ECOSYSTEM ACCOUNTS FOR THE INSULAR EXCLUSIVE ECONOMIC ZONE OF ECUADOR

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THE MISSION OF THE CHARLES DARWIN FOUNDATION AND ITS RESEARCH STATION IS TO TACKLE THE GREATEST THREATS AND CHALLENGES TO GALAPAGOS THROUGH SCIENTIFIC RESEARCH AND CONSERVATION ACTION, IN ORDER TO SAFEGUARD ONE OF THE WORLD'S MOST IMPORTANT NATURAL TREASURES IMPORTANT IN THE WORLD.

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"ECOSYSTEM ACCOUNTS FOR THE INSULAR EXCLUSIVE ECONOMIC ZONE OF ECUADOR"

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ABSTRACT

Ecosystem Accounts provide a conceptual and analytical framework and a systematic approach to measuring, monitoring, and valuing the ecosystem services provided by nature. Additionally, they serve as a tool for integrating the values of ecosystem services into national economic accounts and, consequently, into public policy and decision-making processes. Traditionally, the methodological development of ecosystem accounts has focused primarily on terrestrial ecosystems, making their application to a marine-coastal and insular context a pioneering contribution both nationally and regionally.

Ecuador's Insular Exclusive Economic Zone (EIEEZ) is the maritime area where the Ecuadorian state exercises sovereignty and exclusive rights for the use and exploration of marine, coastal, and oceanic resources. The EIEEZ extends beyond Ecuadorian territorial waters near the coastal profile and is specifically located around the Galápagos Archipelago, holding significant economic and geopolitical importance for the country. Within this zone, there are two protected areas: the Galápagos Marine Reserve (GMR) and the Hermandad Marine Reserve (HMR). Both marine protected areas (MPAs) are managed under a zoning scheme with differentiated uses, where human activities related to productive exploitation and the sustainable use of ecosystems are clearly identified and play a central role in key productive sectors such as artisanal fishing, industrial fishing, tourism, passenger maritime transport, and cargo maritime transport. These economic activities utilize and transform key ecosystem services. Additionally, carbon sequestration, particularly in the mangroves of the Galápagos Marine Reserve, is an ecosystem service that generates economic benefits within this marine area, reinforcing its importance for global carbon emission mitigation, biodiversity conservation, and local sustainable development.

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This research presents the main findings related to the application of ecosystem accounting methodologies in a marine context, aiming to assess the ecosystem services of the EIEEZ and analyze their environmental and economic impacts. The study includes an evaluation of the extent and condition of marine ecosystems, including mangroves, pelagic zones, and coral reefs, as well as the quantification of their biodiversity and contributions in both physical and monetary terms. Key biological aspects, such as species diversity in rocky reefs, have been analyzed. Additionally, the study estimates the value of essential ecosystem services provided by these ecosystems, including blue carbon sequestration in mangroves, the economic impact of tourism, and the economic valuation of industrial and artisanal fishing.

The results of this study reveal that the most significant and relevant ecosystem services of the EIEEZ, based on their importance for the local economy, their connection to human well-being, and their value for policymakers and decision-makers, include blue carbon sequestration in the mangroves of the Galápagos Marine Reserve, which stored 1,824,240 tons of carbon in 2018, with an annual flux of 600.9 tons. This ecosystem service not only contributes to climate change mitigation but also functions as a highly efficient carbon sink, generating direct and indirect benefits for both the local and global economy.

Tourism is another strategic economic activity in the region, showing a notable 27% growth in visitor numbers between 2014 and 2018. In 2018 alone, inbound tourism generated over $275 million, representing 93% of the province's tourism expenditure. This report disaggregates tourism data based on visits to different ecosystems within the EIEEZ. The findings indicate that this sector, in addition to driving economic growth, depends directly on the biodiversity and ecosystems of the EIEEZ, as the natural appeal of the Galápagos is a key factor in attracting visitors and sustaining tourism activities.

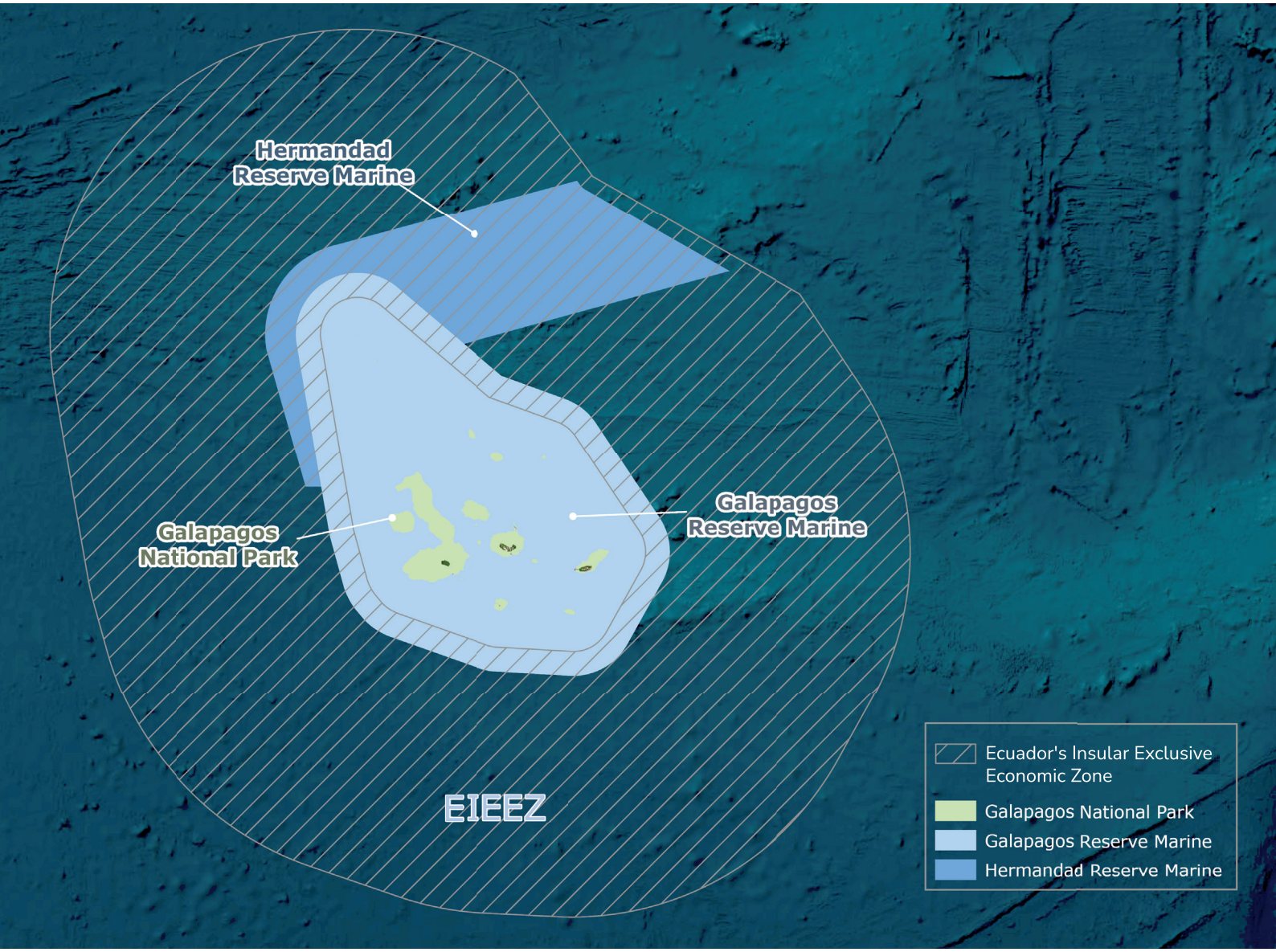
In the fishing sector, another highly relevant economic activity, industrial fishing generated $87.5 million in revenue in 2014 and $101.6 million in 2018, while artisanal fishing, although smaller in scale, remains essential for the local economy and food security of coastal communities, generating $10.38 million in 2014.

From a biological and ecological perspective, marine environments exhibited concerning trends in some ecosystem condition indicators. For example, the Shannon-Weaver diversity index for rocky reefs in the Galápagos Marine Reserve showed a slight decline in species diversity between 2014 and 2018, which may reflect structural changes in marine communities. This result highlights the need to strengthen conservation measures to preserve biodiversity and enhance ecosystem resilience.

Finally, economic activities within the EIEEZ, primarily tourism, industrial and artisanal fishing, and maritime transport, generated more than 41,000 jobs in 2018, reflecting their crucial role in Ecuador's socioeconomic development. This study not only quantifies the benefits of marine ecosystems but also provides a solid foundation for designing public policies that balance economic development with environmental sustainability, positioning the EIEEZ as a model for integrated marine ecosystem management in the region. This research underscores the importance of the EIEEZ as a strategic space for Ecuador's sustainable development, both economically and environmentally. The findings highlight how productive activities and ecosystem services within the EIEEZ not only contribute to the well-being of local communities but also help address global challenges such as climate change and biodiversity loss. Furthermore, the application of ecosystem accounts in a marine context demonstrates their potential to effectively integrate conservation and development, offering a replicable model for other regions worldwide.

BACKGROUND

The Exclusive Economic Zone (EEZ) is the maritime area extending from the outer edge of a country's territorial sea up to 200 nautical miles offshore. Ecuador's Insular Exclusive Economic Zone (EIEEZ) refers to the maritime area surrounding the Galápagos Islands, measured from the coastal baseline, and extending up to 200 nautical miles, equivalent to 370.4 kilometers ***(Ministry of the Environment, Water and Ecological Transition).***



Ocean base map sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors.
Prepared by MAATE (Directorate of Environmental and Water Education and Information for the Ecological Transition, Management of Environmental and Water Geoinformation) and intended for educational purposes.

In 1998, the Law of the Special Regime for the Conservation and Sustainable Development of Galápagos (LOREG by its Spanish acronym) expanded the marine protected area and created the Galápagos Marine Reserve (GMR). With an area of 138,665 square kilometers, the GMR is one of the 15 largest marine protected areas in the world, also recognized internationally as a premier site for scuba diving ***(DPNG, 2014).***

Following the Ministerial Agreement No. 005-2022, issued on January 14 and published on January 21, 2022, a new marine protected area adjacent to the GMR was established, namely the Hermandad Marine Reserve (HMR). Located in the open waters of the EIEEZ, northwest of the GMR, this reserve covers 60,000 square kilometers. The HMR is part of the Eastern Tropical Pacific Marine Corridor (Galápagos – Hermandad – Cocos – Coiba – Malpelo – Gorgona), a region rich in seamounts and pelagic ecosystems. These features are essential for marine biodiversity as they serve as important natural aggregation areas and migratory routes for endangered and commercial species ***(Ministerio del Ambiente, 2023).***

Historically, the development of ecosystem accounts has focused on terrestrial ecosystems such as forests, wetlands, and agricultural lands ***(Bagstad et al., 2021).*** In contrast, applications in marine and coastal environments remain limited. A recent global review found only ten publicly available ocean ecosystem accounting studies, highlighting a significant gap in the development and application of methodologies for these settings, particularly in regions of global importance ***(Cummins et al., 2023).***

Most existing studies concentrate on coastal and nearshore habitats, which are easier to access and map due to better data availability. However, deep-sea and offshore ecosystems, such as seamounts and pelagic zones, present ongoing methodological challenges to developing ecosystem accounts. In this context, assessing the EIEEZ offers a critical opportunity to extend the reach of ecosystem accounting into offshore ocean environments, contributing to more comprehensive and representative assessments.

Experiences in the United States and the European Union demonstrate the value of implementing ecosystem accounting approaches to guide environmental policymaking, while also revealing difficulties in integrating biophysical and economic data in marine contexts **(Cummins et**

al., 2023). Pilot projects such as the Long Island Coastal Bays study explore the application of the System of Environmental Economic Accounting – Ecosystem Accounting (SEEA-EA) in marine settings. These efforts underscore the need for improved data availability and quality to support effective implementation **(Dvarskas, 2019)** and serve as a seminal reference for the present study.

This research aims to:

- Apply the SEEA-EA framework to ecosystem services within Ecuador's Insular Exclusive Economic Zone (EIEEZ).
- Quantify the extent and condition of marine ecosystems, including mangroves, pelagic zones, and coral reefs.
- Estimate the economic and physical value of key ecosystem services in the EIEEZ, focusing on blue carbon sequestration, and provision service to tourism and fisheries activities.
- Identify trends and threats affecting marine ecosystems and highlight their importance to the local economy.

The report is organized into several key sections, beginning with a description of the SEEA-EA methodology and its application to marine ecosystems. It then analyzes blue carbon sequestration in the EIEEZ, with a focus on the role of mangroves as important carbon sinks. This is followed by an assessment of the economic contribution of tourism and its relationship with biodiversity conservation. Next, the report examines both industrial and artisanal fisheries, discussing their economic significance and sustainability challenges. A hybrid supply–use table is presented to integrate physical and monetary data, providing a clearer picture of how ecosystems support economic activities. The report concludes with key findings and policy recommendations, followed by references and annexes with supplementary information.

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METHODOLOGY OF ECOSYSTEM ACCOUNTING AND ITS APPLICATION TO MARINE ECOSYSTEMS

The concept of ***"Ecosystem Accounting"*** *was formalized in 2012 by the United Nations through the launch of the System of Environmental Economic Accounting (SEEA).*

Since then, this methodological framework aims to integrate environmental and economic data to better reflect the interactions between ecosystems and human economic activity. By doing so, it provides a solid foundation aimed at informing public policies for sustainable development. Ecosystem accounts are developed through the integration of biophysical and economic data using the SEEA-Ecosystem Accounting (SEEA-EA) framework. These accounts typically include variables such as the extent and condition of ecosystems, the supply of ecosystem services (e.g., carbon sequestration, water provision, fisheries, recreation), and their value expressed in both physical and monetary terms. This information is derived from satellite imagery, ecological inventories, national economic statistics, and biophysical models, enabling a systematic and quantitative assessment of nature's contributions to the economy and human well-being.

Ecosystem accounting is essential for understanding and valuing the critical role ecosystems play in sustainable economic development and human welfare. These accounts provide a comprehensive framework for measuring a country or region's natural capital and quantifying the economic benefits derived from ecosystem services such as clean water provision, crop pollination, climate regulation, and biodiversity conservation. By integrating the value of ecosystem services into national accounts, decision-makers can make more informed and balanced choices that account for both economic growth and environmental sustainability (UN, System of Environmental-Economic Accounting, 2021). In the case of marine and coastal ecosystems, quantifying these benefits is particularly important, as over three billion people rely directly on these ecosystems for their livelihoods and food security (FAO, 2022). However, growing threats such as fishery collapses, pollution, and climate change pose significant risks to marine ecosystems and the communities that depend on them. Marine degradation not only impacts biodiversity but also has serious economic and social consequences for the most vulnerable populations.

Methodologically, the SEEA-EA begins with the account of ecosystem extent, which identifies and measures the area covered by different ecosystems within a defined region. Based on this, the ecosystem condition account is developed to assess the health and quality of these ecosystems using biophysical indicators such as biodiversity, ecological integrity, and key ecosystem functions. Next, a physical supply and use table is constructed to describe the flow of ecosystem services in biophysical units (e.g., metric tons of carbon sequestered, or kilograms of fish harvested), capturing the availability and demand for these services. Finally, economic valuation techniques are applied to translate these physical flows into monetary terms, resulting in a monetary supply and use table. This integration allows the inclusion of ecosystem data into national accounts and supports the formulation of evidence-based environmental policies.

ECOSYSTEM EXTENT AND CONDITION ACCOUNTS

Within the EIEEZ, ecosystems are generally classified into two broad categories: coastal ecosystems and marine ecosystems. The variation in terrestrial ecosystems is primarily determined by vegetation types, which in turn are influenced by abiotic factors such as climate, soil type, precipitation, and altitude. In contrast, differences in marine ecosystems are shaped by characteristics such as seafloor depth, and the geomorphology of the ocean floor, specifically the slope of rocky walls and the presence of underwater features like seamounts or mid-ocean ridges, the type and size of the sediment, orientation, and the influence of currents and wave action, among others. ***(Moity and Rivas-Torres, 2018).***

For the ecosystem accounts of the Galápagos Marine Reserve (GMR) and the Hermandad Marine Reserve (HMR), both located within the EIEEZ, the study focuses on two reference years: 2014 and 2018. These years are selected based on the availability of relevant biophysical and socioeconomic data needed for the valuation of ecosystem services. The year 2014 serves as a baseline due to its detailed information on ecosystem extent and condition, as well as consolidated data on associated economic activities. It is considered a stable reference point without major data revisions or reprocessing. The year 2018 is chosen as the most recent period with accessible and representative information, although it remains subject to updates as new scientific studies are finalized. Table 1 summarizes the marine ecosystems included in this study and provides estimates of their spatial extent within the GMR and HMR areas of the EIEEZ. Specifically, mangroves (MT) cover approximately 36.57 km²; rocky bottoms and vertical walls (M1) span 306.71 km²; coral reefs (M1) extend over 1.82 km²; sandy bottoms (M1) cover 38.94 km²; pelagic zones (M2) represent by far the largest area, with an estimated 843,423.60 km²; and shallow banks (M3)[1] account for 3,349.70 km². Table 2 presents indicators of the condition of ecosystems existing within the EIEEZ; ecosystems are classified based on the functional typology of biomes present in the areas where such ecosystems are located.


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[1] Established in Table 1, on the functional typology of biomes, the acronyms represented in this paragraph represent: MT: Marino terrestres
M1: Marine shelf biome
M2: Pelagic oceanic biome
M3: Deep seabed biome

Table 1. Estimated Extension of ecosystems and habitats in the Galapagos Marine Reserve and Hermandad Marine Reserve, within Ecuador's Insular Economic Exclusive Zone (EIEEZ)

Ecosystem	Extension in km²
Mangroves – MT	36.57
Rocky bottoms and vertical walls - M1	306.71
Coral reefs - M1	1.82
Sandy bottoms - M1	38.94
Pelagic zones - M2	843,423.60
Shallow banks - M3	3,349.70

Source: Moity, Nicolas, 2024 (Fundación Charles Darwin, datos no publicados); Moity et al., 2019
Elaborated by authors.

Condition data in the IEEZ are established based on the functional typology of biomes within the areas where the different ecosystems are located.

Table 2. Condition of marine ecosystems in Ecuador's Insular Exclusive Economic Zone (EIEEZ)

Indicators of condition by ecosystem	Units	2014	2018
Pelagic zones - M2			
Chlorophyll concentration	mg/m^3	0.2430385	0.2645192
Dissolved oxygen	mmol/m^3	212.0046	213.9094
Rocky reef – M1			
Reef health index: Fish	Shannon-Weaver Diversity Index	3,26	3.10
	Species richness	33	32
	Sorensen Dissimilarity Index	0,53	0.42
Reef health index: Mobile macroinvertebrates	Shannon-Weaver Diversity Index	1.83	1.95
	Species richness	10	13
	Sørensen Dissimilarity Index	0.53	0.48
Mangrove – MT			
Mangrove cover	Hectares (ha)	3,657.1	3,800.5
Seamounts and shallow features – M3			
Ecological index – Fish community	Kg/m^2	No data	No data
Ecological index – Macroinvertebrate community	Kg/m^2	No data	No data

Source: E.U. Copernicus Marine Service Information; https://doi.org/10.48670/moi-00019; CDF, 2023; Moity et al., 2019. Elaborated by authors.

CARBON SEQUESTRATION IN ECUADOR'S INSULAR EXCLUSIVE ECONOMIC ZONE (EIEEZ)

Carbon sequestration in marine ecosystems, commonly referred to as blue carbon, *is a key regulating ecosystem service provided by habitats such as mangroves, salt marshes, and seagrass meadows. .*

These ecosystems absorb and store atmospheric carbon dioxide (CO_2), playing a significant role in climate change mitigation ***(Duarte, Middelburg, & Caraco, 2005)***. In the Galápagos Islands, mangroves are particularly valuable due to their high capacity to retain carbon in both soil and biomass, making them among the most efficient natural carbon sinks of the archipelago. In addition to their climate function, mangroves contribute to coastal protection, reduce erosion, support marine biodiversity, and provide critical habitats for key species ***(Tanner et al., 2019; Moity et al. 2024).***

Their conservation and sustainable management not only contribute to global climate goals but also generate direct and indirect economic and social benefits for local communities.

This study uses market prices to estimate the economic value of carbon sequestration. In 2014, the market price of carbon was relatively low at US $6.00 per metric ton of CO_2, largely due to a surplus of emission permits ***(WorldBank, Ecofys, and VividEconomics, 2017).*** By 2018, this price rose to US $20.00 per metric ton, driven by policy reforms in the European carbon market aimed at reducing permit supply and boosting value ***(WorldBank, Ecofys, and VividEconomics, 2024).*** Table 3 presents the estimated carbon biomass, stock, annual sequestration flows, and corresponding economic values for mangroves

and pelagic zones in Ecuador's Insular Exclusive Economic Zone (EIEEZ). In both years, mangroves accounted for the entirety of the measurable annual carbon sequestration flow, while pelagic zones, although storing substantial carbon stocks, did not show measurable annual fluxes. Accordingly, the economic value of carbon sequestration in mangroves increased from US $3,605 in 2014 to US $12,018 in 2018, highlighting their growing importance as natural climate solutions.

Table 3. Estimated Carbon Biomass, Stocks, Flows, and Economic Value in Ecuador's Insular Exclusive Economic Zone (EIEEZ), 2014 and 2018.

	2014	2018
ECOSYSTEM TYPE [1]	**Biomass (t)**	**Biomass (t)**
Mangroves – MT	1,151,986.5	1,197,157.5
Pelagic Zones - M2		
TOTAL	**1,151,986.5**	**1,197,157.5**

[1] Table referring to the estimated amount (t) of organic matter, both living and dead, present in these ecosystems.

CARBON SEQUESTRATION (Stock)[2]	**Total (t)**	**Total (t)**
Mangroves – MT	1,755,408.0	1,824,240.0
Pelagic Zones - M2	966,815,944.9	966,815,944.9
TOTAL	**968,571,352.9**	**968,640,184.9**

[2] The table refers to the carbon stock in tons in the two mentioned ecosystems. The accumulated carbon values on the seafloor in the EIEEZ are based on Atwood, 2020; Cartapanis, 2016; and spatial analysis by Moity, 2024 (unpublished data).

CARBON SEQUESTRATION (Flow)[3]	**Total (t/year)**	**Total (t/year)**
Mangroves – MT	600.9	600.9
Pelagic Zones - M2	$6.6x10^{-16}$	$6.6x10^{-16}$

[3] Table referring to the estimated carbon fluxes for the years 2014 and 2018 in the two proposed ecosystems, based on Vaughn et al., 2020.

CARBON MARKET PRICE [4]	**Total (US$/t)**	**Total (US$/t)**
Mangroves – MT	6	20
Pelagic Zones - M2	6	20

[4] Price in US$ per metric ton of carbon.

ECONOMIC VALUE	**Total (US$)**	**Total (US$)**
Mangroves – MT	3,605.46	12,018.20
Pelagic Zones - M2		
TOTAL VALUE	**3,605.46**	**12,018.20**

Source: Moity, Nicolas, 2024 (Charles Darwin Foundation)
Elaborated by authors.

TOURISM IN THE ECOSYSTEM ACCOUNTS OF THE EIEEZ

The integration of tourism and its associated services in the Ecosystem Account follows the guidelines set out by the United Nations' Tourism Satellite Account: Recommended Methodological Framework (2008).

In this framework, tourism is evaluated from the demand side—that is, through the expenditures made by tourists engaged in experiential tourism activities, focusing specifically on inbound and domestic tourism in the Galápagos Islands. This study focuses on inbound tourism, which accounts for the vast majority (93.45%)[2] of total tourism expenditure in Galápagos. In practical terms, for every 100 monetary units spent on tourism-related products, 93.45 units were spent by non-resident visitors ***(Rosero & Turismo, 2015).***

In 2014, the Galápagos National Park (GNP) reported 215,691 visitors, of which 70,000 were domestic (Ecuadorian) and 145,691 were international visitors ***(PNG & OTG, 2014).***

By 2018, the total number of visitors had increased to 275,817, including 75,000 domestic and 200,817 international tourists ***(PNG & OTG, 2018).*** This increase reflects a significant growth in both domestic and international tourism.

The total inbound tourism expenditure is the sum of expenditures by domestic and international visitors. These were calculated by multiplying the average expenditure per tourist by the number of visitors in each group. According to 2024 monitoring data, the average expenditure was US $251.67 for domestic tourists, and US $1,393.73 for international visitors.

To express these values in real terms and account for inflation, expenditures were deflated using the Consumer Price Index (CPI), with 2014 as the base year. Applying this deflation, the adjusted domestic tourist expenditure accounts for US $221.58 in 2014, and US $231.98 in 2018. Meanwhile, the adjusted expenditure of foreign tourists accounted for US $1,227.09 in 2014, and US $1.284,66 in 2018.

[2] **Inbound Tourism:** : Refers to the activities of people who travel to a country other than their usual residence for a period of no more than one year, and whose primary purpose is not to engage in paid activity in the country visited.
Outbound Tourism: Involves the activities of residents of a country who travel to another country for no more than one year, for purposes other than earning income in the country visited.
Domestic Tourism: Includes the activities of residents of a country who travel within the same country, but outside their usual environment, also for a period of no more than one year (Cañada, Regional Tourism Satellite Account, 2015).

Table 4. Inbound tourist expenditure in Galápagos, 2014 and 2018

EXPENDITURE ON TOURIST SERVICES			
Domestic tourists			
Year	Number of visitors	Average expenditure (US$/visitor)	Total expenditure (US$/year)
2014	70,000	221.58	15,510,565.24
2018	75,000	231.98	17,398,147.29
Foreign tourists			
Year	Number of visitors	Average expenditure (US$/visitor)	Total expenditure (US$/year)
2014	145,691	1,227.09	178,776,120.29
2018	200,817	1,285.66	257,982,005.17

Source: Galápagos National Park Directorate and lead author.
Elaborated by authors

Table 4 summarizes the estimations of tourism production based on the tourist expenditure figures presented above. The total tourism-related production is estimated at US $194.29 million in 2014, rising to US $275.38 million in 2018. In 2014, 32.45% of visitors were domestic tourists and 67.55% were international. By 2018, international visitors represented 72.8% of the total, highlighting the growing importance of inbound tourism for Galápagos. The average length of stay for visitors in the Galápagos is approximately 7 days, based on local survey data.

According to the visitor's management system of the Galápagos National Park Directorate, SIMAVIS, there were 29 mangrove-associated visitation sites receiving up to 558,000 annual visits, and 29 pelagic ecosystem dive sites permit up to 296,000 annual visits. These figures highlight the ecological and economic importance of both mangrove and pelagic ecosystems to Galápagos' tourism industry.

FISHERIES IN THE ECOSYSTEM ACCOUNTS OF THE EIEEZ

Fisheries represent one of the most important economic activities in the Ecuador's Insular Exclusive Economic Zone (EIEEZ), including both industrial and artisanal fishing. The primary distinction between the two lies in their scale and operational characteristics: artisanal fisheries are conducted on a small scale, typically by local fishers using modest vessels, whereas industrial fisheries involve large-scale operations with advanced fleets and equipment.

According to the Inter-American Tropical Tuna Commission (IATTC), the Ecuadorian tuna fleet captured 51,480 metrictons of tuna in the EIEEZ in 2014, increasing to 67,773 metric tons in 2018. However, industrial tuna fishing extends beyond the EIEEZ to the continental Ecuadorian EEZ, where 53,261 metric tons were recorded in 2014 and 70,697 metric tons in 2018. Additionally, Ecuadorian vessels operate in international waters and third-country zones, where captures reached 203,293 metric tons in 2014 and 209,684 metric tons in 2018—constituting a substantial share of Eastern Tropical Pacific regional tuna fisheries (Table 5).

The unit price of tuna in the EIEEZ was estimated at US $1700 per metric ton in 2014 and US $1500 per metric ton in 2018, according to FAO-GLOBEFISH. The decline in prices reflects global overproduction of tuna, highlighting the importance of monitoring both economic and ecological impacts of fishing activities in the region. From this data, the monetary value of tuna captured in the EIEEZ was US $87.52 million in 2014, and US $101.66 million in 2018

Table 5. Tuna catches of the Ecuadorian fishing fleet, by maritime zone

CATCH BY ZONES (TONS)	2014	2018	2014 PRICE US$/t	2018 PRICE US$/t
Continental EEZ of Ecuador – Catch (t)	53,261 t	70,697 t		
Insular EEZ (IEEZ)	51,480 t	67,773 t	USD 1,700	USD 1,500
International and third-country waters	203,293 t	209,684 t		
CAPTURA TOTAL	256,564 t	280,364 t		

Source: CIAT, Pew Trusts (Anastacio & Ponce, 2020)
Elaborated by authors

As established in Table 5, by multiplying the catch in tons by the price, the valuation of tuna catch for the year 2014 is estimated at $87,516,000.00, and for the year 2018, the valuation of tuna catch is $101,659,500.00.

Table 6 presents the registered catches and estimated stocks of key target species for Galápagos artisanal fisheries. The ecosystem accounting exercise estimates that the total value of artisanal fish production was USD 10.38 million in 2014, and US $6.24 million in 2018.

Table 6. Catches and stocks of main commercial artisanal fisheries in the Galapagos Marine Reserve

Year	Indicator	Unit	2014	2018
Lobsters	Stocks		n.d.	n.d.
	Catches (tails only)	t	231	184
Sea cucumber	Stocks	Millions of individuals	19.23	17.43
	Catches	Individuals	552,064	closed season
Bacalao	Stocks	Individuals/100 m^2	1.42	-
	Catches	t	143	70
Yellowfin tuna	Stocks		n.d.	n.d.
	Catches	t	273	244
Brujo	Stocks		n.d.	n.d.
	Catches	t	69	45

Source: Fundación Charles Darwin, Informe de Pesquería 2015 DNPG, (Ramírez-Gonzáles, et al., 2020), (Pontón-Cevallos, et al., en preparación), and databases from the Galapagos National Park Directorate.
Elaborated by authors.

HYBRID SUPPLY AND USE TABLE FOR THE EIEEZ

Hybrid supply and use tables describe the physical and monetary flows of goods and services associated with economic activities.

For the fisheries sector, these tables provide insights into resource extraction, distribution across markets, and the associated economic contributions. Their objective is to integrate physical flows (e.g., catch volumes) with market-based values, enabling an assessment of how ecosystem-derived goods contribute to the broader economy.

In the case of artisanal fishing in the Galápagos, the hybrid matrix specifically seeks to capture the relation between ecosystems and the goods and services derived from small-scale fishing, as well as the economic significance of these flows. Such matrices, aligned with the System of National Accounts (SNA), can be expanded into supply-use tables and input-output matrices, which describe relationships between ecosystem service values and the physical units of natural resources used in production processes. Understanding these linkages, such as the extraction of fishery resources or carbon sequestration, and their monetary equivalents is essential for developing environmental policies that aim to prevent ecosystem degradation and promote sustainable use ***(Rosero, 2015; Rosero, 2022).***


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[3] In a Supply-Use table, economic activities and products are described, both of which are related to the International Standard Industrial Classification (ISIC) and the Central Product Classification (CPC), respectively. For guidance on using these classifications, refer to the System of National Accounts Manual, 2008 edition. In the case of the Experimental Ecosystem Account for artisanal fishing in the Galápagos, the product description used is "fishing."

SUPPLY MATRIX

The supply matrix (see Annexes 1 and 2) reflects the origin of production activities within the EIEEZ. Rows represent ecosystem types or biomes, while columns detail economic activities across the following marine ecosystems: mangroves (MT), rocky bottoms and vertical walls (M1), coral reefs (M1), sandy bottoms (M1), pelagic zones (M2), and seamounts (M3).

Table 7. Production: Ecuador's Insular Economic Exclusive Zone (EIEEZ)

	2014		2018	
	Physical units	**US$**	**Physical units**	**US$**
Artisanal Fisheries	730 t	10,380,477	543 t	6,239,075
Industrial Fisheries	51,480 t	87,516,000	67.773 t	101,659,500
Tourism	215,691 visitors	194,286,686	275,817 visitors	275,380,152
Maritime Passenger Transport	73,000 visitors	8,493,770	71,000 visitors	8,157,383
Maritime Cargo Transport	23.03 million t	449,243,906	23.90 million t	530,995,716
Government and Non-Profit Entities		3,959,867		2,130,105
Total value US$		**753,880,706**		**924,561,931**

Source and elaboration: Author's own, based on public data and supply-use tables.

Note: [a] The Economic Exclusive Zone of Ecuador is divided into continental (CEEZ) and insular (IEEZ) zones, with the latter representing over 60% of Ecuador's marine territory. The figures reported for maritime cargo transport reflect the proportion attributed to the EIEEZ, based on national-level supply-use tables compiled by the Central Bank of Ecuador (BCE).

The value of non-market production by government institutions and non-profit entities serving households is estimated by summing three components: compensation of employees, intermediate consumption, and consumption of fixed capital. For the Galápagos, these values are calculated based on the executed budgets of decentralized autonomous governments (GAD by its Spanish acronym) and the Galápagos National Park Directorate. The estimates presented in Table 7 assume that 5% of total spending by these institutions is allocated toward the management of the EIEEZ.

USE MATRIX

The use matrix describes the destination of production from economic activities in the Galápagos Marine Reserve (GMR), the Hermandad Marine Reserve (HMR), and the EIEEZ. Production is allocated to final consumption (households and government), intermediate consumption, and exports to other regions or countries (e.g., mainland Ecuador). Intermediate consumption refers to inputs used in the production process, such as fuel, ice, or gear in the case of fisheries. Intermediate consumption is estimated using technical coefficients derived from the national hybrid supply-use table (Banco Central del Ecuador, 2020), reflecting the proportion of inputs relative to total production in each economic activity.

[4] Exports refer to the foreign trade of Galapagos, in this case the export of products to the mainland.

Table 8. Exports: Goods and services provided by the EIEEZ to mainland Ecuador entities

	2014		2018	
	Physical units	**US$**	**Physical units**	**US$**
Artisanal Fisheries	389 t	5,530,977	178 t	2,040,155
Industrial Fisheries	51,480 t	87,516,000	67,773 t	101,659,500
Heavy sea freight	23.03 millions of t	449,243,906	23.90 millions of t	530,995,716

Source and elaboration: Author's own calculations based on national accounts and official statistics.

Table 8 reports exports from the EIEEZ to mainland Ecuador for key economic activities in 2014 and 2018. Exports are defined as the value of goods and services produced in the EIEEZ and consumed by non-resident entities, including industrial and artisanal fisheries and maritime cargo transport.

SOCIAL INFORMATION

Table 9 presents the distribution of gross value added in Ecuador's Insular Exclusive Economic Zone (EIEEZ) for the years 2014 and 2018. The gross value added is broken down into four main components: compensation of employees, gross operating surplus, mixed income, and taxes on production. Compensation of employees represents the payment to labor as a production factor. These estimates are based on the number of employees in various economic activities in the EIEEZ, obtained from the Galápagos Population and Housing Census and the National Employment, Unemployment, and Underemployment Survey, multiplied by average sectoral wages.

Compensation of employees was estimated at US $164 million in 2014 and increased to US $249 million in 2018. Gross operating surplus reflects returns to capital as a production factor. It was estimated at USD 244 million in 2014 and US $247 million in 2018. Mixed income accounts for the earnings of households directly engaged in production, notably in artisanal fishing. It was valued at US $3.87 million in 2014 and US $4.09 million in 2018. Taxes on production include compulsory payments to the government not directly linked to a service in return. These were estimated at US $7.57 million in 2014 and US $8.07 million in 2018.

Table 9. Income distribution, Ecuador's Exclusive Economic Zone (EIEEZ).

Income distribution	**2014**	**2018**
Compensation of employees (US$)	164,333,110	249,099,658
Gross operating surplus (US$)	244,048,372	246,831,575
Mixed income (US$)	3,875,413	4,092,210
Taxes on production (US$)	7,568,289	8,068,289
Gross Aggregated Value (US$)	**415,325,183**	**509,091,731**

Source and elaboration: Author's own calculations based on national accounts and official statistics.

Table 10 shows employment estimates in six key economic activities in the EIEEZ, disaggregated by sex and employment type, for the years 2014 and 2018. Total employment increased from 35,876 employees in 2014 to 41,998 in 2018, with wage workers being the predominant category. Employees (wage workers) rose from 18,592 in 2014 to 22,801 in 2018. Own-account workers, representing independent or self-employed individuals, increased from 14,449 to 15,720. The number of employers and unpaid family workers also grew slightly during this period.

Table 10. Employment, Ecuador's Exclusive Economic Zone (EIEEZ)

Category	2014			2018		
	Male	Female	TOTAL	Male	Female	TOTAL
Wage employees	10,572	8,020	18,592	12,965	9,836	22,801
Employers	542	411	953	664	504	1,168
Own-account workers	8,216	6,233	14,449	8,939	6,781	15,720
Unpaid family workers	1,070	812	1,882	1,313	996	2,309
Total employees	**20,400**	**15,476**	**35,876**	**23,881**	**18,117**	**41,998**

Sources: INEC (2018, 2022); Central Bank of Ecuador.
Elaborated by authors.

Note: Total employment in the EIEEZ exceeds the resident population of the Galápagos. This is primarily due to two nationally significant economic activities based in this marine area: industrial fishing (representing around 20% of Ecuador's total production) and maritime freight transport (which accounts for over 60% of national output in this sector).

CONCLUSIONS

GENERAL CONCLUSIONS

1. **Pioneering marine ecosystem accounting:** This study constitutes a pioneering effort in the Latin American region by applying the System of Environmental Economic Accounting—Ecosystem Accounting (SEEA-EA) framework to a marine context. It provides an integrated approach to valuing ecosystem services within Ecuador's Insular Exclusive Economic Zone (EIEEZ), particularly focusing on the Galápagos and Hermandad Marine Reserves.

2. **Economic and environmental importance of the ZEEI:** The EIEEZ, which includes two major marine reserves, plays a critical role both in Ecuador's economy and in ensuring environmental sustainability. Key ecosystem services identified include artisanal and industrial fishing, tourism, maritime transport, and carbon sequestration in mangrove ecosystems, all of which contribute to human well-being and climate change mitigation.

3. **Quantification of marine ecosystems:** The research presents a comprehensive assessment of the extent and condition of marine ecosystems in the EIEEZ, highlighting their biodiversity and the essential services they provide. Ecosystems such as mangroves, pelagic zones, and coral reefs are analyzed using both physical and monetary indicators, underscoring their environmental and economic value.

4. **Vulnerabilities and opportunities:** The findings reveal major threats to these ecosystems, including overfishing, pollution, and climate change, emphasizing the need for urgent conservation measures. At the same time, opportunities are identified to promote sustainable economic activities, such as ecotourism and responsible fisheries management.

5. **A replicable methodological framework:** By integrating physical and monetary data through the SEEA-EA methodology, this study demonstrates the potential of ecosystem accounting as a tool for informed decision-making. The approach offers a model that can be replicated in other marine and coastal ecosystems, enhancing natural resource management at both national and global scales.

SPECIFIC CONCLUSIONS

1. **Quantification of blue carbon:** The study highlights the importance of mangroves in the EIEEZ as efficient blue carbon sinks. In 2018, it is estimated that mangroves stored a total of 1,824,240 metric tons of carbon, with an annual estimated sequestration flow of 600.9 metric tons. These results underscore their strategic role in climate change mitigation and the necessity of conserving this ecosystem.

2. **Tourism's impact on the local economy:** Inbound tourism accounted for 93.45% of total tourist expenditure in the Galápagos, with the number of visitors increasing from 215,691 in 2014 to 275,817 in 2018. This growth led to an economic output of US $275.38 million in 2018, establishing tourism as a key economic driver in the region.

3. **Economic valuation of industrial and artisanal fishing:** Industrial fishing in the EIEEZ generated revenues of US $87.5 million in 2014 and US $101.6 million in 2018. Artisanal fishing, meanwhile, yielded US $10.38 million in 2014 and US $6.23 million in 2018. These figures emphasize the economic significance of both sectors and the pressing need for sustainable practices to ensure their long-term viability.

4. **Condition and health of marine ecosystems:** Biodiversity indicators, such as the Shannon-Weaver diversity index for rocky reefs, declined slightly from 3.26 in 2014 to 3.10 in 2018. These results highlight the need for effective conservation policies to protect marine biodiversity.

5. **Income distribution and employment generation:** Labor compensation in the EIEEZ rose from US $164 million in 2014 to US $249 million in 2018, suggesting improved labor conditions. The number of employees also increased from 35,876 to 41,998 during the same period. Industrial fishing and maritime transport emerged as significant sources of employment in the region.

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ANNEXES

Annex 1. Supply-Use Table 2014

Hybrid Supply and Use Table
EXPERIMENTAL ECOSYSTEM ACCOUNTS FOR THE INSULAR EXCLUSIVE ECONOMIC ZONE OF ECUADOR
Year 2014 – US dollars

International Standard Industrial Classification of All Economic Activities (ISIC)	A		B		C		D		E		F	
ECOSYSTEM SERVICE DESCRIPTION	ARTISANAL FISHING		INDUSTRIAL FISHING		TOURISM		MARITIME PASSENGER TRANSPORT		MARITIME FREIGHT TRANSPORT		GENERAL GOVERNMENT AND NON-PROFIT INSTITUTIONS SERVING HOUSEHOLDS	
Units	Physical account	Monetary account	Physical account	Monetary account	Physical account	Monetary account	Physical account	Monetary account	Physical account	Monetary account	Physical account	Monetary account
PRODUCTION - MT (Mangroves)	6 Tn	141.891										
PRODUCTION - M1 (Marine Platform Biome)	449 Tn	9.036.378										
PRODUCTION - M2 (Pelagic Waters Biome)	273 Tn	1.202.207	51.480 Tn	87.516.000								
PRODUCTION - M3 (Deep-Sea Floor Biome)												
OTHERS (Not allocated)					215.691 persons	194.286.686	73000 persons	8.493.770	23,03 millions of Tn	449.243.906		3.959.867
TOTAL PRODUCTION		10.380.477		87.516.000		194.286.686		8.493.770		449.243.906		3.959.867
INTERMEDIATE CONSUMPTION		3.427.487		28.896.546		83.418.737		4.114.027		217.594.991		1.103.735
GROSS VALUE ADDED		6.952.990		58.619.454		110.867.949		4.379.742		231.648.915		2.856.133

MT Coastal-Marine
M1 Marine Shelf Biome
M2 Pelagic Ocean Waters Biome
M3 Deep-Sea Floor Biome

PRODUCTION	753.880.706
INTERMEDIATE CONSUMPTION	338.555.522
GROSS VALUE ADDED	415.325.183

EXPORTS

ARTISANAL FISHING	5.530.977
INDUSTRIAL FISHING	87.516.000
MARITIME FREIGHT TRANSPORT	449.243.906

BASIC PRICE PRODUCTION (BP)	BASIC PRICE SUPPLY (BP)	NET TAXES ON PRODUCTS		PURCHASERS' PRICE PRODUCTION (PP)	PURCHASERS' PRICE SUPPLY (PP)	PURCHASERS' PRICE USE (PP)
		Taxes	Subsidies			
141.891	141.891			141.891	141.891	
9.036.378	9.036.378			9.036.378	9.036.378	
88.718.207	88.718.207			88.718.207	88.718.207	
-	-			-	-	
655.984.229	655.984.229			655.984.229	655.984.229	
753.880.706	**753.880.706**			**753.880.706**	**753.880.706**	
	-					753.880.706

5 Note: Government and Non-Profit Institutions: Refers to the non-market production by decentralized autonomous governments and the Galápagos National Park. The primary data source is accrued budget reports. Intermediate consumption refers to the input used by economic activity. The technical coefficient (input-output ratio) is derived from the national supply and use tables for the years 2014 and 2018.

Annex 2. Supply-Use Table 2018 (provisional)

Hybrid Supply and Use Table
EXPERIMENTAL ECOSYSTEM ACCOUNTS FOR THE INSULAR EXCLUSIVE ECONOMIC ZONE OF ECUADOR
Year 2018 – US dollars

International Standard Industrial Classification of All Economic Activities (ISIC)	A		B		C		D		E		F	
ECOSYSTEM SERVICE DESCRIPTION	ARTISANAL FISHING		NOUSTRIAL FISHING		TOURISM		MARITIME PASSENGER TRANSPORT		MARITIME FREIGHT TRANSPORT		GENERAL GOVERNMENT AND NON-PROFIT INSTITUTIONS SERVING HOUSEHOLDS	
Units	Physical account	Monetary account	Physical account	Monetary account	Physical account	Monetary account	Physical account	Monetary account	Physical account	Monetary account	Physical account	Monetary account
PRODUCTION - MT (Mangroves)	6 Tn	110.060										
PRODUCTION - M1 (Marine Platform Biome)	203 Tn	4.784.196										
PRODUCTION - M2 (Pelagic Waters Biome)	244 Tn	1.344.819	67.773 Tn	101.659.500								
PRODUCTION - M3 (Deep-Sea Floor Biome)												
OTHERS (Not allocated)					275.817 persons	275.380.102	71.000 persons	8.157.383	29,90 millions of Tn	530.995.716		2.130.105
TOTAL PRODUCTION		6.239.075		101.659.500		275.380.102		8.157.383		530.995.716		2.130.105
INTERMEDIATE CONSUMPTION		2.060.054		33.506.530	43%	118.236.947	48%	3.951.096		257.192.154		463.419
GROSS VALUE ADDED		4.179.020		68.092.970		157.143.206		4.206.287		273.803.562		1.666.686

MT Coastal-Marine
M1 Marine Shelf Biome
M2 Pelagic Ocean Waters Biome
M3 Deep-Sea Floor Biome

PRODUCTION	924.561.930
INTERMEDIATE CONSUMPTION	415.470.199
GROSS VALUE ADDED	509.091.731

EXPORTS

ARTISANAL FISHING	2.040.156
INDUSTRIAL FISHING	101.659.500
MARITIME FREIGHT TRANSPORT	530.995.716

BASIC PRICE PRODUCTION (BP)	BASIC PRICE SUPPLY (BP)	NET TAXES ON PRODUCTS		PURCHASERS' PRICE PRODUCTION (PP)	PURCHASERS' PRICE SUPPLY (PP)	PURCHASERS' PRICE USE (PP)
		Taxes	Subsidies			
110.060	110.060			110.060	110.060	
4.784.196	4.784.196			4.784.196	4.784.196	
103.004.318	103.004.318			103.004.318	103.004.318	
-	-			-	-	
816.663.355	816.663.355			816.663.355	816.663.355	
924.561.930	**924.561.930**			**924.561.930**	**924.561.930**	
	-					924.561.930

6 Note: Government and non-profit institutions refer to the non-market production carried out by decentralized autonomous governments and the Galápagos National Park. The main source of information is the accrued government budget data. Intermediate consumption refers to the inputs used in economic activity. The technical coefficient (i.e., the ratio of inputs to output) is obtained from the national supply and use tables for the years 2014 and 2018

PRESIDENT OF ECUADOR
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