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Future Blue Economies

Activating sustainable growth in Southeast Asia

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"Sustainable Ocean economies can transform lives and livelihoods not only in small island developing states, but in all vulnerable and fragile communities in all developing countries including those pockets of fragility at sub-national levels"

DR. CINDY TIANGCO
Principal Energy Specialist, Emerging Areas
ASIAN DEVELOPMENT BANK

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Acknowledgments

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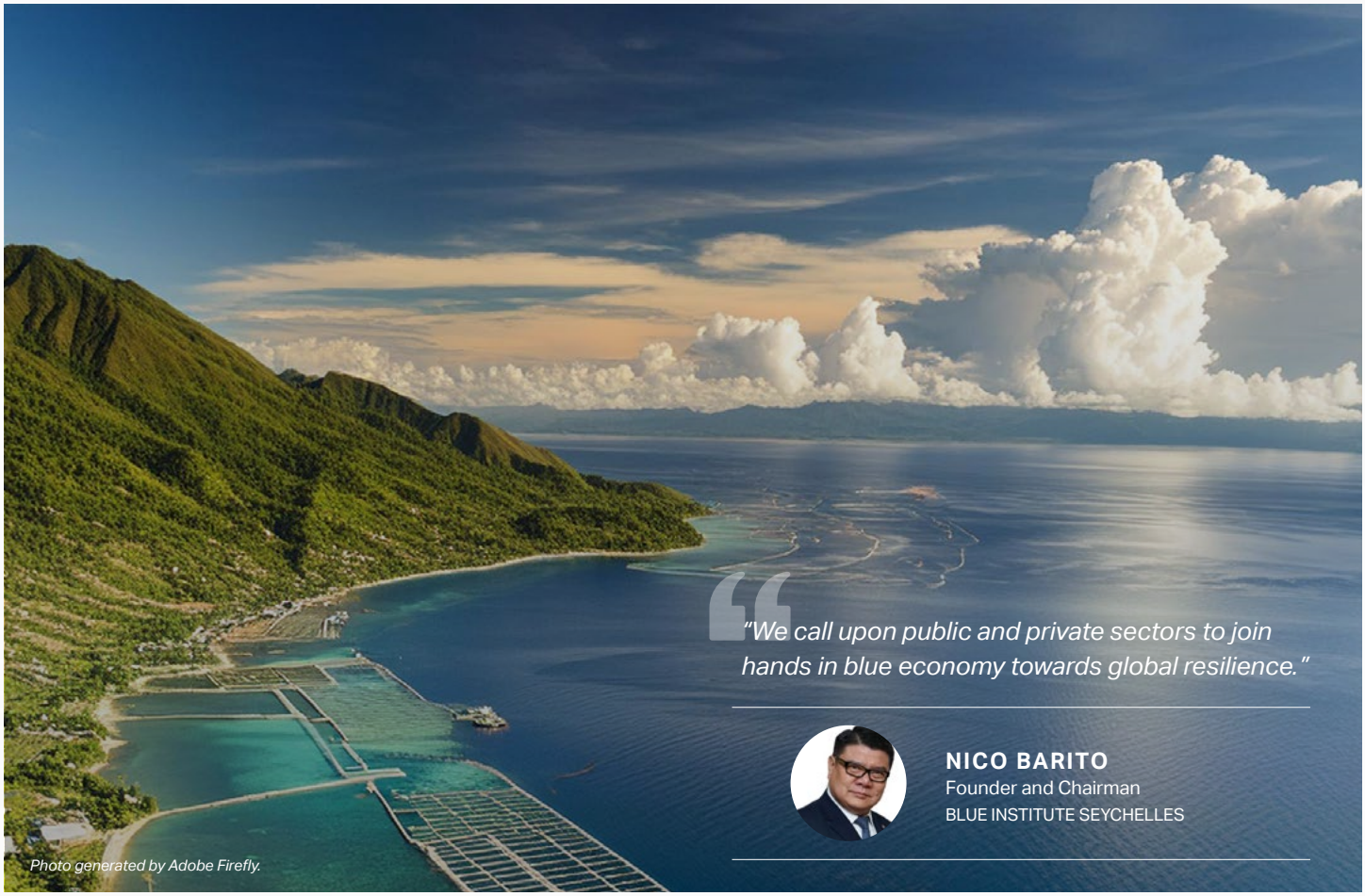


Executive Summary

> *"The Blue Economy is critical to sustainability for our planet."*

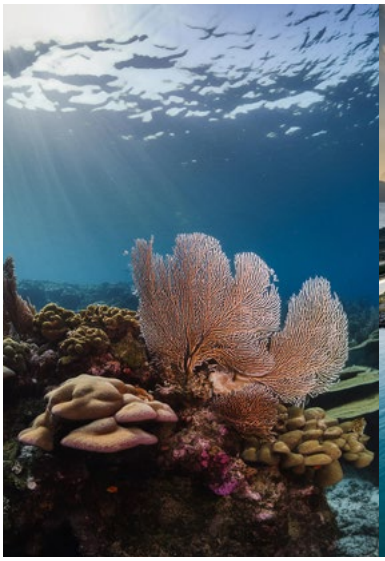
DR. MICHAEL L.S. ABUNDO
CEO
OCEANPIXEL PTE LTD

The blue economy comprises various sectors fundamental for sustainable development, and this is especially true for island nations. Small Island Developing States (SIDS) and developing countries confront distinctive challenges due to limited financial resources and greater vulnerability to climate change and natural disasters. This whitepaper highlights the necessity for integrated approaches to effectively manage and utilize marine resources. We emphasize the top ten blue economy sectors, focusing on three key areas for each island in the Asia-Pacific region, underscoring their market sizes and critical roles in local economies and ecosystems.

While concentrating on the Philippines, this whitepaper aims to extend these solutions to other nations with similar challenges. The five major case studies presented – Mindoro and Verde Island Passage, Metro Cebu Blue Loop, Bohol Blue Geopark, Northeast Mindanao, and Tawi-Tawi - demonstrate the application of complex, integrated solutions tailored to specific regional needs and vulnerabilities, whether they are structural, economic, or environmental. These case studies illustrate the need of a synergistic approach involving government, technology, and financial institutions to achieve sustainable outcomes. Energy consistently serves as a critical enabler in these projects, supporting various blue economy initiatives.

The role of technology is paramount, with tools like AI, predictive machine learning, and Marine Spatial Planning (MSP) being central to these efforts. However, the availability of robust, compatible data is crucial, yet current gaps and inconsistencies often hinder progress. There are numerous acts and legislations that bolster the blue economy movement, but further expansion and reinforcement are essential. Solo solutions, while valuable, represent lower-hanging fruits that have already been explored. The focus now shifts to complex, integrated solutions that promise greater value and sustainable impact.

To ensure the effective implementation of these solutions, a comprehensive checklist can help stakeholders identify the key sectors to focus on for each specific case. This guarantees that strategies are customized to local contexts and address vulnerabilities. By fostering collaboration among government, technology, and financial sectors, we can drive sustainable development in the blue economy and ensure a resilient future for island nations.



> *"The Philippines' vast ocean resources hold incredible potential. Harnessing the potential responsibly, efficiently and effectively requires a digital revolution. At Aboitiz Data Innovation, we believe data and AI are the keys that can transform this island nation into a global leader in the sustainable blue economy."*

DR. DAVID HARDOON
CEO
ABOITIZ DATA INNOVATION

Background and Context

Prioritizing environmental health and economic stability, we must reassess our relationship with the ocean. The ocean is vital for life on Earth, producing half of the needed oxygen, absorbing a quarter of carbon dioxide emissions, and capturing almost 90% of the excess heat[1]. Despite its fundamental role in supporting biodiversity and regulating macrosystems, ocean health continues to deteriorate under anthropogenic factors. As human-related activities increasingly infringe upon marine environments, the "Sustainable Development Goal (SDG) 14: Life Below Water" set by the United Nations must be spotlighted.

According to the World Bank, the blue economy is the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystems"[2]. Meanwhile, the Organisation for Economic Co-operation and Development (OECD) defines the blue economy as "the sum of the economic activities of ocean-based industries, together with the assets, goods and services provided by marine ecosystems"[3]. Universally, the blue economy is valued at over $2.5 trillion USD annually and generates more than 30 million jobs while providing essential nutrition to over three billion people. All these factors account for the equivalent of the world's seventh-largest economy[4].

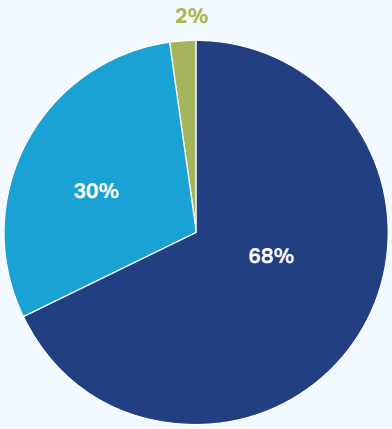
The integral complexity of the blue economy derives from its cross-governmental and cross-sectoral nature, obliging collaboration among various stakeholders, including governments, private sector (self-governance), and local communities. Guaranteeing inclusivity at the local level is key, matching with special attention to communities as active stakeholders—both as beneficiaries and key players. This comprehensive approach is important because the blue economy incorporates traditional sectors like fisheries, maritime transport, and tourism, alongside developing industries such as offshore renewable energy, marine biotechnology, and blue carbon projects. Despite this, current economic indicators often fail to take into consideration the full value of the ocean's contributions, particularly in the ecosystem services domain. Therefore, bridging sectors and countries is vital to create a self-sustaining economy that can adapt to arising challenges and channel opportunities to higher levels.

"With 68% of the world's Blue Economy in Asia Pacific, it is critical that Governments and Industries join hands to solve related challenges, as well as boost the sector".

CHRISTIAN DOSE
Partner. Asia Lead for Energy and Resources
BARINGA

Island countries are extremely dependent on ocean resources for their economic and environmental welfare. These nations contribute to almost 13% of the global GDP, with island countries in the APAC region alone accounting for $9.57 trillion, which is 8.7% of the world's GDP and 68.2% of the GDP of all island countries[5].

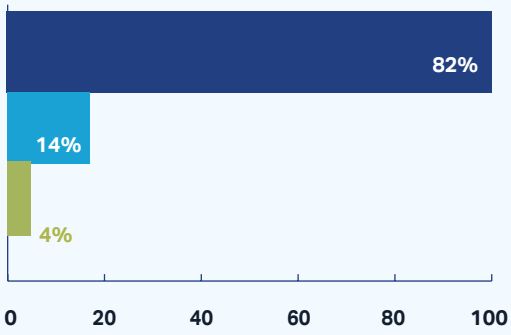
GDP Islands - APAC, EMEA, LATAM



APAC: $9,574,686
EMEA: $4,236,285
LATAM: $230,203

Total: $14,041,174

Island Population



APAC: 614,729,327
EMEA: 106,025,358
LATAM: 27,978,751

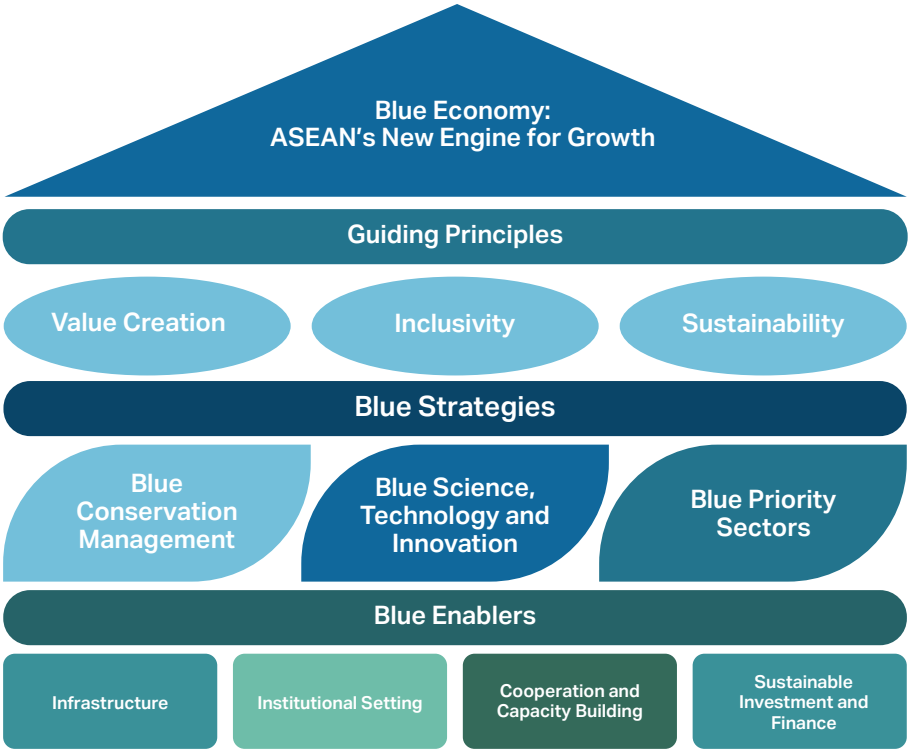
Total: 748,733,436

"To support the Blue Economy for Island Nations, Archipelagic countries, and all developing countries with opportunities for sustainable development in their coasts, marine, and offshore areas, we must work across sectors and borders."

WILLIAM BYUN
Principal
CONCHUBAR CAPITAL AND CALIFORNIA CLIMATE EXCHANGE (CCEX)

The recent United Nations Climate Change Conference (COP28) in Dubai signified a prominent milestone for global climate action that indicated the "beginning of the end" for the fossil fuel era and committing developing and developed nations to transition their energy systems towards alternatives. Simultaneously, the Association of Southeast Asian Nations (ASEAN) has adopted the blue economy as a cross-cutting initiative. The ASEAN Leaders'

Declaration on the blue economy focuses on the need for collaborative efforts among ASEAN Member States to promote sustainable and inclusive economic growth. These coordinated actions at COP28 and the ASEAN Summits set a clear direction for Asia-Pacific countries to guide in global sustainability efforts.



ASEAN defines the Blue Economy is an integrated, holistic, cross-sectoral, and cross-stakeholder approach that creates value-added and value-chain of resources from oceans, seas, and fresh water in inclusive and sustainable way, making the blue economy the new engine for ASEAN's future economic growth. The ASEAN Blue Economy covers upstream downstream sectors, serving as an accelerator of the conventional marine sector such as fisheries, aquaculture, fish-only processing, and tourism and a catalyst for emerging sectors such as renewable energy, biotechnology, and marine and freshwater-based research and education as well as other emerging sectors from aquatic resources.

"Blue Economy: Sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystems (World Bank[6])". Image Source: WWF (World Wildlife Fund). (n.d.). Sustain our seas. https://ocean.panda.org/

Island GDP. Source: IMF (International Monetary Fund). (2024, April). World Economic Outlook Database. Retrieved May 17, 2024, from https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD. Excludes Timor Leste and Cuba due to lack of data.

#	Countries	GDP (million)	GDP per capita	PPP (million)	PPP per capita	APAC	EMEA	LATAM
1	Japan	$4,110,452	$33,138	$6,720,962	$54,184	YES		
2	United Kingdom	$3,495,261	$51,075	$4,029,438	$58,880		YES	
3	Australia	$1,790,348	$66,589	$1,791,358	$66,627	YES		
4	Indonesia	$1,475,690	$5,271	$4,720,542	$16,861	YES		
5	Taiwan	$802,958	$34,432	$1,792,349	$76,858	YES		
6	Ireland	$564,020	$106,059	$712,056	$133,822		YES	
7	Singapore	$525,230	$88,447	$794,179	$133,737	YES		
8	Philippines	$471,516	$4,130	$1,391,800	$12,192	YES		
9	New Zealand	$257,626	$48,531	$285,582	$53,797	YES		
10	Dominican Republic	$127,356	$11,774	$293,365	$27,120			YES
11	Sri Lanka	$74,404	$3,342	$319,248	$14,255	YES		
12	Bahrain	$46,790	$28,876	$101,549	$62,671		YES	
13	Cyprus	$34,221	$37,149	$54,104	$58,733		YES	
14	Iceland	$33,338	$84,594	$29,077	$73,784		YES	
15	Papua New Guinea	$31,716	$2,530	$44,300	$3,534	YES		
16	Trinidad and Tobago	$28,365	$19,861	$46,679	$32,685			YES
17	Haiti	$24,046	$1,941	$38,506	$3,108			
18	Malta	$22,737	$41,738	$36,870	$67,682		YES	
19	Jamaica	$20,098	$7,309	$37,239	$13,543			YES
20	Madagascar	$16,465	$538	$60,551	$1,979		YES	
21	Mauritius	$16,359	$12,973	$40,468	$32,094		YES	
22	Brunei	$15,510	$35,111	$34,249	$77,534	YES		
23	Bahamas	$14,390	$35,257	$18,989	$46,524			YES
24	Maldives	$7,199	$17,818	$15,124	$37,433	YES		
25	Barbados	$6,863	$23,596	$5,989	$20,592			YES
26	Fiji	$5,801	$6,287	$16,059	$17,403	YES		
27	Cape Verde	$2,718	$4,656	$6,016	$10,304		YES	
28	Saint Lucia	$2,582	$14,101	$3,610	$19,718			YES
29	Seychelles	$2,203	$21,875	$4,345	$43,151		YES	
30	Antigua and Barbuda	$2,127	$20,533	$2,829	$27,309			YES
31	Solomon Islands	$1,707	$2,253	$2,056	$2,713	YES		
32	Comoros	$1,422	$1,384	$3,629	$3,532		YES	
33	Grenada	$1,406	$12,255	$2,502	$21,799			YES
34	Vanuatu	$1,289	$3,734	$1,015	$2,939	YES		
35	Saint Kitts and Nevis	$1,134	$23,705	$1,860	$38,870			YES
36	Saint Vincent and the Grenadines	$1,128	$10,150	$2,133	$19,196			YES
37	Samoa	$1,024	$4,840	$1,421	$6,721	YES		
38	Sao Tome and Principe	$751	$3,167	$1,005	$4,238		YES	YES
39	Dominica	$708	$9,455	$1,144	$15,280	YES		
40	Tonga	$581	$5,840	$742	$7,462	YES		
41	Micronesia	$484	$5,120	$443	$4,690	YES		
42	Kiribati	$311	$2,446	$460	$3,614	YES		
43	Palau	$308	$17,441	$307	$17,381	YES		
44	Marshall Islands	$305	$6,711	$287	$6,313	YES		
45	Nauru	$161	$12,362	$141	$10,823	YES		
46	Tuvalu	$66	$6,001	$66	$6,056	YES		

"The Blue Economy is essential to support sustainable development and improve economic conditions of island nations like the Philippines."

ROMEO MONTENEGRO
Assistant Secretary, Deputy Executive Director
MINDANAO DEVELOPMENT AUTHORITY

Even among island countries in this region, the situation regarding the blue economy varies significantly based on their level of development. For developed island nations such as Japan and Singapore, the focus is often on exploiting sea resources, addressing pollution, and managing the extra carbon dioxide generation associated with advanced industrial activities. These nations have the technology and infrastructure to push the boundaries of marine resource utilization while also facing the challenge of mitigating their environmental impact.

In contrast, developing island countries like Indonesia and the Philippines are equalizing rapid economic growth with the attempt of sustainable management of their marine resources. These countries are working to enhance their fisheries, aquaculture and tourism, whilst reducing the effect of overfishing, coastal degradation, and inadequate regulatory frameworks.

For Small Island Developing States (SIDS) and island clusters within Developing Member Countries (DMCs) such as Fiji and Papua New Guinea the blue economy is vital for their economic survival and development. More than 680 million people, nearly 10 percent of the global population, live in low-lying coastal zones. These nations heavily rely on the ocean for their economic activities, including fishing and small-scale maritime industries. Regions with high vulnerability levels face greater challenges in achieving sustainable development, leading to fluctuations in GDP growth. Moreover, they face exposures to climate change, including rising sea levels and increased frequency of extreme weather conditions. They are 15 times more likely to be killed by floods and storms compared to regions with low vulnerability[1]. As a result, their priority is to build resilience through sustainable practices and international support to protect their marine ecosystems and communities.

For island states like Kiribati, where the ocean constitutes 99.9% of their national territory[7], and "Large Ocean States / Big Ocean States" like the Philippines, where the ocean-to-land ratio is approximately 7 to 1, the blue economy is not just an economic driver but a life belt.

The Philippines, with coastline reaching over 36,000 kilometers, is a key player in the blue growth. The country has made significant commitments to sustainable development, associated with the UN Sustainable Development Goals. The National Economic and Development Authority (NEDA) has defined long-term plans through AmBisyon Natin 2040 and Pagntanaw 2050, aiming to achieve middle-class developed country status by mid-century. By utilizing the potential of the blue economy, the Philippines can strategically press forward on these long-term objectives and cultivate both economic growth and environmental sustainability.

Legislative support for the blue economy in the Philippines includes Senate Bill No. 1693 by Senator Loren Legarda, and House Bill No. 6876, authored by Jose Francisco "Kiko" Benitez. These bills focus on the conservation of marine resources. Additionally, blue carbon initiatives led by the Department of Environment and Natural Resources (DENR) and the Marine Science Institute (MSI) underline the crucial role of marine ecosystems in carbon sequestration.

However, advancing the blue economy faces several key challenges, particularly for coastal communities. First, there is a significant data gap in blue economy sectors; the entire data chain is underdeveloped. Data gaps can subsist on many levels but primarily are either due to inability to use the existing data or its nonexistence. The biggest gaps acknowledged are in socio-economic, cultural, and governance data types[8]. This obstructs the ability to make informed decisions

"Despite the diversity and vastness of the Philippines' marine resources and the role these play in sustaining life and livelihoods, the marine economy has so far received relatively scant attention in national development plans and programs. This must change, and fast. If the country is to pivot onto a development trajectory that features climate-risk resilience and inclusive, sustainable development, the blue economy must be recognized as central to local and national life and institutions must be directed to empower it."

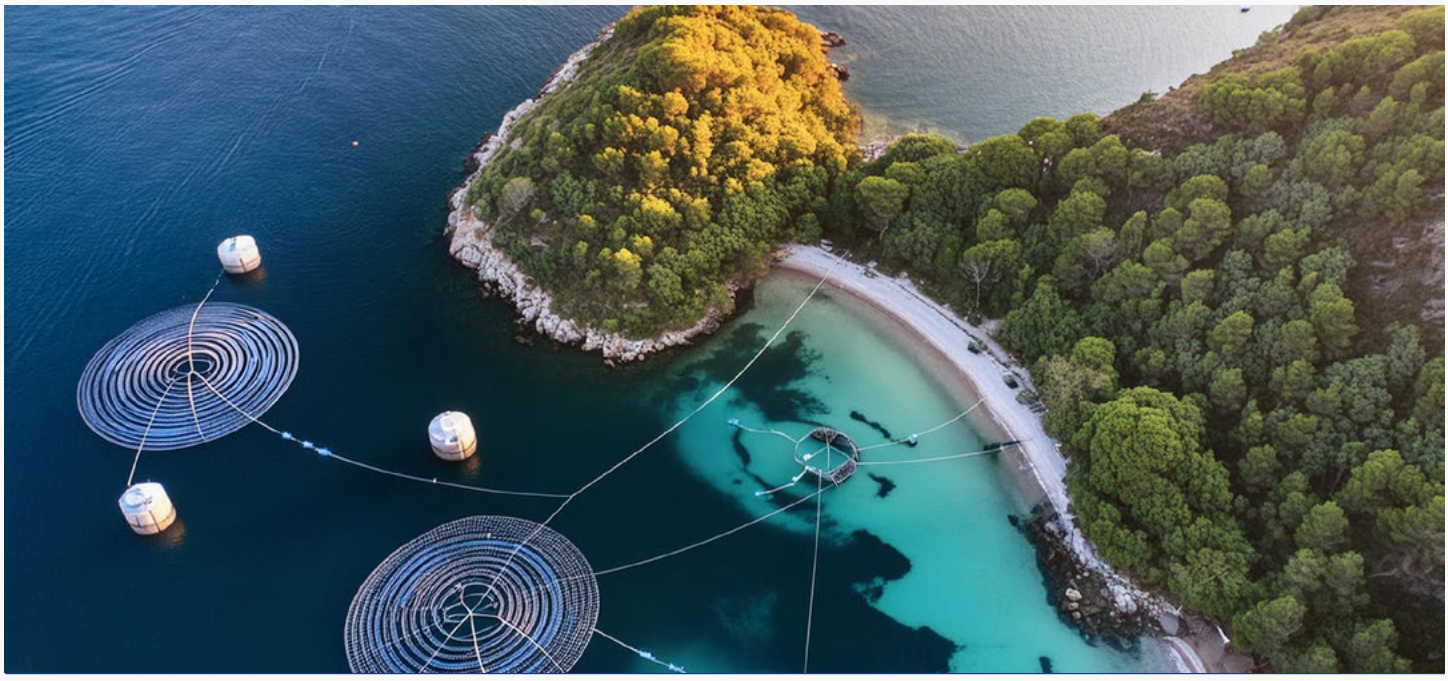
TOBY MELISSA C. MONSOD
Professor at School of Economics
UNIVERSITY OF THE PHILIPPINES (DILIMAN)

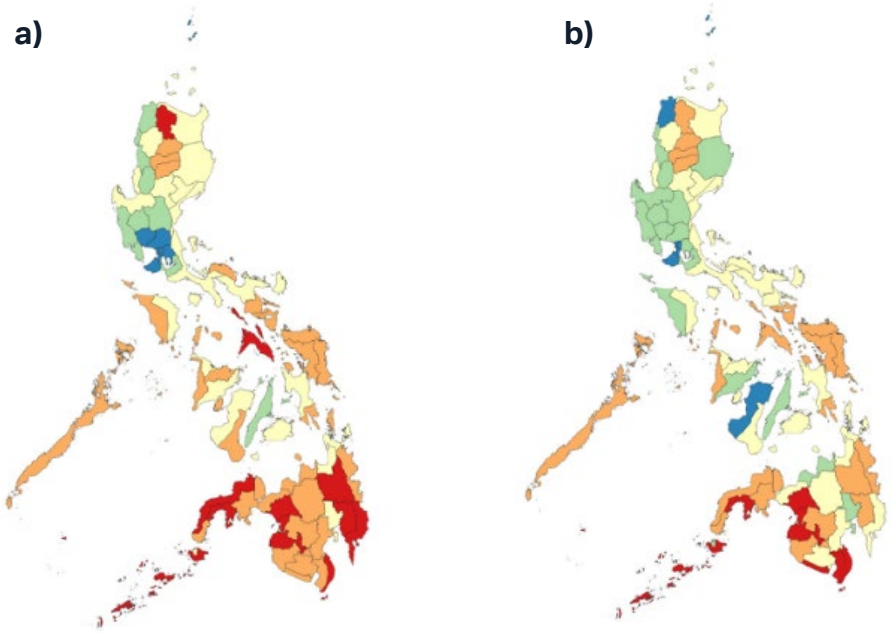
and optimize sector efficiency through data and digital technology. Moreover, according to the Sustainable Development Report for SIDS 2023, one of the most alarming metrics is SDG 17 – the Statistical Performance Index. This indicator stresses substantial deficiencies in the statistical capabilities of SIDS, with Pacific SIDS performing exceptionally poor. This weak performance is frightening, especially given the key role that data and statistics play in monitoring and managing the complex SDG challenges in these countries.

Second, economic data related to the blue economy is often fragmented, making it almost impossible to assess the ocean's contribution to sectors like tourism and shipping. The Special Report on the Ocean and Cryosphere highlights that marine-related governance arrangements are regularly too fragmented across administrative boundaries to deliver integrated responses to climate-related changes[9].

Third, seamless integration of environmental factors and their subsequent interplay are imperative; the economic benefits derived from the ocean economy must account for the health of marine ecosystems, as a damaged environment can undermine long-term gains. Same is emphasized by the Taskforce on Nature-related Financial Disclosures initiative, that aspires to help businesses understand how to best disclose nature-related opportunities and risks[10].

Fourth, there is a need for standardization and comparability of big data to allow for meaningful comparisons between different coastal cities and regions. Often, economic, social, and environmental data is collected by various government bodies and at different timelines and thus cannot be easily blended for successful policymaking. Ocean accounts and digital data dashboards can consolidate these data into a consistent and comparable framework, safeguarding full utilization of existing data sources with concurrent easy identification of gaps[11]. With this in place, well-organized and accessible data are key to unlocking the full potential of data science and artificial intelligence (AI) solutions. These solutions can lead to game-changing applications that benefit businesses, improve people's lives and even protect marine ecosystems. Alternative data, such as geospatial and remote sensing information, plays a crucial role in achieving this. It provides a more holistic understanding of the context and can even substitute for lower-quality traditional data sources. For example, ADI has used geospatial and remote sensing data[12] to train an AI model that predicts the wealth index for cities across the Philippines. By leveraging alternative data, wealth levels can now be tracked frequently, with minimal cost and at a highly localized level. While the model's average error rate is currently at 22.7% (see a comparison between the ground truth DHS wealth index and the AI output in the map below), this information still empowers governments and humanitarian organizations to make a significant impact. It allows them to target interventions, optimize resource allocation and ultimately reduce poverty in areas with the greatest need. Predicting wealth across the Philippines, particularly in coastal areas, can inform investments in blue economy solutions. This can include funding for sustainable fishing practices in areas with lower wealth, or supporting eco-tourism initiatives in wealthier coastal communities.





Visual comparison of the (a) ground truth DHS wealth index (b) and the predicted DHS wealth index from the machine learning model.

The rapid development of AI technologies promises transformative solutions, but it is crucial to address potential risks alongside these advancements. Responsible use of AI is key. Research has shown that a thoughtful approach to data processing and AI model development can lead to positive outcomes. A compelling study[13][14] by Aboitiz Data Innovation (ADI), Union Bank of the Philippines and Smith School of Business at Queen's University has demonstrated that responsible AI practices can significantly reduce gender discrimination. The study resulted in nearly threefold reduction in gender bias coupled with an 8% increase in firm profitability. This highlights the achievability of a win-win scenario where we harness the power of AI while minimizing its negative impacts on individuals, communities, and society as a whole. Proactive steps towards responsible AI are essential to ensure this positive future.

Lastly, engaging local communities in the blue economy, particularly through renewable energy and carbon credit markets, holds significant potential but requires targeted strategies and support. According to Malampaya (Philippines) superintendent Clarissa Pador, village government-led mangrove reforestation initiatives have positively helped to increase mangrove coverage since 2017. This effort, combined with ongoing outreach and education on environmental laws, has led to better community participation in coastal law enforcement and advocacy. This demonstrates the positive influence of community engagement on environmental and economical sustainability[14].

In the context of the blue economy, reducing gender bias in AI can ensure equitable access to resources and opportunities within the maritime sector. This can empower women in fisheries, aquaculture, and maritime professions, ultimately leading to a more diverse and sustainable blue economy.

The Blue Economy

The blue economy comprises a substantial range of sectors, each playing an important role in promoting SDGs. While this whitepaper highlights the top 10 blue economy sectors, we want to note that there are more areas contributing notably to the environmental and economic well-being of island nations. The sectors chosen here are based on their impact, relevance to the Asia-Pacific region (with an emphasis on the Philippines), and importance to island economies.

Market Size and growth prospects of top 10 blue economy sectors.

#	Blue Economy Sector	Market Size			Growth Prospects
		Global	SEA	Philippines	
1	Shipping & Maritime	US$ 14 trillion (2019)[27]	US$ 13.7 billion (trade in goods (export) in 2021)[28]	US$ 23.7 million (expected in freight and logistics market by 2027)[29]	Low
2	Tourism	US$ 9 trillion (2019)[30]	US$ 31.53 billion (expected by 2024)[31]	US$ 52.3 billion (GVA of tourism in 2019); US$ 3 billion (GVA of coastal and marine tourism in 2016)[32]; US$ 8.2 billion	Medium
3	Aquaculture / Algaculture and Seaweed	US$ 281.5 billion (2020)[34]	US$ 350 million (seaweed in 1997)[35]; 1.7 million tons (aquaculture production in 1990)[36]	US$ 4.6 billion (2022)[37]	High
4	Blue Carbon	US$ 190.67 ± 30 billion/year[38]	US$ 68 billion (mangroves) US$40 billion (seagrass)[39]	US$ 1.8 billion/year (mangroves, seagrass, and coral reefs)[40]	Medium
5	Marine Fishing	US$ 152 billion (fisheries production in 2017) [41]	US$ 107.30 billion (fish and seafood market projection in 2028)[42]	US$ 5.5billion (fisheries production in 2022)[43]	High
6	Waste Management	US$ 35.4 billion (plastic, 2022)[44] -with total economic damage caused by plastics to ~ US$ 13 billion/year [45]	US$ 239.90 billion (2023)[46]	US$ 31.2 million (waste treatment and disposal projection by 2024)[47]	High
7	Desalination	US$ 19.6 billion (2022)[48]; US$ 28.83 billion (expected by 2030)[49]	US$ 0.22 billion (water (seawater utilization; desalination) in PR China) (water (seawater utilization; desalination) in PR China) [50]	The economic assessment indicates a total capital expenditure of US$ 2.3 million[51]	High
8	Marine Renewable Energy	US$ 1.03 billion (2022)[52]	US$ 27 billion (invested between 2006 and 2016)[53]; US$3 billion (target investment in clean and renewable energy by 2030)[54]	~US$ 1.5 million (investments in solar PV in 2015)[55]	High
9	Ocean Health	US$ 24 trillion (estimated annual value of US$ 2.5 trillion in goods and services)[56]	US$ 3.1 trillion (total investment opportunity, including land-based and ocean-based, between 2016 and 2030)[57]	US$ 11.9 million (2016)[58]	High
10	Ocean Governance	US$ 1.5 trillion – US$ 3 trillion (estimated by 2030)[59]	US$ 684 billion[60]	15% share from SEA region (US$ 684 billion)[61]	High

"Bringing together key sectors such as fisheries, biotechnology, tourism, ocean energy, maritime security, and conservation is crucial for establishing a thriving blue economy."

PROF. SITTI ZAYDA B. HALUN, PH.D.

Director, Seaweed Research and Development Center, Mindanao State University (Tawi-Tawi)

PROFESSOR AT THE INSTITUTE OF OCEANOGRAPHY AND ENVIRONMENTAL SCIENCE (MSU TAWI-TAWI)

1. Marine Fishing

Marine fishing is a key component of the blue economy, because it provides 16% of the globally consumed animal protein and serves as the principal protein source for 1 billion people[15].

Marine fisheries contribute more than $140 billion annually to global GDP. In coastal communities about 60% of households rely on fishing as a means of poverty reduction[16]. However, with estimates forecasting the total annual marine catch to reach 95 million tons by 2050 and exceeding the maximum sustainable yield, there is a need for optimal management of fisheries to ensure the sustainability of marine ecosystems and the long-term feasibility of fish stocks[17].

In the Asia-Pacific region, key species include tuna, shrimp and prawns, squid and cuttlefish, mackerel, anchovies, sardines, crab, snapper, grouper, tilapia, milkfish, and sea bass. To understand the scale, the average tuna catch from Pacific Island exclusive economic zones (EEZs) sources over 30% of the global tuna market.

2. Aquaculture / Algaculture and Seaweed

Aquaculture and seaweed farming offer an alternative to traditional fishing. They successfully reduce pressure on populations of wild fish, providing coastal citizens with a more reliable source of protein. DNV in their most updated report states that annual worldwide marine aquaculture production (excluding seaweed) will double from 32 million tones in 2018 to 73 million tones by 2050[17].

In the APAC region aquaculture is a fundamental industry that employs over 7,000 people in Fiji, New Caledonia, and the Solomon Islands. The local sector is ruled by shrimps and blacklip pearls, which collectively account for 90% of the total market, estimated at $250 million per year.

Seaweed production is estimated to reach 50 million tones by 2050, up from 30 million tones in 2018[17]. This industry is deep-rooted in island provinces of Kiribati, Fiji, Papua New Guinea, and the Solomon Islands, where it has high socioeconomic impact despite comparatively low market value. Moreover, seaweed farming provides significant environmental advantages, such as absorbing CO_2 and helping combat climate change.

3. Renewable Energy

The potential of renewable energy derived from oceans is colossal and predominantly concentrated in offshore wind, wave and tidal energy. These allow to reduce dependence on fossil fuels and decrease carbon emissions.

Offshore wind energy is projected to overtake the oil and gas industry and turn into a major player in the blue economy sector. By mid-century, offshore wind energy will make up for 50% of ocean's CAPEX, while the oil and gas sector's share will drop from 80% to just 25%[17]. Offshore wind energy will also provide about as much energy as offshore oil by 2050.

In 2019 in developing markets, such as the Philippines, Brazil and India the total technical potential for offshore wind was estimated at 3.082 terawatts[18]. The increase in the usage was explained by the fact that costs associated with offshore wind farms have fallen significantly by 30% from 2001 to 2015, resulting in a drop in the levelized cost of energy (LCOE) by $70/megawatt-hour (MWh).

It is expected that Small Island Developing States (SIDS) will benefit greatly from offshore renewables, as they can replace costly power generation systems working on diesel and reduce land use for energy facilities[19]. However, the land consideration will still be significant, as by 2050, offshore wind energy will require 82% of the total area of ocean occupied, reflecting its expanding footprint[17].

Floating solar photovoltaic (FPV) technology is another promising area of ocean-based renewable energy. Although current FPV capacity, which reached about 2 GW in 2020, is primarily situated at freshwater sites in Southeast Asia and Greater China, advancements in protection against corrosion will drive their further development. Synergies with the offshore wind and aquaculture sector could speed up the utilization of offshore FPV systems, improving the renewable energy landscape.

> *"As a boat / ship builder, we at Stoneworks Specialist Intl Corp contribute our share in the blue economy by Developing eco-friendly and sustainable vessels: for various sectors and applications (that Promote sustainable tourism, Enable marine renewable energy, and Support all marine industries). And Fostering innovation by collaborating with industry partners and sharing knowledge to develop the blue economy."*
>
> **MARILYN ONG**
> Chief Executive Officer
> STONEWORKS SPECIALIST INTERNATIONAL CORPORATION

4. Shipping & Maritime

Shipping is essential for global trade. According to ADB, globally by the end of 2020 around 11 billion tons of goods was transported by ship, which represents approximately 1.5 tons per person.

The shipping industry, inherent to economic connectivity, links markets and facilitates international trade, as 80% of goods traded globally are transported by shipping[4]. Innovations and sustainable practices, such as increasing fuel efficiency and cutting emissions, are critical for minimizing the environmental impact of maritime transport. Despite being the lowest in carbon footprint compared to other modes of transportation, shipping still accounts for 3% of global GHG emissions.

The global shipbuilding market, estimated at roughly $114.3 billion in 2018, continues to grow, with new vessel segments evolving to serve the offshore wind industry[18]. These special vessels are expected to increase by 31% in tonnage and 53% in value by 2050[17]. Simultaneously, seaborne trade growth is projected to slow to 35% at the same time.

5. Tourism

Coastal and marine tourism are significant economic drivers that attract more than 41 million visitors annually to Coastal Least Developed Countries and Small Island Developing States (SIDS). These sectors provide extensive economic benefits, including job creation and revenue generation. For example, tourism in the APAC region relies heavily on natural assets, with the Pacific Ocean being the main attraction. Tourists coming here spend approximately $2.3 billion, contributing 7% to the regional GDP[20]. Additionally, tourism creates employment opportunities, contributing 188,500 jobs or 6% of formal employment, with countries like the Cook Islands reporting almost 60% of their workforce in tourism-related jobs. In 2006, the estimated global revenue from marine tourism surpassed the combined global revenue from marine fisheries and aquaculture sectors[21].

Sustainable tourism practices ensure the preservation of natural habitats and cultural heritage, while promoting long-standing economic growth. Research indicates that coastal and cruise tourism constitutes 10% to 40% of total tourism, varying with the region[17].

Based on GDP per capita, coastal tourism as measured by visitor time is expected to double from around 4 billion tourist-days in 2018 to more than 8 billion by mid-century.

6. Blue Carbon

Mangroves, seagrasses, and salt marshes are very important for storing carbon and helping the economy grow. Investing in these projects is valued at $190 billion every year[22]. These carbon ecosystems absorb and store large amounts of CO_2 and hence help to mitigate climate change. For instance, seagrasses account for less than 0.2% of the world's oceans but sequester approximately 10% of the carbon buried in ocean sediment. Blue carbon ecosystems can additionally enhance coastal resilience and protect shorelines from erosion. Despite their importance, these ecosystems are some of the most threatened on Earth, with an estimated 340,000 to 980,000 hectares being destroyed each year. Up to 67% of mangroves, 35% of tidal marshes, and 29% of seagrass meadows have already been lost globally.

As everything is interrelated, investing in blue carbon projects supports both climate mitigation and biodiversity conservation. Recently the Philippines' government has decided to join the World Economic Forum's Blue Carbon Action Partnership to help fix and save coastal areas.

7. Desalination

Desalination technology is a tool to combat water scarcity and provide water security. It has been a popular solution for island and coastal areas where there is a resource constraint of freshwater. Changing the seawater into freshwater helps give a steady supply of clean water for farming, factories, and homes.

DNV states that the capacity of desalination is projected to triple by 2050, from 58 million m^3/day in 2018 to 143 million m^3/day[17]. Innovations such as floating structures that combine renewable energy production—wind and wave—with desalination are already under consideration. The Asia-Pacific region, which is home to 60% of the world's population, has the lowest per capita water availability, with only 36% of the needed

water resources[23]. Meanwhile, large areas of Oceania and South-Eastern Asia have only 30% of the population having access to piped water in their homes.

> *"Our coral reef regeneration projects just like the one in Pujada Bay (Mati, Davao Oriental, Philippines) focuses on regenerating degraded reef structure and boosting marine ecosystem services by utilizing rrreefs innovative 3D reef solution and enabling nature-positive investments from companies"*

JOSEPHINE GRAF
Co-Founder and Co-CEO
RRREEFS

8. Ocean Health

Habitat restoration and effective resource management efforts contribute significantly to marine biodiversity. A healthy ocean provides a range of ecosystem services, including support for fisheries, tourism and coastal protection, thereby increasing the performance of the local marine environment.

The economy also benefits from a healthy marine ecosystem. For example, the net present value (NPV) of coral reefs in the Pacific Ocean, excluding the USA and Australia, is $2.08 trillion, of which $751 million comes from non-market values such as coastal protection[24]. In addition, the total economic value (TEV) of coral reefs from five Pacific Island Countries and Territories (PICTs) is estimated at $758 million per year, with mangroves adding another $250 million[20]. These statistics underscore the value of investing in ocean health to ensure the welfare of coastal communities and the environments they depend on.

9. Waste Management

Effective waste management practices are considered one of the most important blue economy sectors as they aim at reduction of marine pollution, which causes a serious threat to both ocean life and human health. Every year, an estimated 8 million tons of plastic waste and 1.5 million tons of microplastics are dumped into the ocean[25]. Rapid population growth and rapid urbanization, in particular in coastal areas, exacerbate the problem. For example, the Philippines contributes 36.38% of global plastic waste going into the ocean[26].

10. Ocean Governance

Effective marine governance ensures balanced use of marine resources. It implements policies and programs that promote sustainable practices. Strong governance arrangements require international collaboration, stakeholder engagement and strict adherence to regulations. Collective blue economy governance strategies help to balance economic development and environmental protection, and guarantee that resources are managed in support of ecosystems and economic activities.

One example of successful ocean governance is Myanmar. When Myanmar began its economic liberalization in 2011, the policy framework for economic reform emphasized the protection and restoration of forest, land and marine resources. The lessons learned from Cyclone Nargis in 2008 and the success of sustainable reform strategies have led to the comprehensive Myanmar Sustainable Development Plan (MSDP), 2018–2030, focusing on sound natural resource management. As part of this plan, the fisheries and aquaculture sectors have seen significant growth, contributing to a 25% rise of total fisheries production and subsequent increase in nominal GDP from 2015 to 2020[27].

> *"The development of the blue economy in the Philippines is a significant game changer. It greatly impacts food security, connects coastal communities, and enhances resilience against traditional and non-traditional security threats. We can boost the economy and strengthen border security by harnessing maritime resources for a sustainable and secure future."*

DR. PIERANGELO A. DOMINGUEZ
San Beda Graduate School of Business, Adjunct Professor
PHILIPPINE PUBLIC SAFETY COLLEGE, FELLOW PHILIPPINE COAST GUARD AUXILIARY, COMMODORE

Ranking Blue Economies

In order to assess these blue economy sectors and identify which of them bring more importance to each of the island countries, the following scoring system was applied. Economically, it considers the market size, job creation potential, and trade flow contributions of each sector. Environmentally, it evaluates the impact on marine ecosystems like coral reefs and mangroves, as well as the adherence to sustainable practices. Socially, it assesses how benefits are distributed among local communities and the improvement in livelihoods for those who depend on the ocean. Finally, the system estimates the global impact and industry influence, determining each sector's potential to drive significant change and create new opportunities.

Scoring Criteria	Description
Economic Factors	
Market Size	Evaluate the sector's current and potential market size
Employment	Assess the job creation potential and the quality of employment provided
Trade Flow	Analyze the sector's contribution to domestic and international trade
Environmental Factors	
Ecosystem Health	Measure the impact on marine ecosystems, including coral reefs, mangroves, and biodiversity
Sustainable Practices	Evaluate adherence to sustainable fishing regulations and pollution control measures
Social Factors	
Equitable Distribution	Assess how benefits from the blue economy are distributed among local communities
Impact on Livelihoods	Evaluate how the sector supports and improves the standard of living for people who depend on the ocean for their income and well-being
Global and Industry Impact	
Global Impact	Determine the sector's potential for creating global change or impacting global markets
Industry Impact	Assess the sector's influence on existing industries or its potential to create new industries

Scoring criteria for top 10 blue economy sectors. Source: authors' assessment

This assessment identifies and prioritizes the top blue economy sectors for island countries within the Asia-Pacific region, categorized into developed, developing (Large Ocean States), and Small Island Developing States (SIDS).

Top 3 economy sectors for island countries in APAC. Source: authors' assessment

Type	APAC Countries	GDP (million USD)	Top Blue Economy Sectors
Developed	Japan	4,110,452	Renewable Energy, Shipping & Maritime, Waste Management
	Australia	1,790,348	Renewable Energy, Tourism, Aquaculture / Algaculture and Seaweed
	New Zealand	257,626	Aquaculture / Algaculture and Seaweed, Tourism, Blue Carbon
Developing (Large Ocean States)	Indonesia	1,475,690	Marine Fishing, Aquaculture / Algaculture and Seaweed, Tourism
	Taiwan	802,958	Shipping & Maritime, Renewable Energy, Marine Fishing
	Philippines	471,516	Marine Fishing, Aquaculture / Algaculture and Seaweed, Renewable Energy
	Sri Lanka	74,404	Marine Fishing, Tourism, Aquaculture / Algaculture and Seaweed
SIDS	Singapore	525,230	Shipping & Maritime, Renewable Energy, Waste Management
	Papua New Guinea	31,716	Marine Fishing, Aquaculture / Algaculture and Seaweed, Blue Carbon
	Maldives	7,199	Tourism, Aquaculture / Algaculture and Seaweed, Desalination
	Fiji	5,801	Tourism, Aquaculture / Algaculture and Seaweed, Blue Carbon
	Solomon Islands	1,707	Marine Fishing, Aquaculture / Algaculture and Seaweed, Blue Carbon
	Vanuatu	1,289	Tourism, Marine Fishing, Aquaculture / Algaculture and Seaweed
	Samoa	1,024	Marine Fishing, Aquaculture / Algaculture and Seaweed, Tourism
	Tonga	581	Marine Fishing, Aquaculture / Algaculture and Seaweed, Tourism
	Micronesia	484	Marine Fishing, Tourism, Blue Carbon
	Kiribati	311	Marine Fishing, Aquaculture / Algaculture and Seaweed, Blue Carbon
	Palau	308	Tourism, Marine Fishing, Aquaculture / Algaculture and Seaweed
	Marshall Islands	305	Marine Fishing, Aquaculture / Algaculture and Seaweed, Blue Carbon
	Nauru	161	Marine Fishing, Aquaculture / Algaculture and Seaweed, Desalination
	Tuvalu	66	Marine Fishing, Aquaculture / Algaculture and Seaweed, Blue Carbon

For developed countries, sectors like renewable energy, shipping, and waste management are prioritized. This could be explained by large market sizes and advanced infrastructure. Japan and Australia, for example, can benefit from renewable energy projects to meet their high energy demands and achieve their 2050 carbon-neutral goals. These countries have financial resources to invest in large-scale projects. Waste management is also crucial to control pollution and maintain ecosystem health, tackling higher levels of consumption, plastic pollution and waste production.

Developing large ocean countries should pay more attention to marine fishing, aquaculture / algaculture and tourism. Countries like Indonesia and the Philippines rely heavily on marine fishing for food security and employment. These sectors support local economies and provide a growing population with essential proteins, while aquaculture and seaweed farming offer alternatives to traditional fishing, thereby reducing pressure on wild fish stocks.

SIDS cope with unique challenges, such as high vulnerability to climate change and limited resources. For these nations tourism, blue carbon, and desalination are of great importance. For instance, the Maldives and Fiji heavily depend on tourism for economic stability. Blue carbon initiatives, like mangrove restoration, are important for carbon sequestration and enhancing biodiversity, whereas desalination provides essential fresh water in regions with scarce natural water resources.

Although the blue economy is prospective for all island nations in the Asia-Pacific region, the case of the Philippines provides a particularly compelling example. As an archipelago, consisting of 7,000 islands, the Philippines is outstandingly positioned to utilize its rich marine resources. However, it also faces challenges that obstruct the development of a sustainable blue economy growth. By analyzing key sectors that hinder development and aligning them with national development policies and laws, we can identify critical areas for sustainable economic development in the Philippines.

Top Blue Economy Sectors in APAC Island Countries: Frequency and Importance

The hindering development sectors are overfishing and illegal fishing, pollution, coastal development and habitat destruction, mining and climate change.

Key national development plans and regulations include:

- NEDA AmBisyon Natin 2040[28]

  This long-term development plan aspires for a thriving, primarily middle-class society where poverty is eradicated. It emphasizes sustainable economic growth and environmental protection.

- Pagtanaw 2050[29]

  This strategic document summarizes steps that the Philippines should take to achieve sustainable and inclusive growth by 2050 with a major focus on innovation, sustainability, and resilience.

- Blue Economy Act and Bills by Legarda[30] and Benitez[31]

> *"At Aboitiz, our commitment to a sustainable blue economy extends beyond energy - it's about empowering people. We are dedicated to supporting island nations through innovative solutions across all our ventures, ensuring that our sustainability efforts enhance the lives of the communities we serve."*

GINGGAY HONTIVEROS-MALVAR
Chief Reputation and Sustainability Officer
ABOITIZ EQUITY VENTURES (AEV)

These legislative measures aim to institutionalize the use of marine resources, while integrating economic, social, and environmental aspects to promote the blue economy.

Differences in definition of sectors within different legislative acts (Philippines). Source: Blue Economy Act - Legarda and Blue Economy Bill – Benitez

	Blue Economy Sector	Blue Economy Acts and Bills - Legarda / Benitez
1	Marine Fishing	*Fisheries, including commercial fishing but with preference to subsistence fisheries, as mandated by Section 7, Art XIII of the Constitution.*
2	Aquaculture / Algaculture and Seaweed	Aquaculture,mariculture and aquasilviculture.
3	Renewable Energy	Production of renewable energy from Marine sources;
4	Shipping & Maritime	Shipping, Logistics and Maritime Transport; Ship-building and ship repair;
5	Tourism	Marine and Coastal Tourism
6	Blue Carbon	Not Available
7	Desalination	Desalination;
8	Ocean Health	Bioremediation, Marine biotechnology and bioprospecting;
9	Waste Management	Priority research and development agenda, maximizing opportunities created for pollution control, remediation, used water economics and other industries that address threats;
10	Ocean Governance	Underwater cultural heritage and maritime archaeology.

"The Blue economy is a critical driver towards Philippines' inclusive growth, economic development, and sustainable use of marine resources. The seas, oceans, and coasts are close to the heart of every Filipino due to the archipelagic nature of his country. Still, we need to refocus strategies and initiatives that can spark more blue economy activities in the near future."

DR. LLOYD BAUTISTA
Executive Education Program
Training Director
ATENEO SCHOOL OF GOVERNMENT

The Blue Solutions

Implementing solutions within the blue economy is a complicated and time-consuming practice. For instance, sustainable fisheries management and artificial intelligence (AI) powered surveillance and monitoring are indispensable tools for confronting overfishing and illegal fishing. Launching such systems can take years of research and significant financial investments. Likewise, attempts to tackle unsustainable seafood practices through tools like spatial data and species distribution modeling necessitate integrating progressive technology along with traditional fisheries management.

The complexity of these solutions is amplified because they are inherently cross-sectional, addressing multiple sectors simultaneously. For example, blue carbon initiatives not only sequester carbon but also enrich marine habitats, reinforce aquaculture and protect coastal areas from erosion. This multidimensional effect obliges synchronized efforts across government bodies, environmental parties, and local populations. These types of projects usually require an 18-month to 3-year development phase, followed by a 5–10-year commitment from the community, and aim for sustainability over a 40-year program.

Alternating to renewable energy sources (ocean energy, offshore wind and solar farms) is another illustration of the complexity and long-term commitment required. Building renewable energy infrastructure must be integrated with existing power grids. For instance, marine spatial planning and grid balancing for offshore wind energy require detailed mapping and coordination, which can take several years to fully implement. This process involves not only creating physical infrastructure but also securing investments, providing regulatory compliance, and promoting partnerships between public bodies and the private sector.

Sustainable tourism development requires creating ecotourism standards, responsible cruise tourism practices, and marine ecotourism certification. These measures are designed to mitigate environmental degradation and resource overexploitation, but they also need stakeholder engagement, training, and policy development. Similarly, sustainable coastal agriculture and aquaponics need the integration of satellite imagery, water quality monitoring, and other technologies compatible with traditional farming practices.

Technology plays an important role in advancing blue economy solutions. Satellite image analytics and risk profiling are essential for monitoring and managing marine environments. For instance, satellite imagery can provide possible cases of illegal fishing, evaluate the health of coral reefs and mangroves, and notice changes in coastal habitats. These technologies will enable better informed decisions.

Marine Spatial Planning (MSP)[32] is another crucial tool that helps balance various uses of marine spaces, namely tourism, marine fishing and renewable energy projects. MSP involves collecting and analyzing diverse data sets, including administrative and political boundaries, biological presence, and georeferenced activities like shipping channels. This comprehensive data collection and integration ensure that MSP decisions are guided by high-quality baseline data, which is crucial for effectively managing transboundary factors, economic sectoral priorities, and stakeholder participation levels[33]. MSP facilitates scenario-building, identifying sectors suitable for optimization, and areas where planning is crucial. It helps establish priorities and criteria for current and future activities, including their potential external impacts.

Multi-modal AI modeling can analyze extensive amounts of data to classify patterns, forecast outcomes, and optimize management of resources. For instance, AI can develop predictive models for fish stock, improve the efficiency of aquaculture processes, and correct the accuracy of climate change impact valuations. Moreover, geospatial data and AI can point out suitable locations and evaluate resource potential, such as renewable energy sites and fish stocks.

Taking into consideration the complexity of applying blue economy solutions and the imperative part of technology in this segment, it's pivotal to examine specific case studies that demonstrate these principles clearly and effectively. Instead of engaging in straightforward solutions that have already been executed by private companies, we aim to prioritize more incorporated and composite strategies that focus on multiple blue economy sectors at once. These progressive solutions are highly replicable and can be easily customized to different contexts, with a shared core framework that can be adjusted across various locations.

Climate change affects all regions and sectors indiscriminately. This fact highlights the need for comprehensive and inclusive solutions. Our approach targets different interconnected sectors such as natural capital (blue carbon and biodiversity), marine

> *"We are entering a new paradigm for investment in ecology and energy infrastructure -- and the Philippines is positioned to be a leader in South East Asia. It is positioned to maximize the value of its Natural Resources as well as the sustainability of its infrastructure investment. Both of which is geared towards striking a balance towards the country's environment and its economy. It is with this foundational design combined with the resilience and creativity of its people that we believe Philippines can define a new way of sustainable economic growth."*

LUIS GONZALEZ
Chief Operating Officer for Power and Industrials and Head of Applied Research
ABOITIZ DATA INNOVATION (ADI)

Three types of vulnerabilities. Source: Massa et al., 2023 (Sustainable Development Report for SIDS 2023: Addressing structural vulnerability and financing the SDGs in Small Island Developing States)

production (fisheries and aquaculture, desalination), marine renewable energy (solar, offshore wind, ocean thermal, wave energy), shipping and transportation, and marine pollution (plastics, oil spills, wastewater). By addressing these sectors, we ensure that solutions are robust, versatile, competent and can be applied effectively across diverse environments.

The proposed solutions, highlighted in ongoing case studies, are tailored for the Philippines but designed to be scalable to other states. By inspecting cases with different vulnerabilities and starting points, these solutions could function as adaptable models.

Despite the fact that the Philippines is not officially categorized as a Small Island Developing State (SIDS), it consists of thousands of little islands, each facing unique vulnerabilities similar to those of SIDS. These islands cope with distinctive economic, structural and environmental challenges that delay their development.

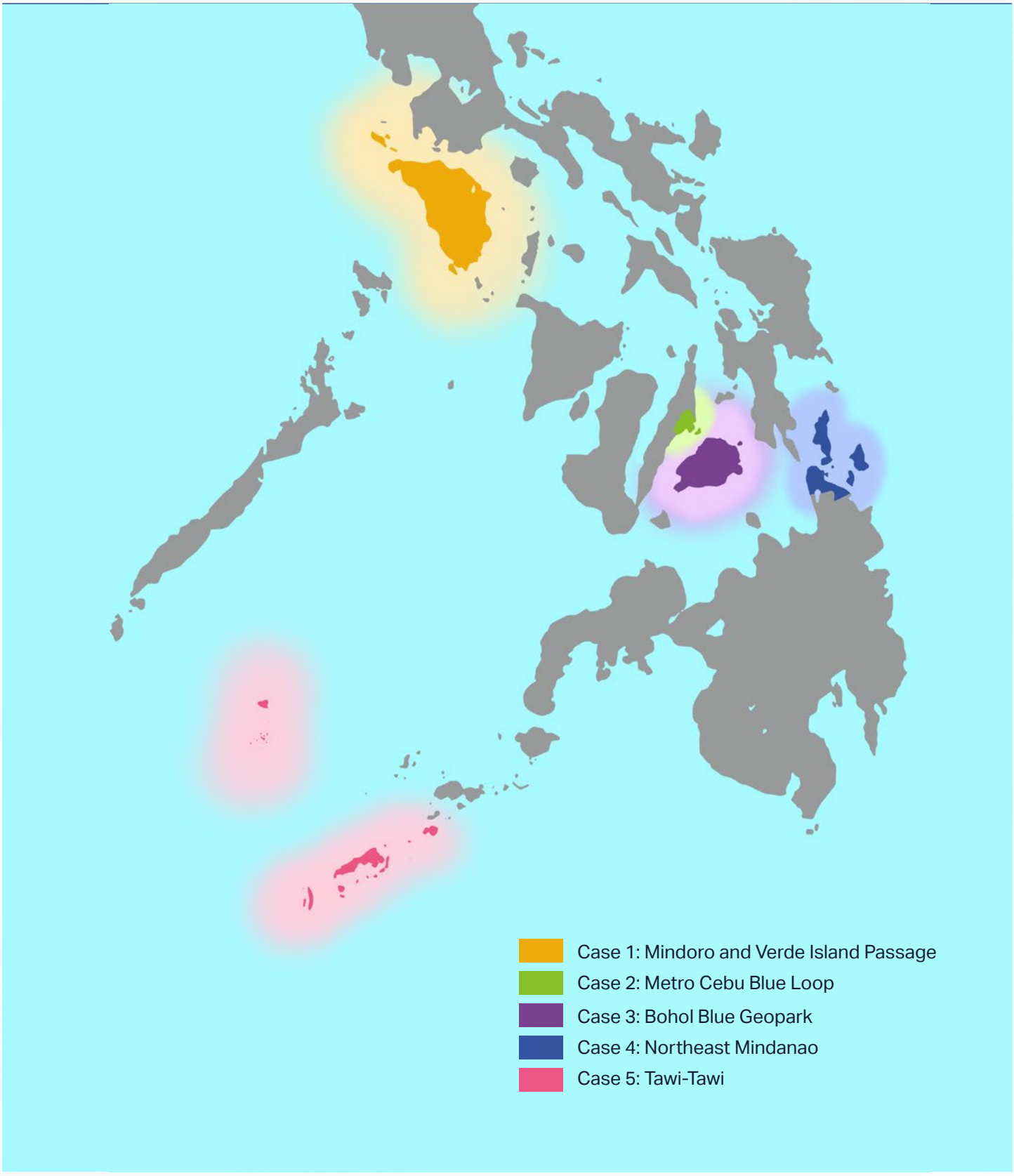
The Multidimensional Structural Vulnerability Index (MSVI) measures vulnerability across three dimensions: economic vulnerability, which relates to a country's exposure to economic and financial shocks; structural development limitations, which refer to geophysical constraints; and environmental vulnerability, which involves risk to climate change and natural hazards[34].

In the Philippines, different regions are susceptible to varying degrees of these vulnerabilities. For instance, Cebu, being more industrialized, faces primarily environmental vulnerabilities, while Bohol, with its emphasis on tourism and pristine environment, is fighting with economic limitations.

#	Case Study	Focus Areas	Primary Vulnerability	Development Status	Assessment Rationale
1	Offshore Wind (Mindoro) and Verde Island Passage	Environmental Impact, Renewable Energy	Coral reefs, fish habitats, and other fragile ecosystems	Developing	Offshore wind projects in the VIP have significant environmental concerns due to their potential impact on marine biodiversity. Investors are interested, but clear government guidelines are crucial
2	Metro Cebu Blue Loop	Marine Biodiversity, Water, Marine Transport and Shipping, Marine Production, Fishing, Aquaculture, Nutraceuticals)	Environmental (Marine Pollution, Water Security, Biodiversity, etc)	Developing	Cebu is on an industrialized side with more advanced infrastructure and into economically-focused sustainability solutions while conserving, protecting, and regenerating marine environments and developing livelihoods.
3	Bohol Blue Geopark	Tourism, Fisheries, Aquaculture, Mangroves, Infrastructure (including Energy and Transport)	Economic (Tourism)	Developing	Bohol's reliance on tourism and a more pristine environment makes it ideal for studying the balance between economic development and environmental preservation
4	Northeast Mindanao	Collaboration, Science-based Management, Circular Economy for Tourism, Establishment of ecozones	Structural (Political Instability)	Least Developed	Northeast Mindanao's unique governance and high environmental vulnerability offer insights into implementing blue economy solutions in remote, challenging areas
5	Tawi-Tawi	Seaweed farming, Renewable Energy	Economic (Trade Dependency	Developing	Tawi-Tawi's focus on renewable energy for its seaweed industry provides a case study on integrating complex energy solutions in economically vulnerable regions

Assessment of five case studies.

Case Studies



Shaded areas indicate the marine space associated with each case

Case 1: Offshore Wind (Mindoro) and Verde Island Passage

The Philippines has a unique opportunity to harness the power of the Blue Economy – utilizing its vast marine resources for sustainable development. The Verde Island Passage (VIP), a globally significant marine corridor teeming with biodiversity, sits at the crossroads of this potential. VIP stands as one of the world's most diverse ecosystems, celebrated as the epicenter of global shore-fish biodiversity[35]. This marine corridor stretches along the coastlines of Batangas, Marinduque, Romblon, Oriental Mindoro, and Occidental Mindoro, effectively separating Mindoro Island from Luzon[36]. Offshore wind projects have emerged as a potential source of clean energy within the VIP. However, this path is fraught with challenges.

Environmental Concerns and Investor Interest

The potential impact of offshore wind projects on coral reefs, fish habitats, and other fragile ecosystems raises significant environmental concerns. Despite these hurdles, investors are drawn to the VIP's wind potential, with projects like the Northern Mindoro Offshore Wind Power Project and the Bulalacao Bay Offshore Wind Energy Project showcasing significant interest. However, clear government guidelines that balance between environmental preservation and capital flow for renewable energy initiatives are crucial to move forward.

- Northern Mindoro Offshore Wind Power Project (Floating Wind Farm)[37]: 3): Located in the VIP between Occidental Mindoro and Batangas. The area has a maximum wind speed of around 10 m/s. The project aims to harness wind energy for power generation while also contributing to regional tourism.Field Data on Biomass and Soil Carbon (from ESA Climate Change Initiative Biomass Project)
- Bulalacao Bay Offshore Wind Energy Project[38][39]]: Situated in Bulalacao Bay, Mindoro with an expected total capacity of 1,200 MW. The wind power project consists of 100 turbines, each with 12MW nameplate capacity. Pressure and Volume Monitoring, which tracks changes in injected CO_2

VIP Concept Note: A Sustainable Roadmap

The VIP Concept Note offers a promising path forward. It emphasizes the passage's significant role and outlines potential for sustainable development. The accompanying Investment Dossier provides additional insights into investment opportunities like BlueFinance – financing projects with positive environmental outcomes [40][41].

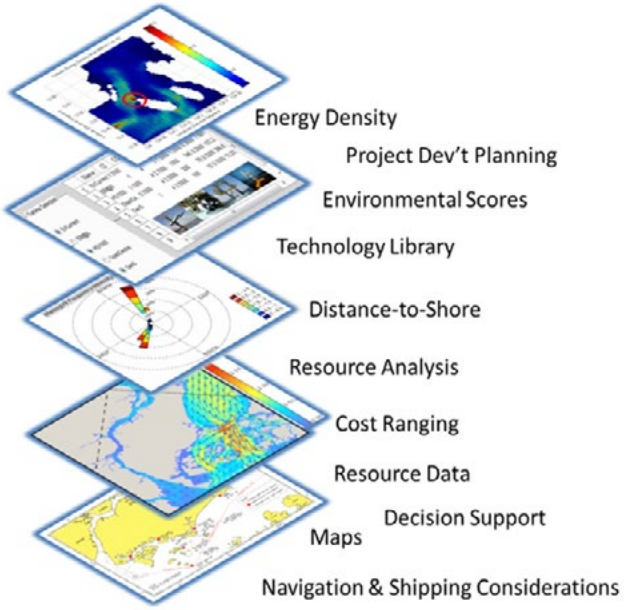
Data Science as a Decision-Making Tool

Data science holds the key to navigating this complex situation. Techniques like geospatial analysis, machine learning, and environmental modeling can be employed to assess the wind farms' impact on the region's fragile ecosystems.

Utilizing data from PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration) can identify optimal turbine locations based on wind patterns (i.e. information on climate and weather data such as wind speeds). Furthermore, incorporating data (on protected areas, biodiversity, and environmental impact assessments in the Philippines) from DENR (Department of Environment and Natural Resources) and GBIF (Global Biodiversity Information Facility) allows machine learning models to predict potential environmental impacts

during construction and operation of wind farms [42]. The Philippines' journey into the Blue Economy demands a delicate balancing act. The rich biodiversity of the Verde Island Passage presents both challenges and opportunities. By embracing a data-driven approach and prioritizing sustainable development, the Philippines can harness the power of offshore wind while safeguarding its precious marine environment.

Utilizing decision support tools that have multiple layers of data can help accelerate the pre-development phase of projects. Such suitability analytics engines can contribute to Blue Economy projects (be they in Renewable Energy and/or other sectors).



Suitability analytics to support Blue Economy projects

Case 2: Metro Cebu Blue Loop

Metro Cebu, the second most urbanized and populated city in the Philippines, offers an exclusive case for the blue economy growth. The Blue Loop project aims to transform Cebu's vast marine resources into sustainable economic drivers. This project, twin to the Green Loop initiative, currently evolving on the mainland, focuses on creating a harmonious balance between urban development and environmental conservation. As the Green Loop links major land uses, promotes controlled densification and preserves natural environments, the Blue Loop integrates multiple marine and coastal uses, promotes sustainable economic activities, and improves the livelihoods of coastal communities[43]. Both initiatives emphasize socio-ecological resilience. Unlike other regions in the Philippines, Cebu's high level of urbanization and industrial development sets it apart, demanding a tailored approach to integrate blue economy initiatives within a densely populated economically active area.

The OceanCrest (Collaborative, Research, Education, and Stewardship for Transformative Ocean Initiative) framework is the base of the Blue Loop project. It centers around sustainable development, stakeholder engagement, ecosystem restoration, policy advocacy and knowledge sharing. The OceanCrest LAB establishes regenerative mariculture practices and drives innovation in various marine sectors to ensure that all components work in synergy.

The Philippines has seen a major regression in seafood consumption, from 36 kg per capita annually in 1993 to just 14 kg in 2019[44]. Cebu's rich fishing fields have not transformed into satisfactory economic benefits for its fishers, who earn an average of $170 per month, the lowest wage rate in the country[45].

Moreover, practices like cyanide fishing and other illegal practices continue to put a pressure on the sustainability of marine ecosystems. Republic Act 8550, or the Fisheries Code of the Philippines, bans the use of dynamites, cyanide, blasting caps and fine nets in fishing. However, execution is lacking, especially in areas like Lapu-Lapu and Talisay cities, a well-known producer of blasting caps[46]. Illegal fishing not only challenges sustainable practices but also destroys coral reefs - key habitats for fish. Given these challenges and its rich marine biodiversity, Cebu represents a perfect location to implement solutions such as blue carbon, marine pharmaceuticals, marine cosmetics and marine biotechnology.

Blue Carbon

Blue carbon projects spotlight the conservation and restoration of coastal ecosystems such as mangroves and seagrasses, which are vital for capturing carbon dioxide. In Metro Cebu, due to its location, implementing blue carbon initiatives is especially important. A study on a protected tropical forest in Cebu found an average of 650 tons of carbon stored per hectare in the forest's biomass[47], with homogeneous areas storing more carbon than heterogeneous areas. This carbon is stored within three pools: soil, litterfall and vegetation. This initiative not only addresses climate change but also provides support to local communities, converting Metro Cebu to a prime

location for such efforts. As part of the Blue Asset inventory efforts in 2023, the project developers have used drone-based assessments coupled with computer vision and AI from VISON Tech (a Philippine start-up company from De La Salle University). The technology is a vision-based computer system equipped to navigate data in a faster, economical and accurate manner, thus saving resources to assess data manually. A novel algorithm was invented for an efficient and effective processing of videos which is compatible with any types of existing cameras for monitoring.

Marine Pharmaceuticals and Biotechnology

Ocean is a source of novel compounds with considerable pharmaceutical potential. Marine pharmaceuticals start with the development of drugs derived from marine organisms that could offer promising treatments for deadly diseases. For example, compounds originated from marine sponges and algae have shown great perspective in cancer treatment[48]. The economic benefits from such innovations can be substantial, potentially bringing in significant revenue and creating high-value jobs in research and development. In Cebu, leveraging this potential can foster a biotech industry focused on marine-derived medical advancements.

Marine Cosmetics and Personal Care

The global marine cosetics market is expected to grow considerably, driven by the demand for natural and sustainable ingredients. In Metro Cebu, this solution can stimulate local industries and provide new economic opportunities.

Electric Maritime Transport and Regenerative Tourism

Innovations in maritime transport, such as the development of electric bangkas, reduce environmental impact and enhance sustainability. Regenerative tourism projects, like the Mandaue Mangrove Ecopark, demonstrate how tourism can contribute to environmental conservation and local economic growth. These solutions are particularly relevant for Metro Cebu's urban setting, providing sustainable alternatives to traditional practices.

Metro Cebu's blue loop project is a comprehensive and multifaceted initiative that leverages various marine-based solutions to address environmental, economic, and social challenges. These solutions, akin to blocks or puzzles, can be tailored or interchanged based on location-specific needs and inputs.

Technology and Data Enablers

Collection of robust data is key for developing conservation strategies and climate change mitigation policies. The carbon sequestration capacity of seagrasses and mangroves in the Philippines - region known for high carbon stocks alongside Indonesia and Australia - can be quantified using following datasets:

- Satellite Imagery (Remote Sensing)
- Field Data on Biomass and Soil Carbon (from ESA Climate Change Initiative Biomass Project)
- Flux Towers that measure the net exchange of carbon dioxide between the ecosystem and the atmosphere
- Pressure and Volume Monitoring, which tracks changes in injected CO_2

"Linking Marine Protected Areas with regenerative resource uses, nature-based livelihood, and the use of appropriate technologies accelerates and enhances our approach towards truly sustainable development."

AMADO BLANCO
Co Founder and COO
COAST 4C

VISON Tech's Computer Vision Technology applied to mangrove assessment

VISON Tech's Computer Vision Technology applied to Vessel identification

By integrating these diverse datasets and applying machine learning algorithms, one can identify correlations between environmental factors such as temperature, precipitation, and land use, and the resilience of coastal ecosystems to climate change[49]. Spatial analysis techniques can help visualize the spatial distribution of carbon stocks and climate resilience indicators across different landscapes, informing decision-makers about areas that require targeted conservation efforts. Additionally, marine scenario planning (MSP) simulations[33] can provide insights into potential future trajectories of carbon storage and climate resilience under different environmental scenarios.

Case 3: Bohol Blue Geopark

Bohol Island presents itself as a captivating case for initiating the blue economy complex solution. Bohol differentiates from other case studies by its tourism-centric nature and pristine unspoiled environment. The timing is critical to start preserving Bohol's natural treasure, as there is a growing aspiration of local citizens to achieve 100% sustainability and avoid the fate of other overly commercialized destinations. The situation in Boracay, which required a six-month closure for rehabilitation in 2018, highlights the significance of preemptive measures. For the period of this closure, Boracay lost $200 million in tourism income, while tourist demand shifted to emerging destinations like Bohol. This situation underscores the potential of Bohol and urgency for sustainable development[50].

The elaboration of fisheries, mangroves, tourism, shipping and infrastructure in Bohol are interconnected and require a composite approach. Sustainable projects in one area can positively impact others, creating a balanced ecosystem. For example, healthy mangrove thickets help fisheries by providing breeding grounds for fish, and this in turn supports tourism through seafood availability. Robust infrastructure facilitates tourism and trade, which all together boosts the local economy.

Fisheries and Aquaculture

The Bohol Sea, covering 7,946 square kilometers, is an important fishing ground for the Philippines. In 2021 alone, fisheries production in Bohol reached 56.3 million metric tons, contributing $58 million to the local economy. This sector is fundamental for the livelihood of Bohol's population, with over 47,772 registered municipal fisherfolk and 20,125 full-time commercial fishers[51]. These fisheries not only support the local economy but also ensure food security.

Mangroves, Blue Carbon, and Corals (Biodiversity)

Bohol boasts extensive mangrove ecosystems, featuring approximately 32 identified species[52]. Prominent areas include Cogtong Bay, which covers 2,200 hectares and is the largest and most biologically diverse mangrove area, and Banacon Island in Getafe, which has around 1,750 hectares of mangroves planted since the 1950s[53]. These mangroves are used for capturing carbon dioxide, making them essential for blue carbon and climate change mitigation, which in turn supports biodiversity conservation and strengthens Bohol's climate resilience and aligns with the island's goal of complete sustainability.

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Tourism

Tourism is a cornerstone of Bohol's economy, with a 52% increase in tourist arrivals in the first half of 2022 . The majority of visitors (93.76%) are domestic with foreign visitors making up to 6.03%. Attractions like Panglao Island, known for its resorts, and Balicasag Island, a popular diving site, drive the tourism sector along with prominent whale shark's sites. The Panglao Island Tourism Estate project aims to create a responsible and sustainable resort destination.

Infrastructure

The Bohol-Panglao International Airport enables air traffic, with 12 thousand domestic and 214 international flights in 2019, serving over 1.3 million passengers . The province's seaports also control significant cargo and passenger traffic, with Tagbilaran City Seaport managing the highest passenger capacity and daily vessel traffic. This port infrastructure is also important since Bohol relies significantly on its shipping industry, which is bolstered by nine seaports. Building sustainable infrastructure, such as eco-friendly ports and transportation systems, enhances connectivity, supports tourism, and facilitates the movement of goods and people.

The blue economy initiatives implemented in Bohol can serve as a model for other pristine areas in the APAC region. Locations like Raja Ampat in Indonesia, and the Great Barrier Reef in Australia can benefit from similar approaches.

Technology and Data Enablers

Since healthy mangrove thickets support fisheries by providing essential breeding grounds for fish, thereby enhancing seafood availability and boosting tourism, evaluating the relationships between mangrove and seagrass habitats and fisheries production in the Philippines is crucial.

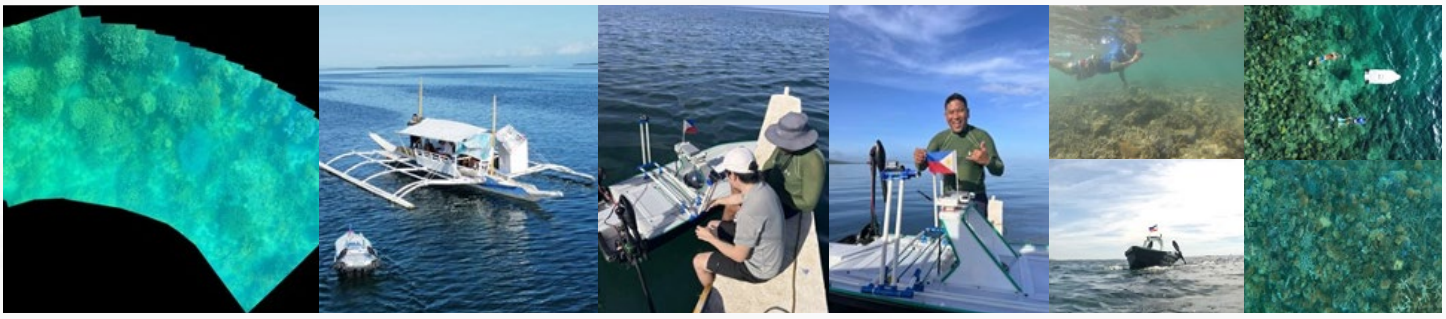
Good data enables sustainable management of fisheries resources and effective conservation of critical habitats.

There is possible data extraction from:

- Fisheries Statistical Report from the Philippine Statistics Authority (PSA)
- Field survey data
- Catch data, including type and quantity of fish, location, and fishing gear used
- Oceanographic data monitoring water temperature, salinity, currents, and oxygen levels

Techniques such as spatial data, network analysis, and species distribution modeling can be utilized to assess and promote sustainable management of fisheries resources and the conservation of these critical habitats . Spatial data analysis can reveal the connections between healthy mangrove/seagrass habitats and productive fisheries. Network analysis can support the creation of sustainable fishing models and conservation efforts, whereas species distribution modeling can predict the distribution of fisheries across geographic areas based on environmental conditions and species occurrence data.

Integrating these techniques can identify suitable mangrove/seagrass habitats, helping to delineate areas critical for conversation and restoration. For example, this can help identify which habitats are most important as nurseries for juvenile fish, which will contribute to the sustainability of the adult fish population. Another application is the prediction of changes in the distribution of key fish species from mangrove/seagrass degradation or loss.



Bohol has Marine Protected Areas that have been assessed by blue economy teams from OceanPixel, Coast 4C, Synerflight, and Fish-i. These enhanced marine environmental assessments use technologies such as Aerial Drones and Autonomous Surface Vessels coupled with data processing with AI and other techniques

Case 4: Northeast Mindanao

Northeast Mindanao, comprising the island provinces of Dinagat, Siargao and Surigao is uniquely different from other regions in Philippines due to its underdevelopment, fragmented politics, and perceived insecurity, whereas on the other hand it plays an essential role in the nation's food security. Mindanao is often treated as a challenging environment due to its history of identity-based armed conflict, political violence and socio-economic problems. Despite these disputes, it is home to pristine ecosystems, which are essential for the blue economy's growth. This area's development is decisive not only for regional stability but also as a prototype for other underdeveloped countries in Small Island Developing States (SIDS).

Mindanao spans over about 34% of the Philippines' total land area and includes six economic regions and 24 provinces[54]. It is one of the country's most resource-rich areas, that supply sardines, tuna, and seaweeds for both export and local consumption. This duality presents an opportunity to test blue economy strategies that tackle both economic and environmental challenges. Unlike more developed areas like Cebu, which can leverage advanced infrastructure and industrialization, Northeast Mindanao requires a tailored approach focusing on community engagement and conflict-sensitive development. These include stakeholder collaboration, scientific management, and introduction of innovative economic zones.

Establishment of Ecozone

Creating an economic zone in Dinagat Island aims to boost economic activities and position the island as an emerging business hub. This initiative highlights the potential for economic development while promoting sustainable practices, making it a model for other underdeveloped regions.

Circular Economy for Tourism

Siargao demonstrates the need for circular economy approaches in tourism. Implementing legislation, promoting waste reduction, and fostering community involvement can minimize marine litter, a critical threat to tourism's long-term viability. The "Huy-anan nan Badjao sa Surigao" project, also known as "Supporting blue-green recovery, strengthening resilience, and promoting sustainable growth in Philippine cities and communities through Nature-Based Solutions and Circular Economy (RRSG thru NBS-CE),"[55] aims to strengthen government capacities to support vulnerable populations disp laced by natural disasters. This project's focus includes culturally-appropriate nature-based solutions and circular economy approaches, emphasizing the humanitarian-development nexus, environmental sustainability, and climate change adaptation. The primary target groups for this project are the Badjao community and nomadic sea-based indigenous people of Mindanao.

Renewable Energy

MinDA is actively promoting and supporting the development of blue energy and blue economy initiatives in Mindanao as part of its energy transition strategies. The agency is working to establish the Mindanao Blue Economy Hub[56], which focuses on accelerating the development of projects such as ocean technology and tidal energy. With technical assistance from the Asian Development Bank, this hub aims to harness ocean resources sustainably, producing food, generating energy, creating jobs, and improving the lives of residents, particularly in island communities.

Science-Based Management

Implementing sound policies based on scientific data is vital for sustainable resource use. This approach is particularly important in Siargao, a popular tourist destination. However, the available biodiversity data for many key areas remain incomplete. A significant disparity in the information available on biodiversity exists across different provinces of Mindanao. For example, the western provinces have had no records of biodiversity for more than two decades. This gap highlights critical threats and challenges to biodiversity, including deforestation, agricultural expansion, and mining that impact biodiversity conservation in Mindanao. Therefore, biodiversity conservation efforts should focus not only on areas with high biodiversity levels but also

on regions lacking biodiversity information.

The approach and initiatives in Northeast Mindanao can serve as a model for other underdeveloped regions in the Asia-Pacific, such as parts of Indonesia and Papua New Guinea. These areas face similar challenges of underdevelopment and biodiversity conservation.

To properly develop the different blue economy sectors, planners also need to take into account various risks. A Blue Economy Risk Registry that features an interactive dashboard such as that developed in the Blue Economy Cooperative Research Centre (Australia) can give a rapid understanding of risks.

This Blue Economy Risk Registry supports stakeholders in Summarizing hazards identified across a broad set of domains cross-linked to the Blue EconomyProject Goals, Cross-linking domains and hazard to have an overview of shared hazards, Hazard Impact ranking to help authorities in making impact assessment and mitigation strategies. Thus, such tools help government organizations in policy-making for a sustainable blue economy and, furthermore, new entrants in Blue economy industry can identify their relevant hazards and plan accordingly.

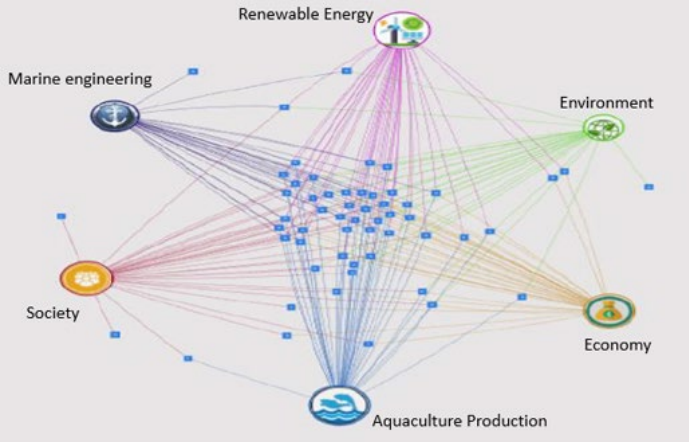
Technology and Data Enablers

Diverse data sets can help in decision-making regarding tidal energy site selection, ensuring a balance between renewable energy development and environmental conservation efforts.

Important Data Sources:

- Global Ocean Currents Database (GOCD) for information on ocean currents
- Ocean Data Inventory (ODI) for coastal temperature and salinity data
- PH Tides app from the Central Mapping Agency of the Philippines for real-time tidal information
- Underwater visual surveys and acoustic monitoring for species diversity, abundance, distribution patterns, migration routes, and spawning grounds

To achieve a balance between harnessing ocean technology while preserving biodiversity, remote sensing techniques and satellite imagery can be utilized. By mapping marine habitats and monitoring coastal ecosystems over time, we can gain insights into habitat changes at critical areas. Integrating spatial analysis methods can help identify optimal locations for tidal energy installations, considering factors like tidal currents, water depth, water temperature, and proximity to human activities. This will ensure that areas with significant energy potential can be prioritized while minimizing ecological risks to marine ecosystems and species, and communities.



Blue Economy Risk Registry - An Interactive dashboard summarizing hazards identified across a broad set of domains cross-linked to the Blue Economy (*Blue Economy Cooperative Research Centre Project with OceanPixel, https://blueeconomycrc.com.au/project/risks-opportunities-for-the-blue-economy/)"*

Case 5: Tawi-Tawi

Tawi-Tawi, well-known as the seaweed capital of the Philippines, which produces 294,595 metric tons of seaweed per year (together with Mindanao it contributes to 87% of total production of Philippines) presents a unique case study for blue economy initiatives due to its heavy reliance on a single industry[57]. This emphasis on one economic area, while providing significant economic benefits, also underlines the vulnerabilities and opportunities for similar regions within SIDS. Tawi-Tawi's case study highlights the need for vertical integration and conservation to support its environment and economy.

Renewable Energy for Tawi-Tawi Seaweeds (RETS)

The RETS project, funded by the EU, focuses on providing sustainable energy solutions for seaweed farming communities in Tawi-Tawi. By deploying hybrid solar power plants with battery storage (BESS), the project ensures reliable and clean electricity. This initiative not only empowers seaweed farmers but also serves as a model for green energy in geographically isolated, disadvantaged, and marginalized areas across Mindanao. The implementation of RETS demonstrates the potential of integrating renewable energy with traditional aquaculture practices.

Solar-powered Ice Making Facility in Sarangani

Another important factor of the blue economy development in Tawi-Tawi is the IPURE Mindanao project[58] . This EU-funded program reinforces the local fisheries by providing a solar-powered ice making facility in Glan. This facility is key for ensuring the freshness of seafood, preserving fish catches and reducing post-harvest losses. The success of this project highpoints the need of integrating renewable energy solutions to support the fishing industry.

Climate-Resilient Water Facilities

A mutual project by the Mindanao Development Authority (MinDA) and the United Nations Industrial Development Organization (UNIDO) develop solar-powered water facilities in island communities. This initiative ensures the provision of clean drinking water and demonstrates the role of solar energy in building climate resilience.

Technology and Data Enablers

Data availability is essential for optimizing off-grid hybrid renewable energy systems in remote island settlements. Different configurations of hybrid solar power plants and storage options can be explored to provide reliable electricity. These configurations undergo comprehensive technical, economic, environmental, and social analyses to determine the most optimal design.

Important Data Sources:

- Historical weather patterns for solar radiation levels, temperature data, and geographic information system (GIS) data to determine the suitability of locations
- Economic data - electricity prices and financial indicators
- Satellite imagery and high-resolution maps to predict solar irradiance and identify areas with the most solar potential.
- Sensor data from solar panels: For AI-powered anomaly detection and performance assessment
- Battery storage data for predictions of energy production, demand patterns, and grid conditions

Technical evaluation for solar installations on islands involves a thorough analysis of historical weather patterns and GIS data to determine the most suitable locations. Predictive models for sun exposure can be used to optimize panel placement, predict energy output, and improve grid integration. AI-generated high-resolution maps can also help to identify areas with the highest solar potential, by considering shading, roof orientation, and local weather patterns.

Machine learning models can enhance this process by forecasting performance configurations, predicting renewable fraction and levelized unit cost of electricity. Furthermore, AI-powered anomaly detection analyzes sensor data to identify performance issues, which will enhance reliability and efficiency. These advanced techniques also contribute to predictive maintenance, with AI algorithms optimizing cleaning schedules and reducing maintenance costs. In addition, battery storage systems for solar energy are optimized by predicting energy production, demand patterns, and grid conditions, ensuring efficiency and resilience. Data science can further enhance solar insurance and financing by assessing risk profiles for solar installations. Overall, integrating AI and machine learning into solar energy systems not only maximizes efficiency and reliability but also supports financial and operational aspects of solar power, driving the transition to renewable energy on islands.

For the clean drinking water case, it is essential to optimize both solar energy utilization and the operation of water facilities[59].

Databases and Data Sources:

- ESA Copernicus Open Access Hub for Sentinel satellite data
- Google Earth Engine for geospatial data and satellite imagery analysis · NASA's Surface Meteorology and Solar Energy (SSE) for global solar radiation data
- National Mapping and Resource Information Authority (NAMRIA) and Philippine Statistics Authority (PSA) for hydrographic data and community water resource maps
- Climate Data Online (CDO) for historical and future climate data.

The above five case studies highlight unique customized solutions for advancing the blue economy in the Philippines. Metro Cebu capitalizes on its urban infrastructure to implement industrial-scale blue carbon projects and marine biotechnology. Bohol focuses on sustainable tourism and environmental preservation. Northeast Mindanao prioritizes collaboration and science-based management to tackle its distinct challenges, while Tawi-Tawi integrates renewable energy to bolster its seaweed farming industry. Each case highlights the need for a comprehensive, context-specific approach to sustainable developmentRenewable energy serves as a critical enabler across these projects, facilitating sustainable development and reducing environmental impact. The Offshore Wind projects in Mindoro and the Verde Island Passage (VIP) exemplifies this potential. VIP, a globally significant marine corridor, offers a unique opportunity to harness wind energy while preserving its rich biodiversity. Projects like the Northern Mindoro Offshore Wind Power Project and the Bulalacao Bay Offshore Wind Energy Project showcase how clean energy can create jobs and push economic growth. By integrating renewable energy, these proposals pave the way for a more resilient and sustainable future. This in turn lines up with the broader goals of the blue economy and provides a blueprint for similar efforts in other SIDS. Data science techniques will enable us to navigate, support and enable these renewable energy use cases. Techniques like geospatial analysis, machine learning, and environmental modeling can be employed to assess the wind farms' impact on the region's fragile ecosystems. Together with data which serves as the foundation of any decision-making and planning process[32]; we can utilize data from PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration) to identify optimal turbine locations based on wind patterns (i.e. information on climate and weather data such as wind speeds). Furthermore, incorporating data (on protected areas, biodiversity, and environmental impact assessments in the Philippines) from DENR (Department of Environment and Natural Resources) and GBIF (Global Biodiversity Information Facility) allows

machine learning models to predict potential environmental impacts during construction and operation of wind farms[42]. The Philippines' journey into the Blue Economy demands a delicate balancing act. The rich biodiversity of the Verde Island Passage (VIP) presents both challenges and opportunities.

One common data technique across the use cases is the need for geospatial analysis and GIS technology for mapping and assessing marine resources, including fish stocks, minerals, and energy potential. By providing detailed spatial data and analysis, GIS helps identify areas suitable for sustainable exploitation, conservation, or restoration. Specifically, Online GIS Mapping Tools such as ARIES for SEEA Explorer enables users to produce rapid scalable and customizable ecosystems of their area of interest[32]. This capability is vital for managing marine resources effectively, ensuring that fishing practices remain sustainable, valuable minerals are extracted responsibly, and energy projects, such as offshore wind farms, are optimally located. Furthermore, GIS aids in monitoring and protecting marine ecosystems, supporting efforts to maintain biodiversity and environmental health. Through comprehensive mapping and assessment, utilizing geospatial analytics and GIS tools enables better informed decision-making for the balanced use and preservation of marine resources.

Nonetheless, it is crucial to emphasize the implementation of robust data collection tools[32] to ensure the sustainable development of data science solutions in blue economy projects. As the blue economy includes various marine and maritime activities, such as fisheries, tourism, and renewable energy, the accurate and comprehensive collection of data is crucial for informed decision-making and sustainable management. Advanced data collection tools, such as remote sensing, IoT devices, and automated data loggers[60], enable continuous and precise monitoring of marine environments, providing real-time insights into oceanographic conditions, biodiversity, and human impacts. By establishing these data tools, we can create a reliable data infrastructure that supports predictive analytics, risk assessment, and resource optimization. Ensuring sustainable data collection and data quality monitoring will enhance the efficacy of blue economy initiatives, and ensure that marine resources will be managed in a way that balances economic growth with environmental preservation. Solving this data gap will pave the way for a sustainable and resilient future.

> *"Coastal conservation and education are key to unlocking the blue economy, with Marine Protected Areas serving as vital pillars of sustainability."*

JOEY GATUS
Natural Resource Management Specialist / Board Member
COASTAL CONSERVATION & EDUCATION FOUNDATION, INC.

The Blue Ecosystem and Enablers

Implementation of blue economy solutions relies on the synergy between government, technology, and financial institutions. Their cooperation is not just favorable but essential to overcoming the challenges caused by adherence to sustainable development.

Data from productive "blue projects" around the world underlines the significance of this trinity. For instance, in Seychelles, the release of the world's first blue bond in 2018 was a revolutionary milestone that was possible only through the collaboration of the technological experts in marine management, government, and financial support from international institutions such as the World Bank. This bond raised $15 million to help sustainable marine initiatives and fisheries projects[61].

Likewise, in the Philippines, the realization of marine spatial planning has been notably boosted by financial investments and technological advancements. The Philippine government, with the continuous backing of technology partners and funding from organizations like the Asian Development Bank, has been able to progress with far-reaching marine spatial plans, which equalize environmental sustainability and economic interests.

The Role of Government

Governments are involved in the formulation of supportive policies and regulations, foster international collaborations, and provide the necessary infrastructure for sustainable projects. During the Forum on China-ASEAN cooperation in the blue economy, held on May 18 in Haikou, South China, experts accentuated the potential benefits of creating a free trade network focused on integrating the blue economy. This integration could notably boost regional economic growth and inject "blue momentum" into regional economic integration. Currently, 30 percent of ASEAN countries' GDP comes from the sea, calling attention to cooperative efforts in the blue economy sector[62].

The Role of Technology

The technological approaches in the four case studies mentioned above expose a number of key similarities and patterns. One significant aspect is the integration of multiple data sources. Projects like monitoring plastic waste and evaluating seagrass habitats leverage diverse data

"As an environmental planner, I believe marine spatial planning is pivotal in developing the Philippines' vibrant blue economy. By integrating local and national development plans with strategic marine resource management, we can achieve sustainable growth, protect marine ecosystems, and enhance the prosperity of coastal communities."

ENP KAREN GATUS
Member
PHILIPPINE INSTITUTE OF ENVIRONMENTAL PLANNERS

Digital Tools and Approaches that can Support Blue Economy Development

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The Role of Technology

The technological approaches in the four case studies mentioned above expose a number of key similarities and patterns. One significant aspect is the integration of multiple data sources. Projects like monitoring plastic waste and evaluating seagrass habitats leverage diverse data sets, including satellite imagery, spatial data, and species distribution models. Machine learning (ML) and predictive analytics are central to these projects. These technologies enable the creation of predictive models that anticipate environmental changes and optimize resource use. Hence, technology is at the heart of advancing the blue economy as it offers essential tools for resource and economic management, environmental monitoring and community engagement.

Digital tools enhance blue economy development and contributes in varying degrees to impactful initiatives- be it is Blue Assets management, Digitalization, Technology and Project development, Environmental assessments, and even in Consultancy and Planning.

The Role of Financing

Financing from international bodies such as the Asian Development Bank, World Bank, UNOPS, DBS, OCBC, HSBC, and Citibank is essential for the realization of blue economy projects. These organizations provide the necessary capital for large-scale initiatives, offer expertise in project management, and support through grants and loans. Different financial institutions have varying focuses and capabilities, making their roles complementary. For instance, ADB and World Bank often support infrastructure projects and policy reforms, while private investors and funds like Deliberate Capital and Infra Crowd Capital can focus on innovative, smaller-scale initiatives. Strategic financial support aligns resources with sustainable development goals, ensuring that projects are both impactful and viable.

These three components must work together seamlessly to achieve sustainable development goals. This synergy creates a robust framework where government policies provide the foundation, technology drives innovation, and financial institutions supply the necessary capital and expertise. Renewable energy serves as a key enabler, supporting various sectors within the blue growth framework. We propose inclusion of vulnerability measures as a criterion for concessional finance allocation and advocate for reforms in credit rating systems. Overcoming local barriers such as limited institutional capacity and weak governance is also crucial for accessing external financing.

Graphic representations of these interdependencies can help stakeholders comprehend the multilayered nature of blue economy initiatives. Diagrams demonstrating the relations between government policies, technological advancements, and financial support can provide a transparent picture of how these elements come together.

"Investing in the blue economy is an investment in our future. UnionBank is committed to financing solutions that empower island communities and contribute to inclusive prosperity."

ANGELICA MARIE JUSTO- OZAETA
CSR and Sustainability Senior Manager
UNION BANK OF THE PHILIPPINES

"We're making significant investments in data science, AI, and geospatial analytics capabilities, recognizing their critical role in accelerating the achievement of the Sustainable Development Goals."

RODOLFO CALZADO, JR.
Assistant Secretary for Development Cooperation
DEPARTMENT OF SCIENCE AND TECHNOLOGY (DOST) OF PHILIPPINES

Government Policies

- Set regulatory frameworks
- Foster international collaborations
- Implement policies supporting sustainable development

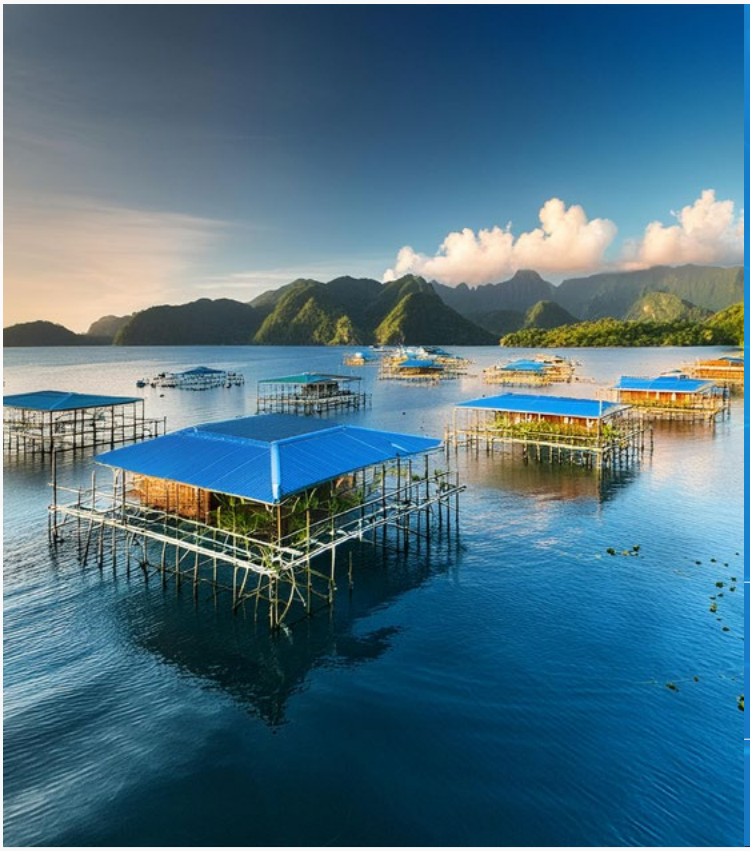
Technological Advancements

- Provide tools for efficient resource management
- Facilitate real-time data collection and analysis
- Drive innovation in sustainable practices

Financial Support

- Offer capital through grants, loans, and investments
- Align financial resources with sustainable goals
- Ensure project viability and impact

Three components to achieve sustainable development goals

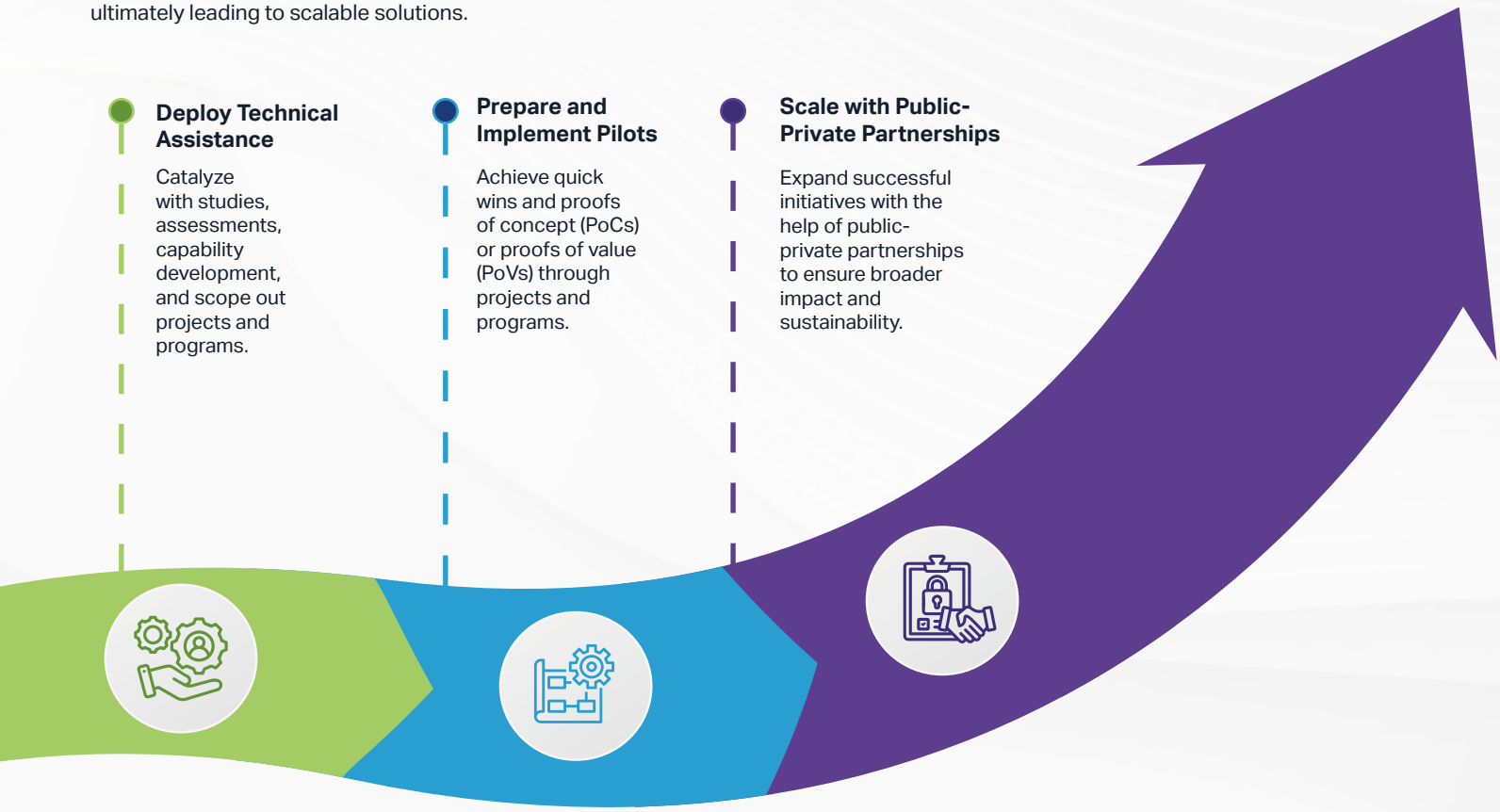


"Investing in the blue economy isn't just about economic growth. It's about leveraging data and AI to build a future where Filipinos and the ocean can flourish together."

FELICIA LI-GAILLARD
Chief Sustainability Officer
ABOITIZ DATA INNOVATION

To effectively deploy blue economy initiatives, a structured approach that outlines main milestones is crucial. This includes a systematic progression from initial assessment to full-scale implementation, maximizing efficiency at each stage. Highlights key milestones necessary for the successful execution of blue economy projects.

These steps create a structured approach to advancing blue economy initiatives. Each phase builds on the successes of the previous one, ultimately leading to scalable solutions.



Key milestones for successful execution of blue economy projects.

Advancing Blue - Next Steps

The successful implementation of blue economy initiatives in Metro Cebu, Bohol, Northeast Mindanao, and Tawi-Tawi demonstrates the potential for these strategies to be applied in other regions, both within the Philippines and across other Small Island Developing States (SIDS). By leveraging unique local strengths along with data science and AI, urban infrastructure in Cebu, pristine environments in Bohol, collaborative governance in Mindanao, and renewable energy integration in Tawi-Tawi—these case studies showcase a customized approach to sustainable development. Applying these principles further can enable other regions to control their marine resources effectively and address specific vulnerabilities. The diverse strategies highlight the importance of adapting solutions to local contexts, ensuring the blue economy's principles are robust and flexible enough to meet different challenges.

To facilitate the effective transfer of these successful strategies to other economies a comprehensive checklist was proposed. This checklist will help determine the suitability and potential success of blue economy initiatives in different contexts. By assessing factors such as local context, enablers and vulnerabilities this tool aims to customize complex solutions for specific regions, ensuring they are effective. The checklist serves as a strategic guide to identify fundable areas for institutions like the Asian Development Bank (ADB) and to ensure that core principles of the blue economy can be tailored to diverse settings.

While the core component of renewable energy is a given, the checklist will help construct a comprehensive framework around it. By answering these questions, stakeholders can determine which areas a customized blue economy solution should include for a given case. For instance, if a region shows significant economic vulnerability due to reliance on a single industry and has strong urban infrastructure, the solution might focus on integrating renewable energy with blue carbon initiatives and sustainable tourism practices.

Checklist to customize complex blue economy solutions for specific regions.

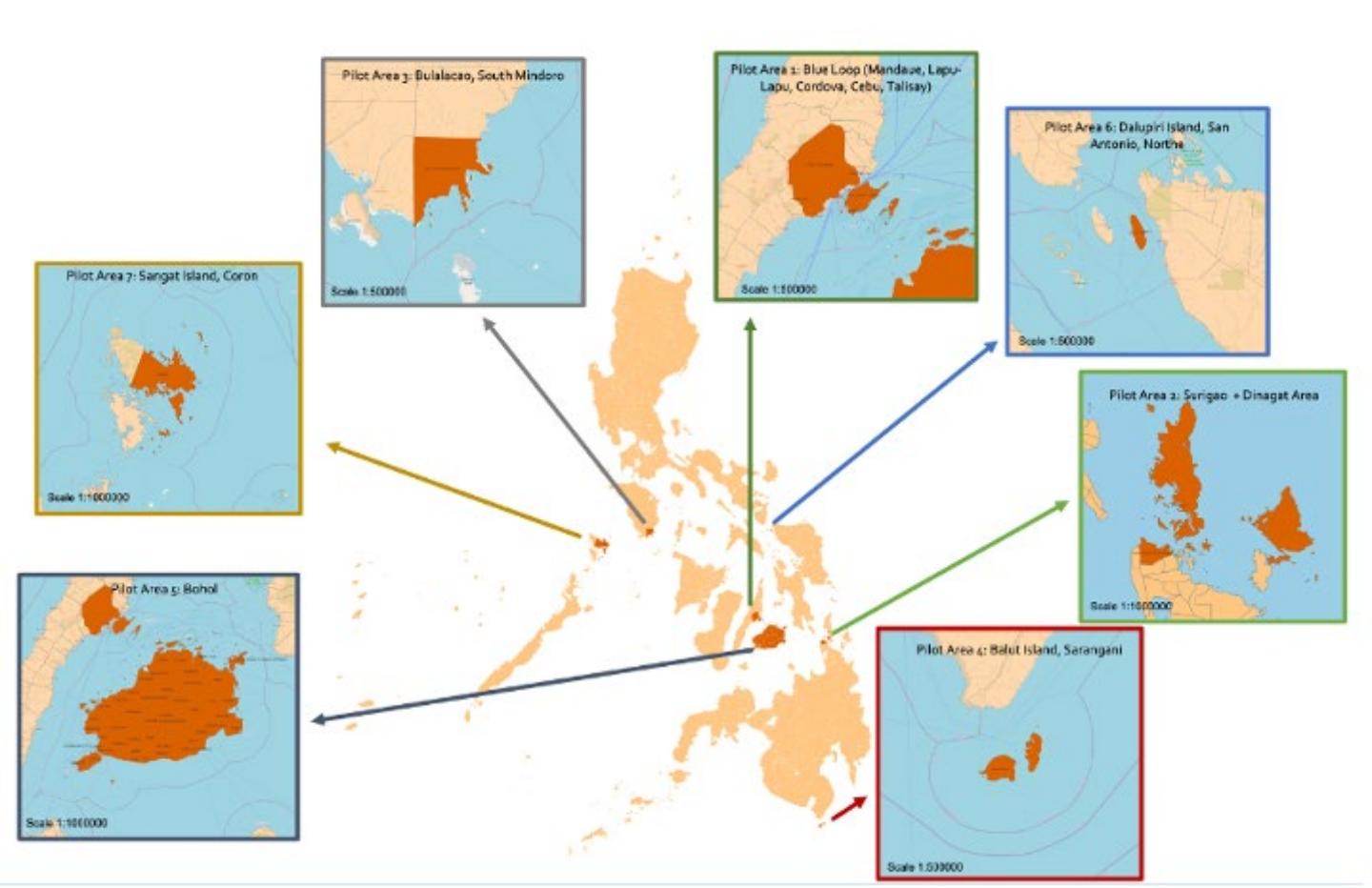
Criteria	Yes	No
Local Context		
Does the region have significant urban infrastructure?	☐	☐
Is the region known for its pristine natural environments?	☐	☐
Are there established collaborative governance structures?	☐	☐
Is renewable energy currently being used or planned for use in the region?	☐	☐
Vulnerabilities		
Are there significant economic vulnerabilities (e.g., reliance on a single industry)?	☐	☐
Are environmental vulnerabilities (e.g., natural disasters, climate change) a major concern?	☐	☐
Are there structural development limitations (e.g., water scarcity, arable land)?	☐	☐
Primary Focus Areas		
Is there a need to enhance blue carbon initiatives (e.g., mangrove restoration)?	☐	☐
Are sustainable tourism practices a priority for the region?	☐	☐
Is there potential for marine biotechnology and pharmaceuticals?	☐	☐
Is the conservation and sustainable use of marine biodiversity a critical need?	☐	☐
Enablers and Support		
Are there policies and governance structures in place to support blue economy initiatives?	☐	☐
Is there access to necessary funding and financial mechanisms?	☐	☐
Are local communities and stakeholders engaged and supportive?	☐	☐
Is there sufficient infrastructure (e.g., transportation, renewable energy) to support the initiatives?	☐	☐

Appendix

Appendix 1: Marine Spatial Planning (MSP) and the Blue Economy

Marine Spatial Planning (MSP) is a new management framework that can help integrate management across multiple sectors and ensure that the ocean is used sustainably. It is a process of developing a blueprint for managing marine areas in an integrated and multi-objective approach considering the ecological, economic, social, and cultural factors. This research initiative aims to develop an MSP framework that can be adapted to local contexts. Specifically to: (1) conduct a thorough review of state-of-the-art tools and processes used for MSP, both globally and within the Philippines; (2) determine the most suitable MSP processes, frameworks, and tools for application at the Local Government Unit (LGU) municipality level in the Philippines and potentially other similar contexts; and (3) identify MSP tools, such as the Geographic Information Systems (GIS), that can support LGUs in blue economy development and strategic planning within the context of the Enhanced Land Use and Comprehensive Plan (CLUP).

The baseline study will focus on several pilot sites, including the Blue Loop (encompassing Mandaue, Lapu-Lapu, Cordova, Cebu, Talisay), Surigao City and the Dinagat Area, Bulalacao in South Mindoro, Balut Island in Sarangani, Bohol, Dalupiri Island in San Antonio Northern Samar, and Sangat Island in Coron.

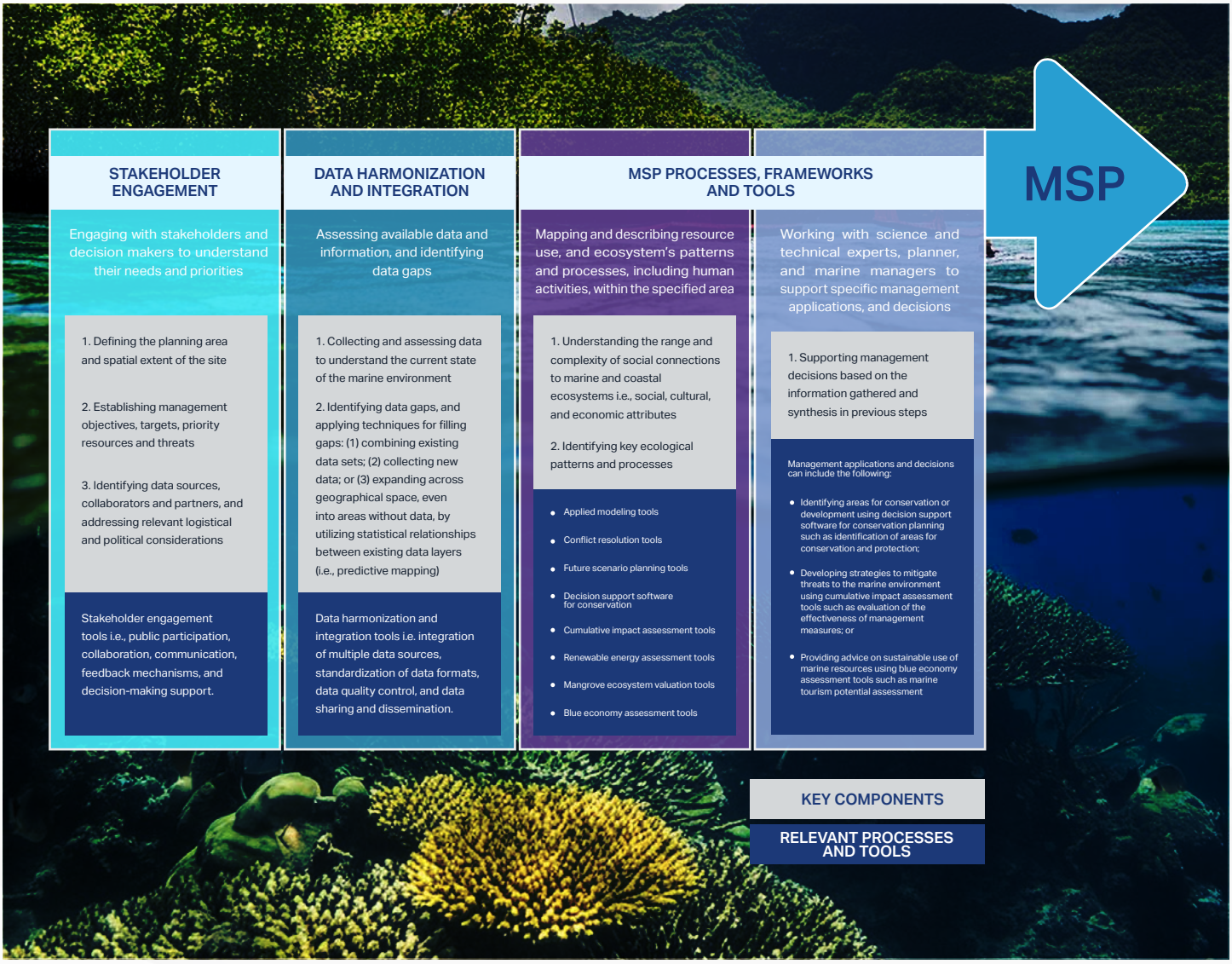


Pilot areas of MSP in the Philippines

MSP serves as a strategic tool for the sustainable management of our oceans. It involves the analysis and allocation of the spatial and temporal distribution of human activities in marine areas, aiming to achieve ecological, economic, and social objectives. Whether you are a policy maker, a marine biologist, or a member of a coastal community, this proposed MSP framework will assist you in understanding and navigating the complexities of MSP, empowering you to contribute effectively to the sustainable use of our marine resources.

The scope of MSP process can vary based on the specific context and objectives. It may include the geographic area, types of regulated activities, and planning goals. In the case of LGUs in the Philippines, the suggested MSP framework takes a comprehensive approach to marine management, recognizing the interconnectedness of marine ecosystems and human activities. This framework is designed for implementation in several phases, aiming to facilitate effective decision-making and stakeholder engagement. The framework is divided into three main sections: (1) stakeholder engagement, (2) data harmonization and integration, and (3) MSP processes, frameworks, and tools. Each section details key components and relevant processes and tools, providing a comprehensive guide for implementing MSP. By following this framework, we aim to promote sustainable use of marine resources, protect marine ecosystems, and foster collaboration among stakeholders.

Phases of MSP

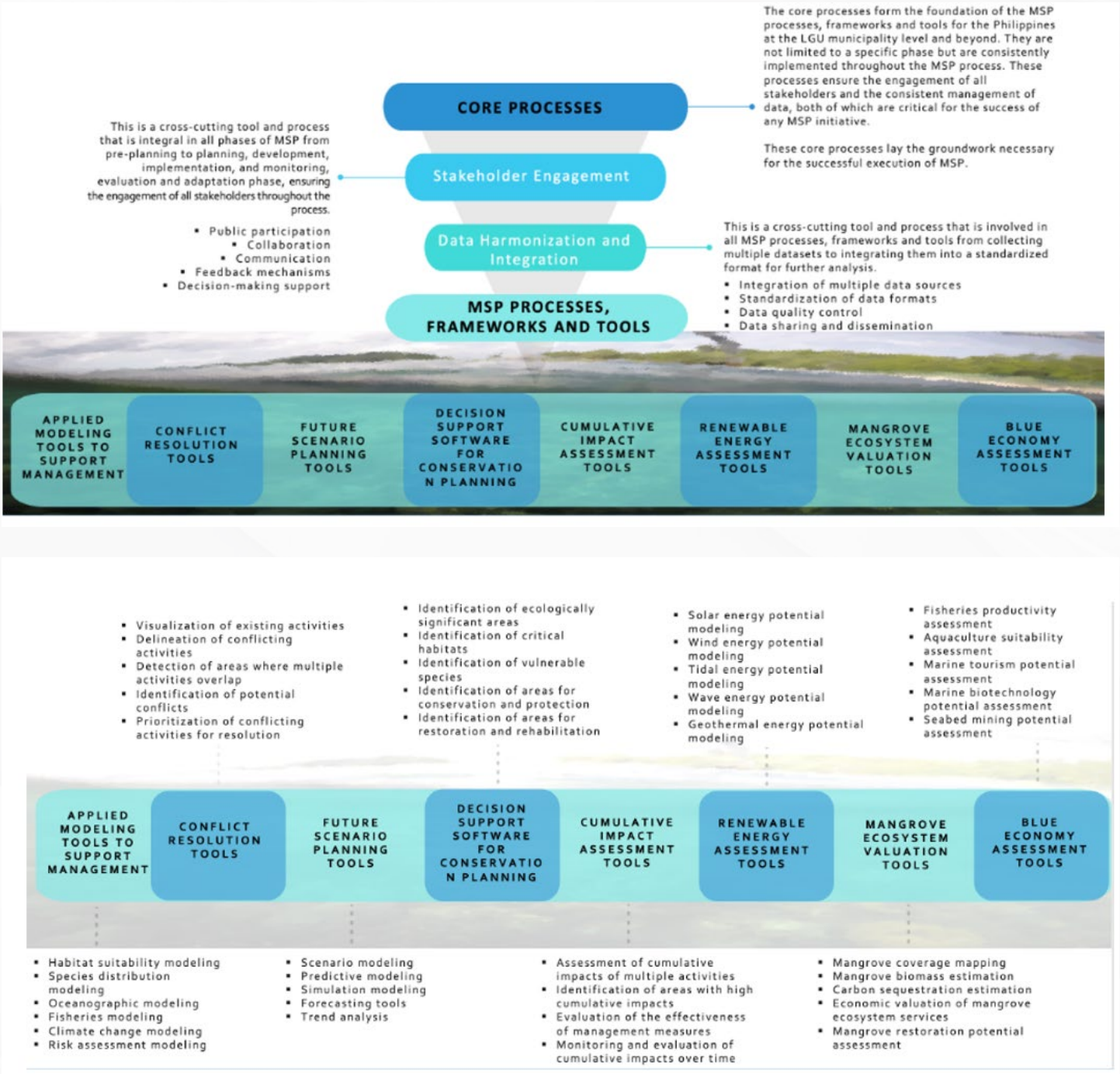


Working version of the suggested MSP framework

This working version of the MSP framework is a significant step towards sustainable marine management in the Philippines. It provides a structured approach to MSP that is adaptable to the unique needs and priorities of different LGUs. By integrating scientific knowledge with stakeholder input, the framework aims to balance conservation and development objectives, ultimately contributing to the health and resilience of the Philippines' marine ecosystems.

MSP Processes, Frameworks and Tools

MSP is a critical tool for sustainable ocean management, particularly in the Philippines where marine resources play a vital role in the economy and local livelihoods. At the heart of MSP are two core processes: Stakeholder Engagement and Data Harmonization and Integration. These processes are consistently implemented throughout the MSP process, from the LGU municipality level to broader scales.



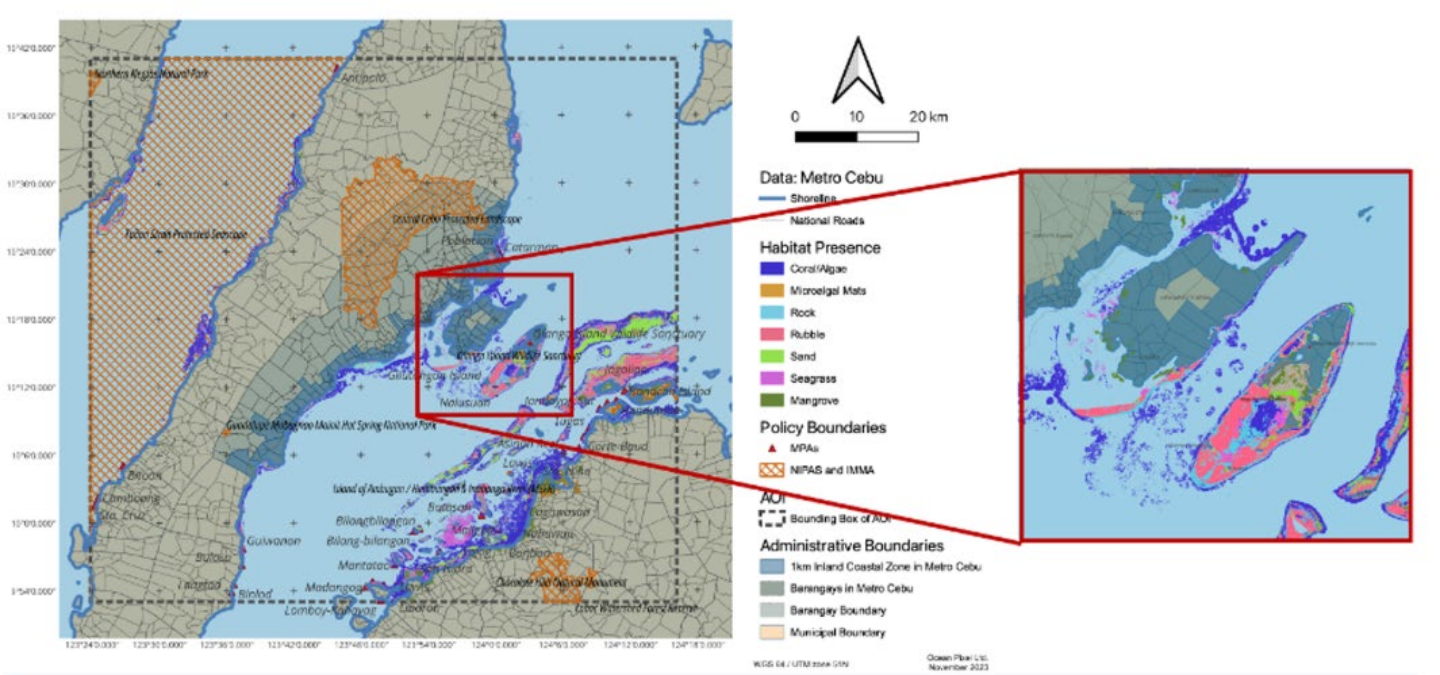
MSP processes, frameworks and tools

The pre-planning steps involve identifying stakeholders and gathering, integrating, and standardizing data, which are crucial before any processing can take place. The MSP processing tools and processes then use this data to analyze, plan, implement, and monitor marine spatial plans.

The GIS Processing Workflow for MSP

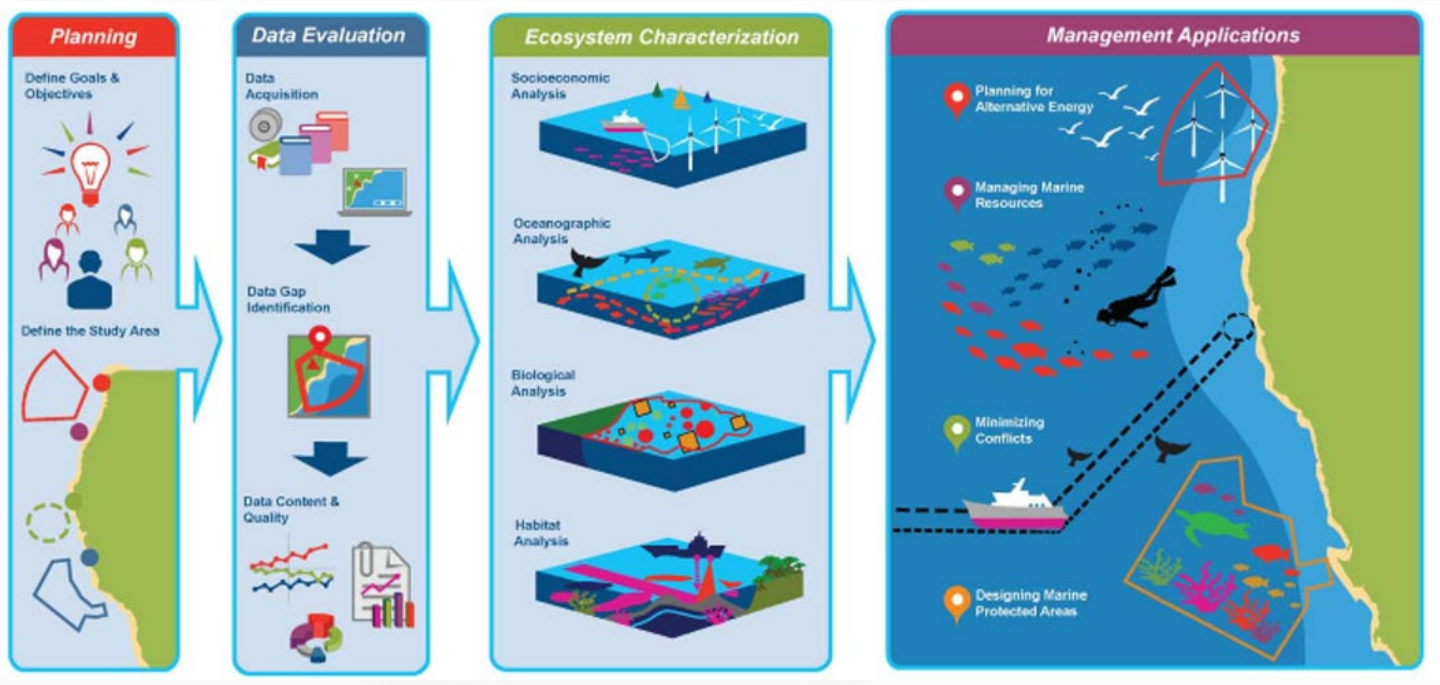
MSP is a practical way to create and establish a more rational use of marine space and the interactions among its uses, to balance demands for development with the need to protect the environment, and to achieve social and economic objectives. To effectively implement MSP, a well-defined GIS processing workflow is essential. This structured approach ensures informed decisions based on sound data, promoting sustainable marine management: (1) Planning area and extent: Define the planning area by selecting spatial and temporal extent, ranging from a small coastal area to an entire ocean basin, depending on the project scale.; (2) Data and information: Identify relevant data sources (e.g.,

satellite imagery, bathymetric surveys, marine life data). Integrate data using harmonization tools to ensure consistency. Fill data gaps to create a complete dataset for accurate decision-making.; (3) Map and describe resource use and ecosystem patterns: Use decision support software to identify conservation or development areas. Develop mitigation strategies (.g., pollution reduction, species protection). Provide advice for sustainable marine resource use.

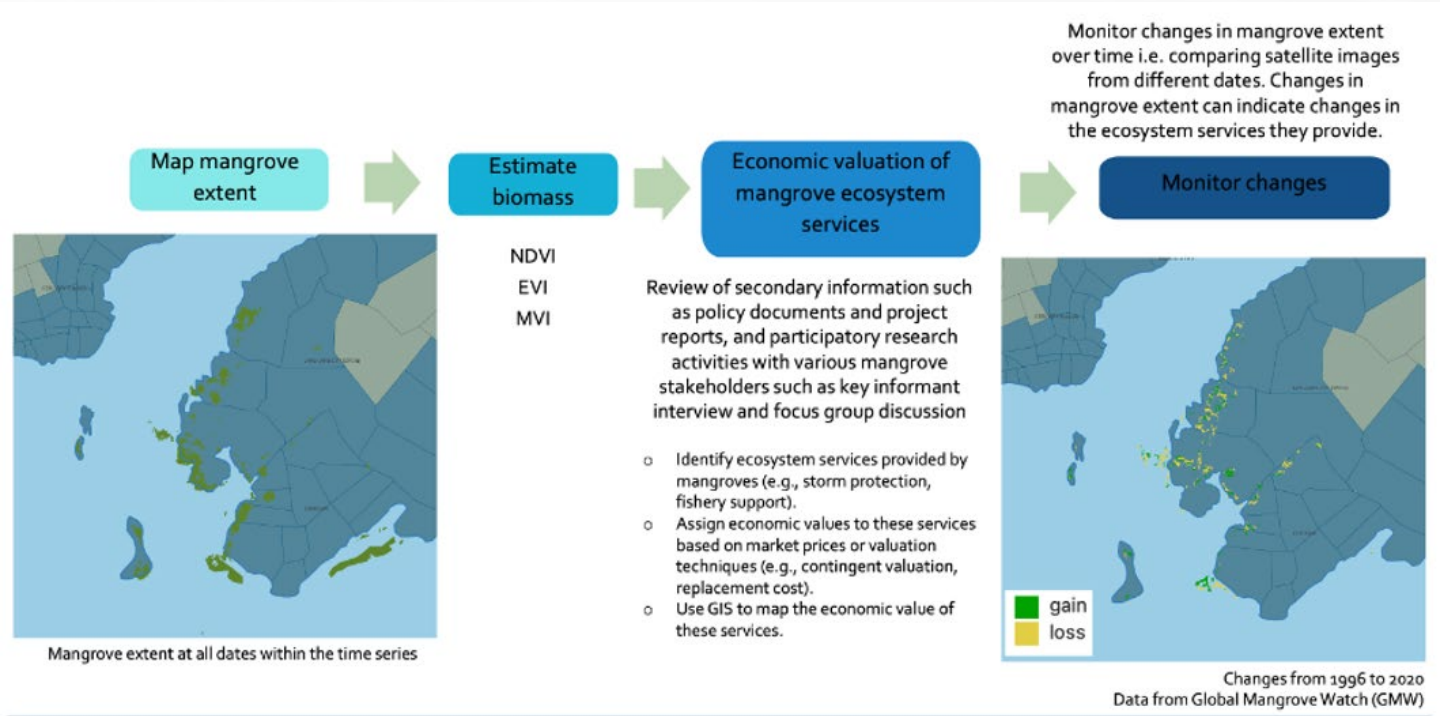


Sample data for MSP

MSP and GIS can be used to estimate the potential for renewable energy (i.e. explore potential for wave energy, tidal, ocean, and riverine current resources, as well as ocean thermal resources), and for economic value estimation.



Potential use of MSP for renewable energy (Source: National Centers for Coastal Ocean Science (NCCOS). (2014, November 20). Innovative management guides marine spatial planning. NCCOS Coastal Science Website. https://coastalscience.noaa.gov/news/innovative-management-approach-aids-marine-spatial-planning/).Science (NCCOS). (2014, November 20). Innovative management guides marine spatial planning. NCCOS Coastal Science Website. https://coastalscience.noaa.gov/news/innovative-management-approach-aids-marine-spatial-planning/).



Potential use of MSP for mangrove ecosystem valuation

Appendix 2: Building Blue Economy Clusters

The paper by Gatdula et al. (2023) explores the concept of building blue economy clusters across various scales in Southeast Asia (SEA). These clusters hold significant potential for generating economic and social benefits. The authors examine challenges within multiple sectors --energy, food (aquaculture), water, transport, environment, tourism --individually, considering projects, programs, and portfolios.

An ecosystem-based approach, emphasizing sectoral synergies as a progressive means to achieve sustainable and inclusive growth pathways, is being advocated. It also highlights the role of technology and innovation in promoting the blue economy. Technologies like marine renewable energy, aquaculture (seaweed farming) electrification of boats, and desalination play a crucial part in sustainable development.

The paper presents case studies and examples of successful blue economy practices: (1) marine renewable energy and aquaculture; (2) digitalization and eco-tourism; (2) clean energy and electric boats; (3) green hydrogen and floating fish farms; and (4) cold storage and hybrid-electric boats.

The paper also discusses the regional efforts of the Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area (BIMP-EAGA).

Source: Gatdula, N.B., Abundo M.L.S., Buhali M.Jr., and Bautista, L. (2023). Building Blue Economy Clusters towards Sustainable Development in Southeast Asia: Ecosystem/s Approach with Sectoral Synergies, Pathways, and Challenges. CAFEO 41 Engineering Conference Proceeding, pages 86-94.

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