ecosystems and aquaculture activities to provide critical data for decision-making, particularly in addressing threats from aquaculture expansion. These are all actions that we can take together to ensure the future of our mangroves and our community.

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