NATIONAL TRANSBOUNDARY DIAGNOSTIC ANALYSIS (TDA) REPORT OF VIETNAM

Implementing the Strategic Action Programme for the South China Sea and Gulf of Thailand (SCS SAP) Project

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This draft report was prepared and submitted by the Vietnamese independent consultant team

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CHAPTER 1. BACKGOUND (TO BE UPDATED)

1. Introduction

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2.1. Key findings

Vietnam's coastal areas exhibit a distinct and compound socioeconomic risk profile that is systematically higher than that of inland areas. Nearly half of the national population is concentrated in coastal areas that account for just over 40% of national land area, creating sustained pressure on infrastructure, public services, and labor markets, and heightening vulnerability to shocks such as natural disasters, pandemics, and economic disruptions. Uneven urbanizationfurther amplifies risk. While major coastal growth centers capture most economic opportunities, many coastal provinces remain weakly urbanized, reinforcing spatial inequality and limiting livelihood diversification.

Socioeconomic vulnerability is intensified by low elevation and population distribution, with around 86% of coastal residents living below 100 m above sea level, particularly in deltaic provinces where exposure to flooding, storm surges, sea-level rise, and salinity intrusion is highest. Rapid expansion of built-up areas along dynamic and eroding coastlineshas increased asset exposure and expected economic losses, especially in the Mekong Delta. Persistent poverty, livelihood dependence on climate-sensitive sectors, and significant gaps between HDI and inequality-adjusted HDI indicate that economic growth has not translated evenly into improved well-being. Finally, strong reliance on shock-sensitive economic structures—notably coastal tourism, energy extraction, and marine transport—creates employment and fiscal volatility, reinforcing the need for diversification and more resilient development pathways.

Among Vietnam's 28 coastal provinces, Ho Chi Minh City and several provinces of the North Central Coast and the Mekong Delta belong to the highest socioeconomic risk group due to extreme population density and exposure despite relatively strong human development outcomes. Nghe An, Thanh Hoa, Bac Lieu, Soc Trang, Kien Giang, Tra Vinh, Ben Tre, and Ca Mau also fall into the high-risk group, reflecting the combined effects of poverty, low elevation, and limited economic diversification. In contrast, Khanh Hoa, Ba Ria–Vung Tau, Da Nang, and Quang Ninh – the highly urbanized and economically dynamic coastal provinces are caterogized into the lowest risk group, although they remain exposed to climate-related hazards.

2.2. Current status by indicators

2.2.1. Demographics

2.2.1.1. Area

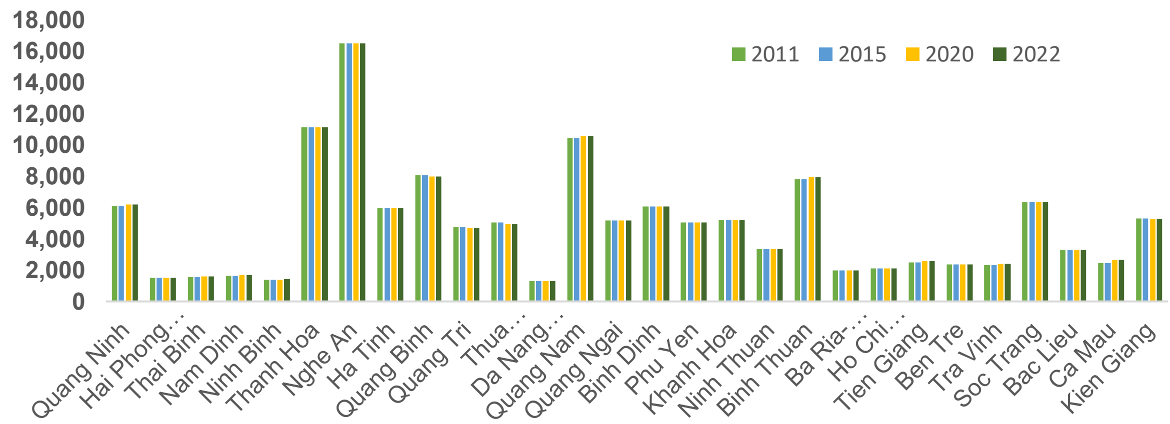
During the 2011–2022 period, the natural area of Vietnam's 28 coastal provinces remained largely stable, exhibiting only minor year-to-year fluctuations. The total coastal area declined slightly from 136,794 km² in 2011 to 136,782.7 km² in 2015, before increasing to 137,218 km² in 2020 and 137,246.0 km² in 2022. Overall, this represents a net increase of approximately 450 km² compared to 2011, which is negligible relative to the national land area.

In terms of its share, the combined natural area of the 28 coastal provinces accounted for approximately 41.3 - 41.4% of the national area over the 2011-2022 period, with a very slight increase from 41.3% in 2011 to 41.4% in 2022. This indicates that the spatial distribution of land between coastal and non-coastal areas has remained unchanged.

Detailed provincial data further confirm the trends. With the exception of Quang Ninh, Thua Thien Hue, Quang Nam, Binh Thuan, and Ca Mau, which experienced minor adjustments, the remaining coastal provinces maintained constant land areas and stable proportions of the national area throughout 2011–2022 (see Indicator SE1-2 and Indicator SE1-4 for details).

Figure 1: Areas of coastal provinces in the 2011 – 2022 period

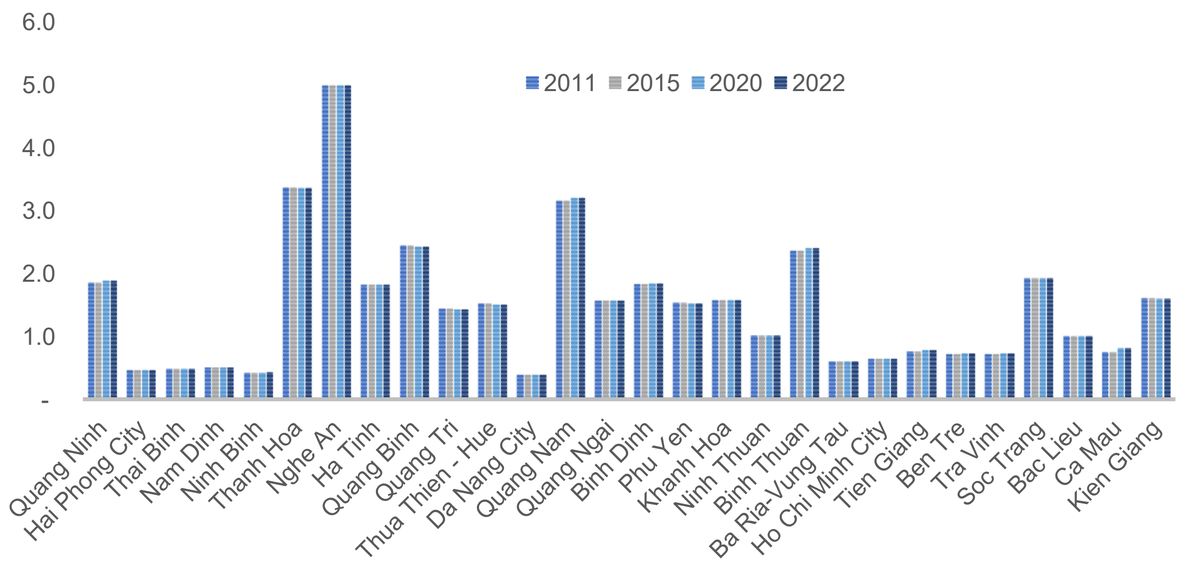
Unit: km²



Source: General Statistic Office

Figure 2: Areas of coastal provinces as proportion of national area in the 2011 – 2022 period

Unit: %



Source: General Statistic Office

2.2.1.2. Population

According to statistical data, during the 2011–2022 period, the total population of Vietnam's coastal provinces increased steadily over time due to the rapid development of industry and urban services in major urban–industrial–port hubs, such as Ho Chi Minh City, Da Nang, Quang Ninh, Ba Ria–Vung Tau, and Khanh Hoa, which acted as key magnets for population concentration. However, the population growth rate of coastal provinces in the same period shows a clear overall slowdown. The share of coastal provinces in the total national population also indicates a steady decrease over years from 50.31% in 2011 to 48.9% in 2022.

Table 1: Population sizes and growth rates of coastal provinces in the 2011-2021 period

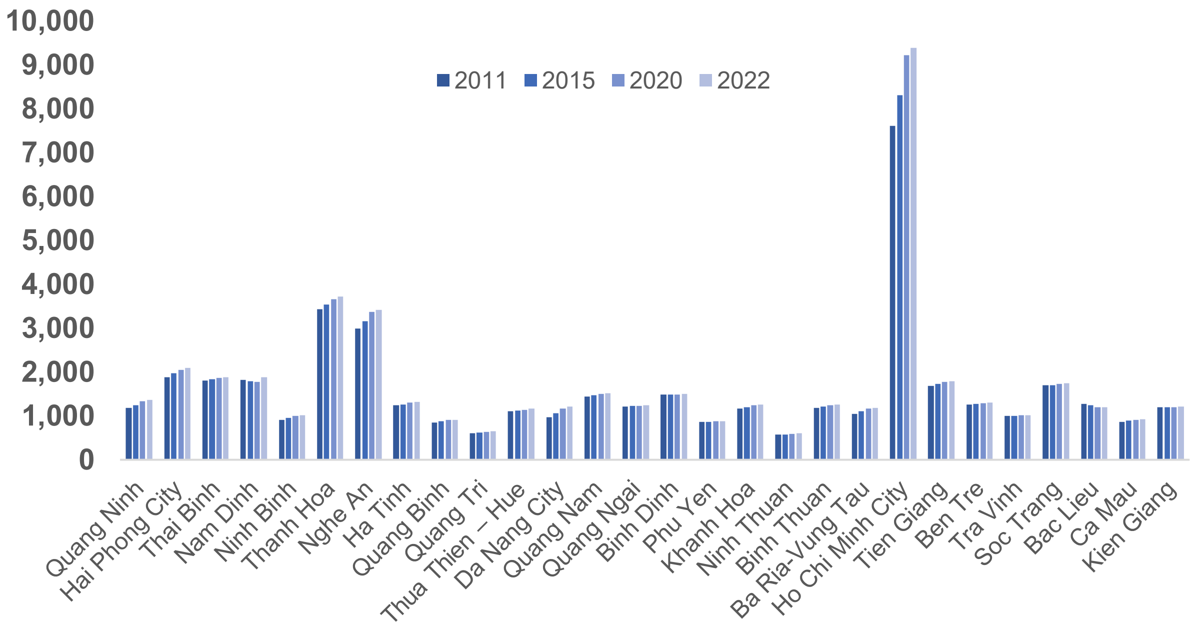
Year	Average population (1,000 persons)		Population growth rate (%)	
	Nation	Coastal provinces	Nation	Coastal provinces
2011	88,145.8	44,354.8	1.24	0.95
2012	89,202.9	44,756.3	1.20	0.91
2013	90,191.4	45,152.4	1.11	0.88
2014	91,203.8	45,509.1	1.12	0.79
2015	92,250.7	45,892.6	1.12	0.84
2016	93,250.7	46,286.6	1.11	0.86
2017	94,286.0	46,680.5	1.11	0.85
2018	95,385.2	47,079.2	1.17	0.85
2019	96,484.4	47,487.4	1,15	0.87
2020	97,582.7	47,881.2	1.14	0.83
2021	98,505.4	48,249.0	0.94	0.77
2022	99,474.4	48,628.6	0.98	0.79

Source: General Statistic Office (2023)

In details, except Bac Lieu, all other coastal provinces experienced an increase in size during the 2011 – 2022 period (see Indicator SE1-1 for details). However, except large coastal cities such as Da Nang and Ho Chi Minh City, which consistently exhibited higher population growth rates, reflecting their role as urban and economic growth hubs, most remaining coastal provinces experienced very low (generally around 0-1% per year) or even negative population growth rates in recent years with a noticeable decline after 2015, especially during 2021–2022, which was likely associated with the impacts of the COVID-19 pandemic on migration and population registration but also indicated population aging and net out-migration trends (see Indicator SE1-5 for details). Meanwhile, the proportion of coastal province's population in the total national population gradually decreased over years in the same period (see Indicator SE1-3 for details).

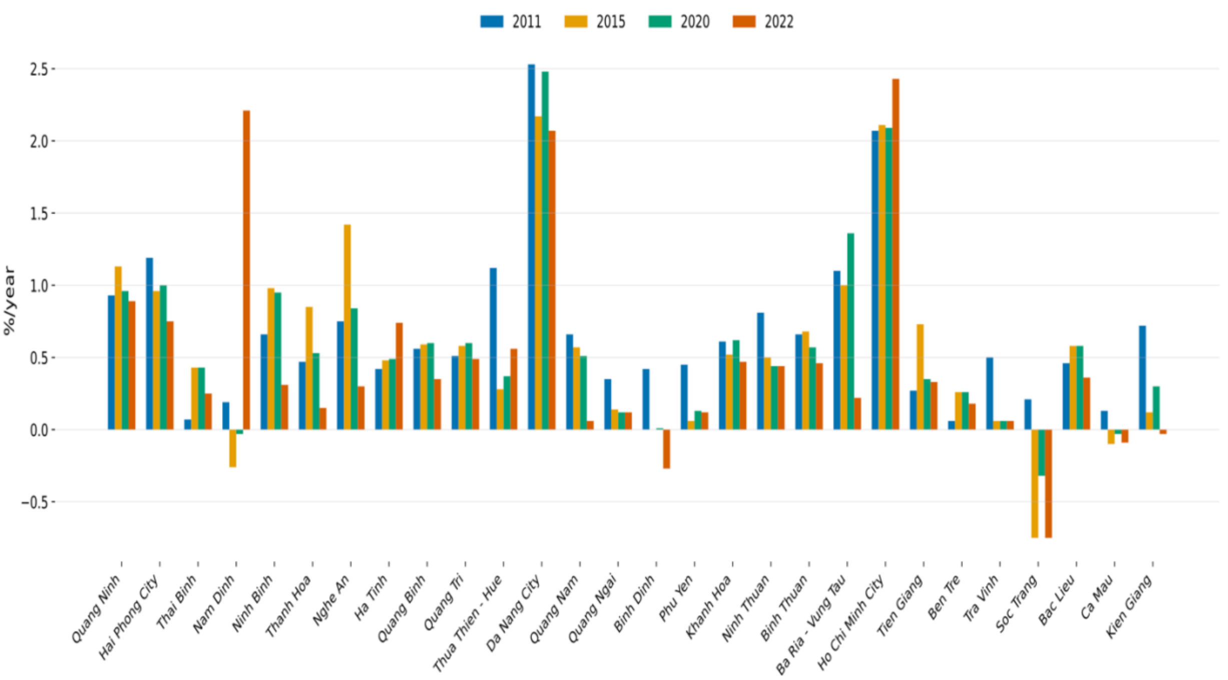
Figure 3: Populations of coastal provinces in the 2011 – 2022 period

Unit: 1,000 person



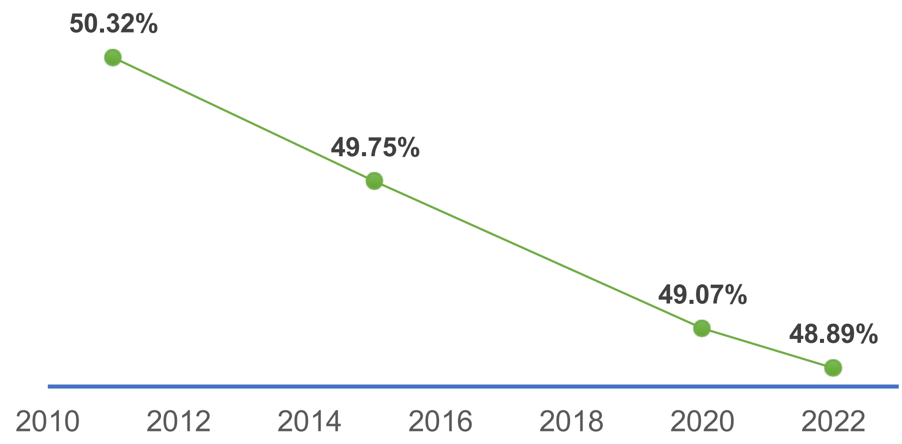
Source: General Statistic Office

Figure 4: Population growth rates of coastal provinces in the 2011-2022 period



Source: General Statistic Office

Figure 5: Coastal provinces' population as propotion of national population in the 2000 – 2022 period

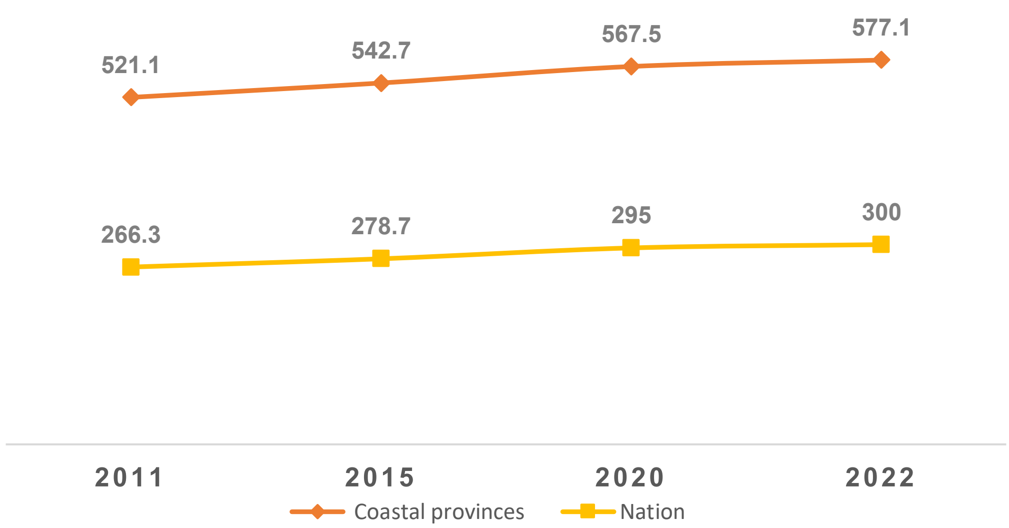


Source: General Statistic Office

2.2.1.2. Population density

Owing to their strong development potential, favorable living conditions, and abundant employment opportunities, coastal provinces and cities have consistently recorded population densities higher than the national average over the 2000–2022 period. In 2022, for instance, while Vietnam's average population density was approximately 300 people/km², the average density of coastal provinces reached 577 people/km²—about 1.92 times higher than the national average and 2.2 times higher than that of non-coastal localities (262 people/km²). Ho Chi Minh City, Hai Phong City, Thai Binh, Nam Dinh, and Da Nang City have remained among the coastal provinces and cities with the highest population densities nationwide for recent decades (see Indicator SE1-6 for details)

Figure 6: Population density trends in the 2011-2022 period



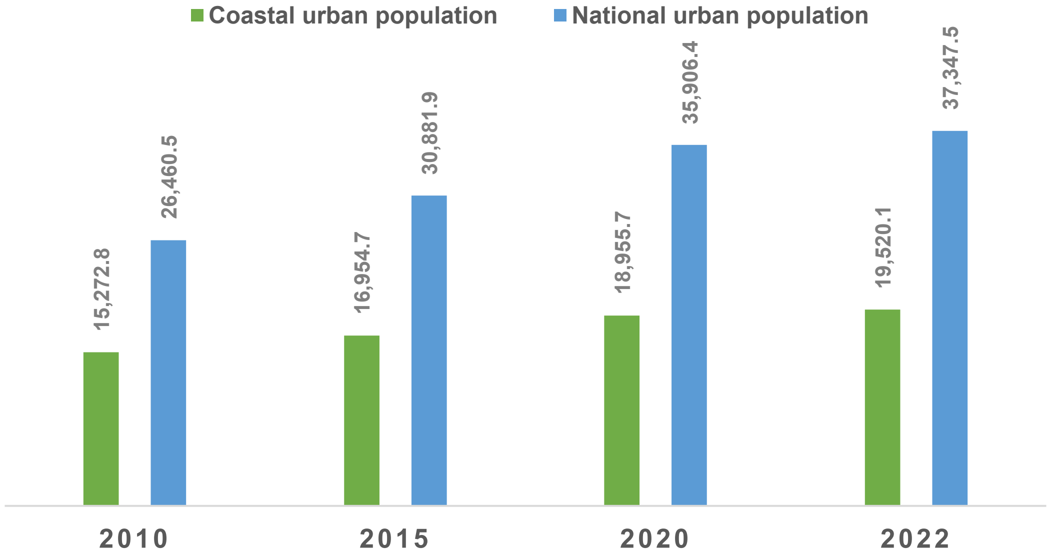
Source: General Statistic Office

2.2.1.3. Urban population

According to data from the General Statistics Office (2023) for the 2011 – 2022 period, the average urban population in coastal provinces continued to expand (and remained higher than the national average national urban population) but growth rates slowed after 2020.

Despite this increase, the coastal share of national urban population declined. Coastal urban population accounted for 57.7% of the national urban population in 2010 but fell to 52.3% in 2022. This implies that urban growth outside the coastal provinces accelerated faster than within the coastal belt over the same period.

Figure 7: Population in urban areas in the 2010 – 2022 period



Source: General Statistic Office

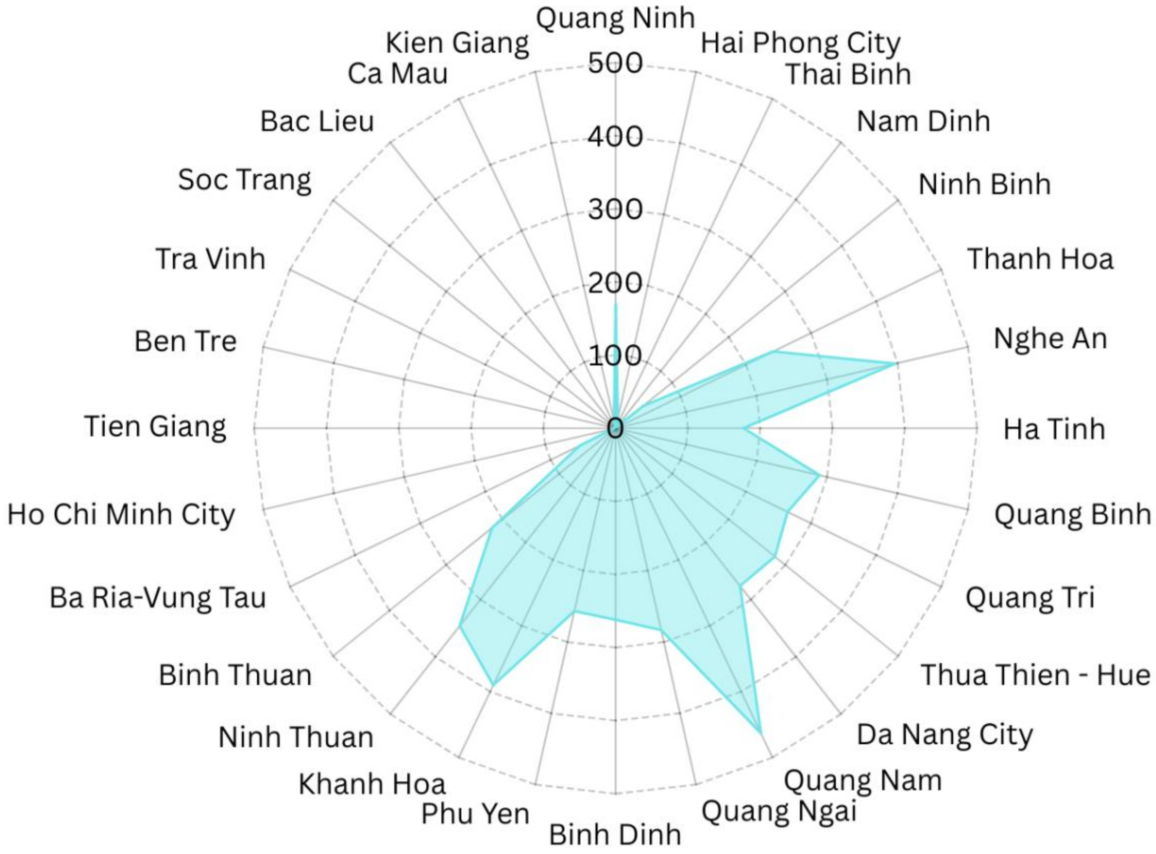
In addition, growth remained highly concentrated in a few major urban–industrial–port hubs. The top five centers, including: Ho Chi Minh City, Da Nang, Thanh Hoa, Hai Phong, Quang Ninh, together accounted for 57.7% of the total urban population of coastal provinces. By contrast, several Mekong Delta coastal provinces (e.g.,, Ben Tre, Ca Mau) experienced much smaller net increases), suggesting more modest urban expansion relative to the leading growth poles (see Indicator SE1-7 for details)

2.2.1.4. Elevation

Vietnam's coastal provinces generally have low elevations, with an average elevation of about 159 m, compared to the national average of 248 m. Many coastal provinces in the Red River Delta and the Mekong Delta have elevations of only a few meters (e.g., 1-5 m) above sea level, making them highly vulnerable to sea level rise, flooding, and saltwater intrusion.

Figure X below shows the average elevation of coastal province in Vietnam in 2022. It can be seen that approximately 50% of coastal localities have an average elevation of less than 100m (see Indicator SE1-8 for details).

Figure 8: Mean elevation of coastal provinces of Vietnam



Source: Adapted from SRTM Digital Elevation Data

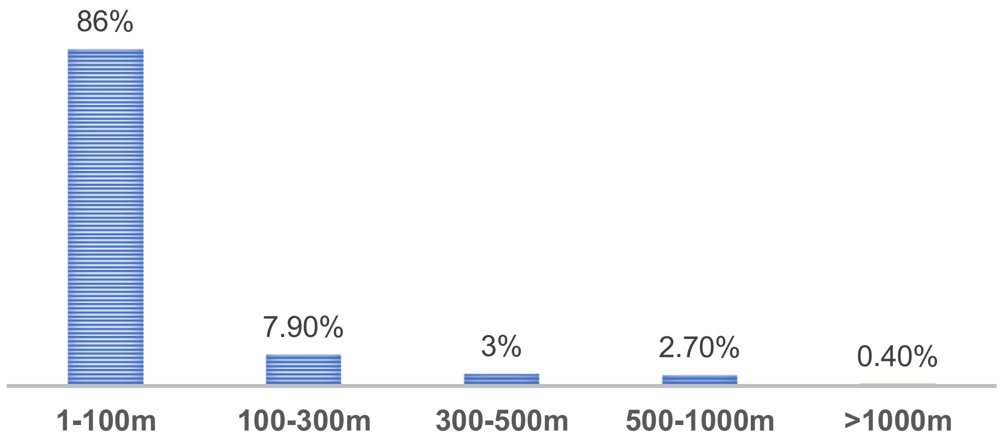
2.2.1.5. Population distribution

Data from the Gridded Population of World Version 4[1] shows that, 9 out of 28 coastal provinces have population concentrated entirely in the 1-100 elevation band, meanwhile 14 out of 28 coastal provinces have more diversified distributions across elevation bands but with little population recorded in higher elevation bands (see Indicator SE1-9 for details)

As can be seen from **Figure 9**, the population of 28 coastal provinces is highly concentrated in low-lying areas. Approximately 86% of the population lives below 100 m above sea level, while less than 6% resides in areas above 300 m. This strong concentration in low-elevation zones highlights the high exposure of coastal populations to sea-level rise, flooding, and saltwater intrusion, particularly in deltaic and coastal plain regions.

[1] The Gridded Population of World Version 4 (GPWv4), Revision 11 models the distribution of global human population for the years 2000, 2005, 2010, 2015, and 2020 on 30 arc-second (approximately 1 km) grid cells. Population is distributed to cells using proportional allocation of population from census and administrative units. Population input data are collected at the most detailed spatial resolution available from the results of the 2010 round of censuses, which occurred between 2005 and 2014. The input data are extrapolated to produce population estimates for each modeled year

Figure 9: Vietnam's coastal population distribution by elevation

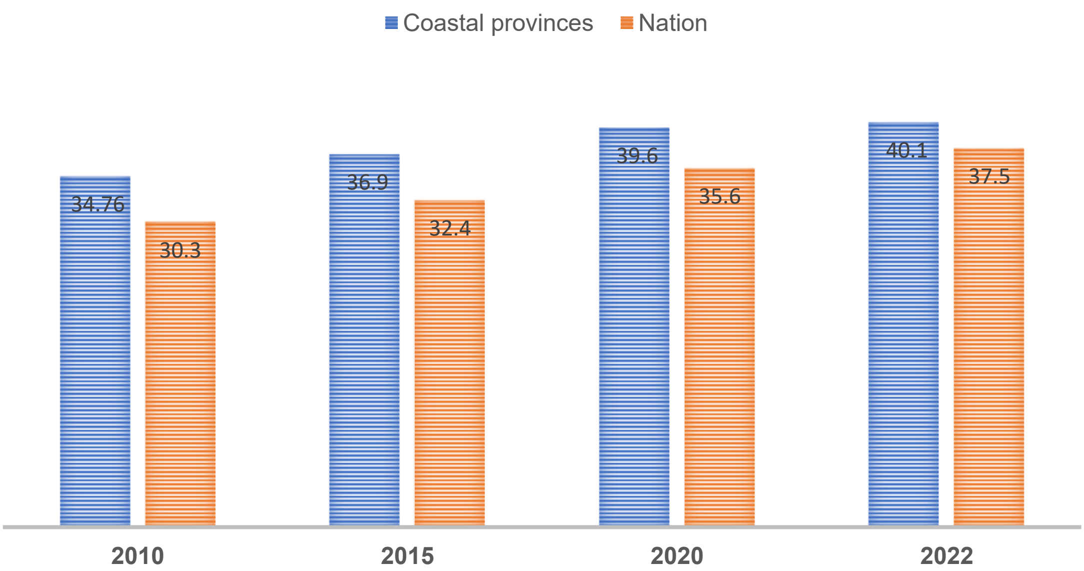


Source: Adapted from Earth Engine Data Cataloge (Population Density)

2.2.1.6. Urbanization

Overall, during the period 2011–2022, the average urbanization rate—measured by the percentage of population at mid-year residing in urban areas by country—of coastal provinces consistently exceeded the national average. In 2022, the urbanization rate in coastal provinces reached 40.1%, compared with the national average of 37.5%. However, substantial disparities existed among coastal provinces. Several provinces, including Quang Ninh, Thua Thien Hue, Da Nang, Ba Ria–Vung Tau, and Ho Chi Minh City, consistently ranked among the most urbanized in the country, with urbanization rates exceeding 50%. In contrast, other coastal localities, such as Thai Binh, Nghe An, Tien Giang, and Ben Tre, remained among the least urbanized nationwide, with urbanization rates below 20% (see Indicator SE1-10 for details)

Figure 10: Urbanization rates of Vietnam



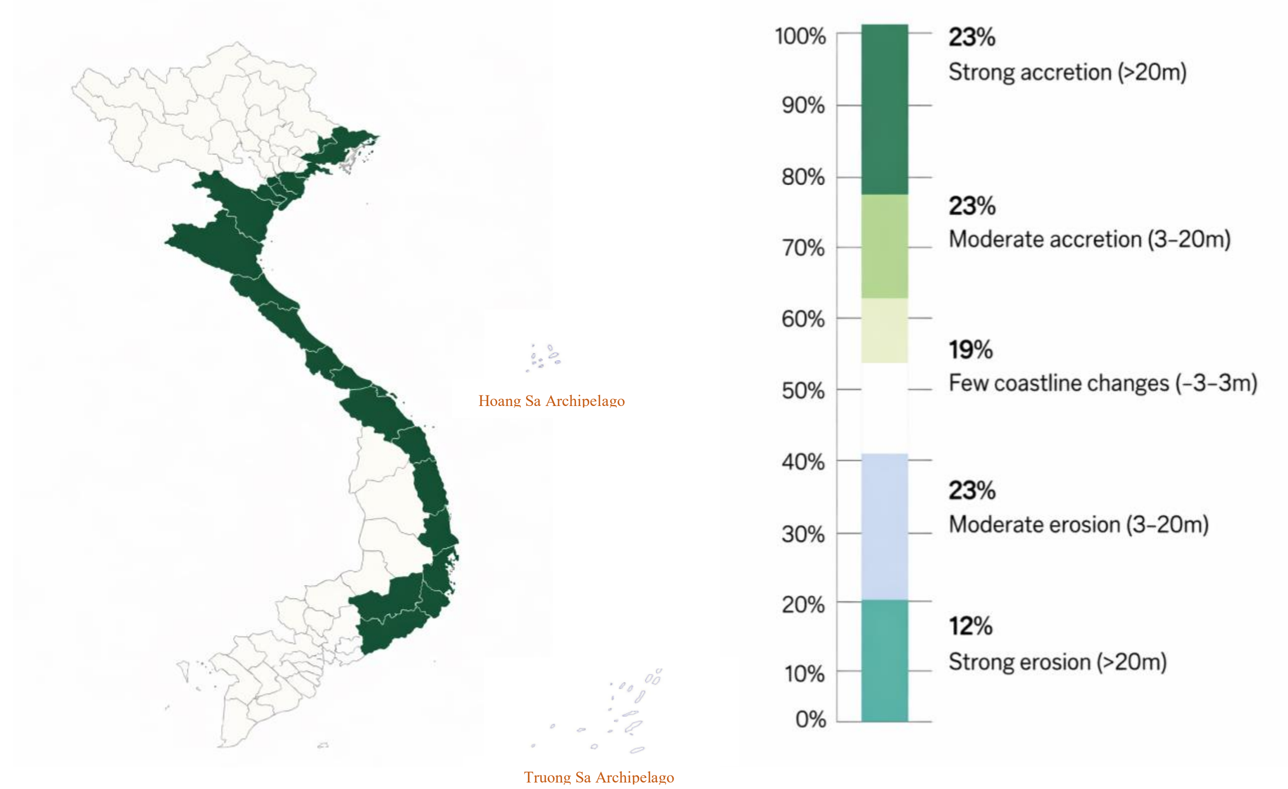
Source: General Statistic Office and The World Bank

2.2.1.7. Build-up surface

Although no specific data on built-up surface areas for Vietnam's coastal provinces are available, a regional study by Zutao Ouyang, Peilei Fan, and Jiquan Chen (2016) provides important insights into urban built-up development in Vietnam. The authors combined multiple remote sensing data, including Landsat, DMSP/OLS night time light, MODIS NDVI data and other ancillary spatial data, to develop a 30-m resolution urban built-up map of 2010 for Vietnam, Laos, Cambodia and Myanmar. The study found that Vietnam had the highest proportion of urban built-up area among the four countries (0.91% of total land area) and also experienced the most rapid expansion of built-up areas, increasing by approximately 8.8 times over the 18-year study period. Spatially, built-up areas in Vietnam were concentrated primarily around the two major metropolitan centers (Hanoi and Ho Chi Minh City) and coastal cities.

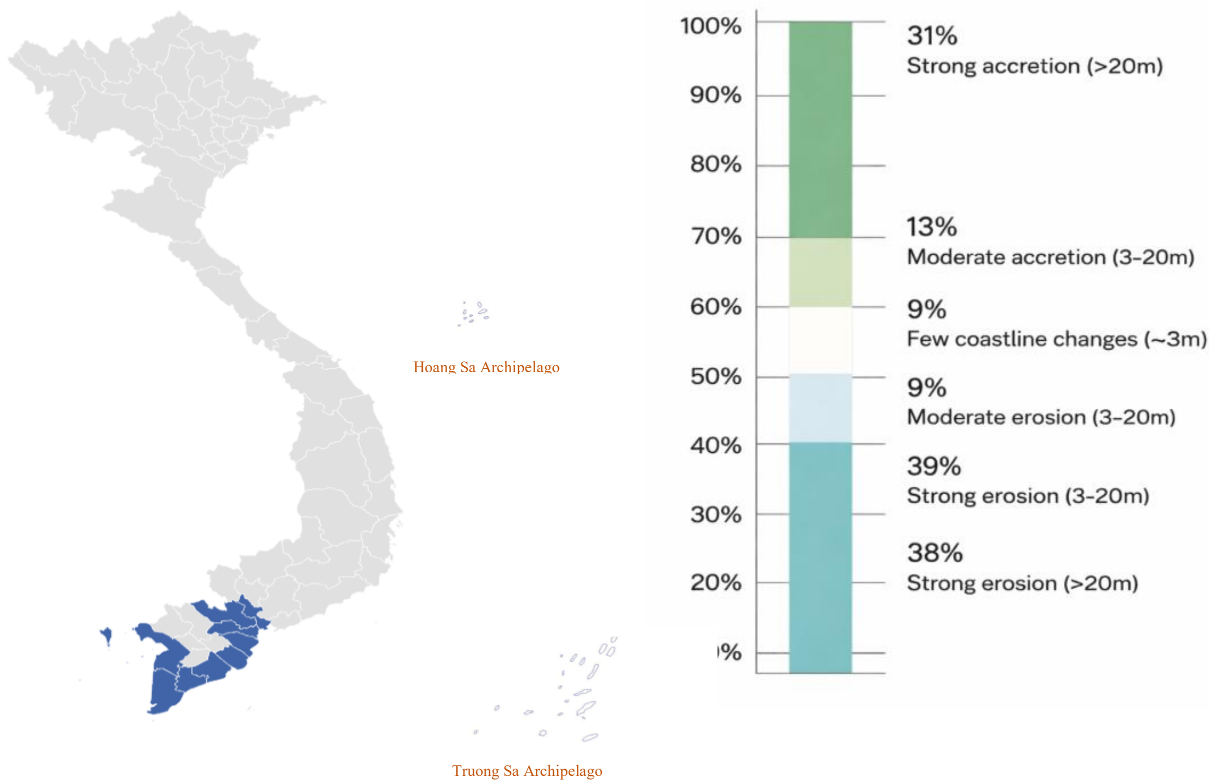
Another study conducted by Rentschler et al. (2020) highlights the vulnerability of built-up areas along Vietnam's coastline. Accordingly, as of 2020, more than one-third of Vietnam's coastal zone was built-up areas; however, only on-fifth of built-up areas was near stable coastlines, more than one-third was near moderately or severely eroding shores, and almost half faced moderate or severe accretion. Spatially, approximately one-third of built-up areas along Vietnam's northern and central coastlines are exposed to erosion (Figure 11). In contrast, more than two-thirds of built-up areas in the Mekong River Delta are subject to intense coastal dynamics and strong shoreline changes (Figure 12).

Figure 11: Share of built-up areas in north and central Vietnam



Source: Adapted from Rentschler et al. (2020)

Figure 12: Share of built-up areas the Mekong River Delta by coastal change level



Source: Adapted from Rentschler et al. (2020)

Data on built-up surface areas for Vietnam as a whole is presented at the Indicator SE1-11.

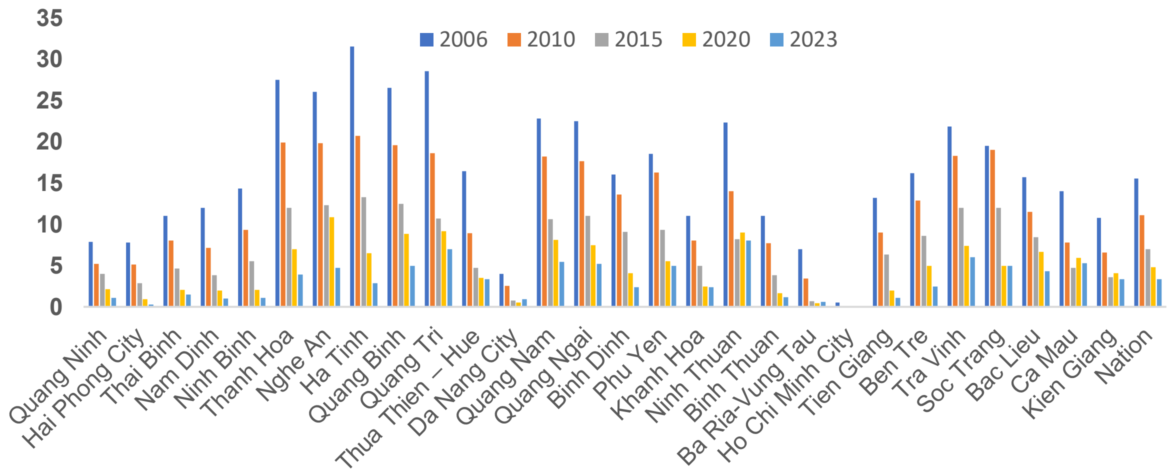
2.2.2. Human well-being

2.2.2.1. Coastal poor

Poverty rate data (measured as % of poor households by income) provided the General Statistic Office show an overall decline at national level and across almost all coastal provinces, though the pace and starting point differ markedly (as illustrated in Figure X), reflecting a broad improvement in local living standards over nearly two decades.

Some coastal provinces (mostly growth hubs) record very low average poverty rates (e.g., well below the national average and near-elimination of income poverty), including: Ho Chi Minh City, Da Nang, Ba Ria-Vung Tau, Quang Ninh, and Hai Phong. In contrast, several coastal provinces, where livelihoods depend on small-scale agriculture, fisheries and informal work, exhibit substantially higher average poverty levels than the national average, notably Thanh Hoa, Nghe An, Ha Tinh, Quang Tri, Quang Nam, Ninh Thuan, Tra Vinh, and Ca Mau (see Indicator SE2-1 for details).

Figure 13: Poverty rate in the 2006 – 2023 period



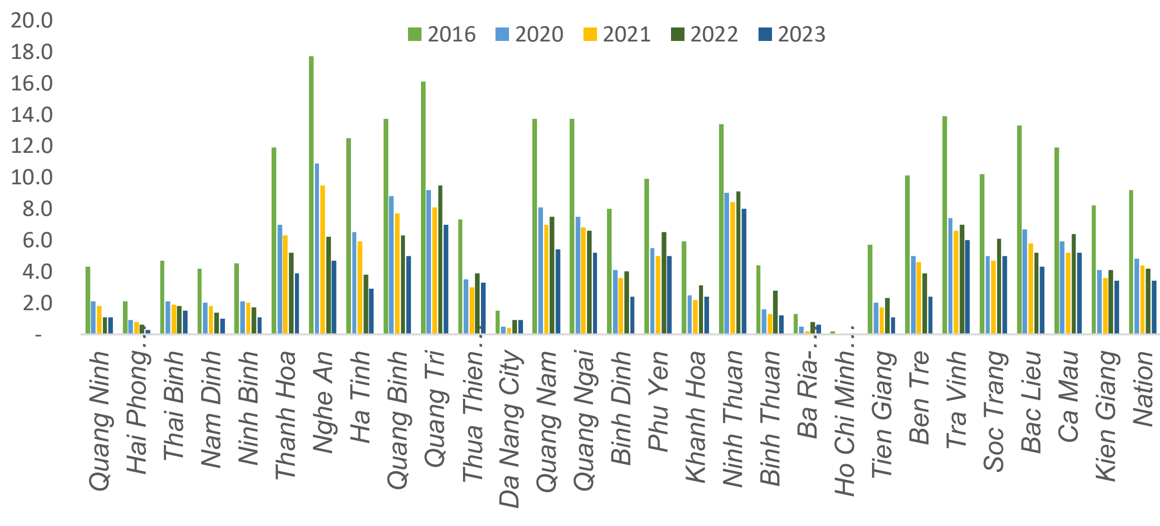
Source: General Statistic Office

The multidimensional poverty rate (measured as % poor households by income plus basic service assess in education, health, and infrastructure) shows a similar improvement since 2016 at both national and coastal provincial levels: the national rate declines from 9.2% in 2016 to 2.3% in 2024 and coastal average rates reduces from 8.7% in 2016 to 3.2% in 2024.

In many provinces, multidimensional poverty rates remain higher than income-based poverty rates in the same period, implying that even when household income improves, gaps in service access in public education, health and infrastructure can persist—particularly in remote coastal communes, estuaries, and lagoon/island areas where access costs are high.

In 2024, large urban centers again perform best (Ho Chi Minh City: 0.0%; Hai Phong: 0.2%), while some provinces remain relatively elevated, such as Quang Tri: 5.6%, Ninh Thuan: 6.6%, and Quang Binh: 3.4% (see Indicator SE2-1 for details).

Figure 14: Multidimensional poverty rate in the 2006 – 2023 period



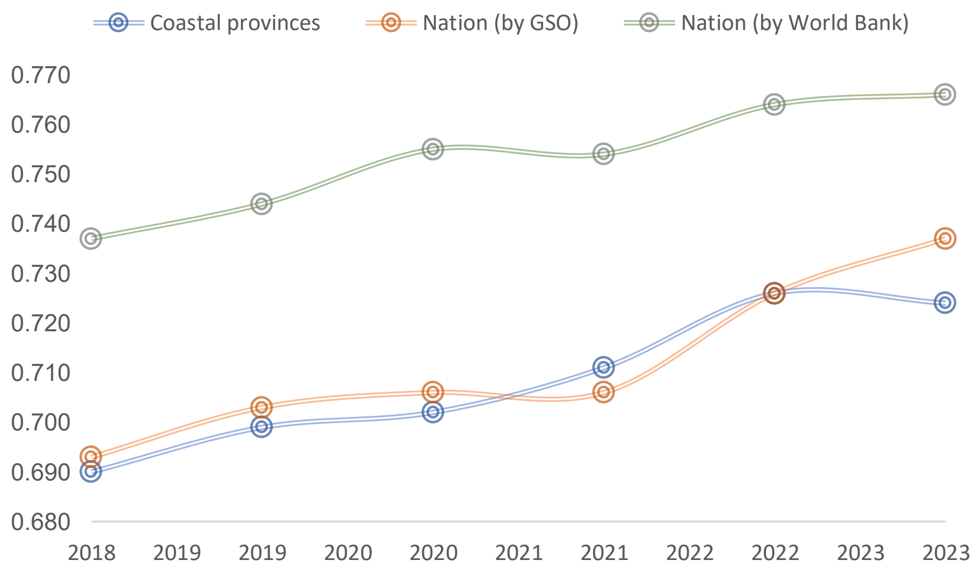
Source: General Statistic Office

2.2.2.2. Contemporary Human Development Index (HDI)

The HDI is a summary measure for assessing long-term progress in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living.

The statistical data indicates that the average HDI of Vietnam's coastal provinces increased steadily during 2018 – 2022 period, before experiencing a slight decline in 2023. Over the 2018 – 2023 period, the average HDI of coastal provinces remained very close to the national average as reported by the General Statistics Office. However, the coastal HDI consistently lagged behind the national HDI reported by the World Bank (2023), which follows an internationally standardized methodology and reports higher absolute values. This gap reflects methodological differences rather than a deterioration in coastal development performance.

Figure 15: HDI of Vietnam and coastal province in 2018 - 2023



Source: General Statistic Office and UNDP (2025)

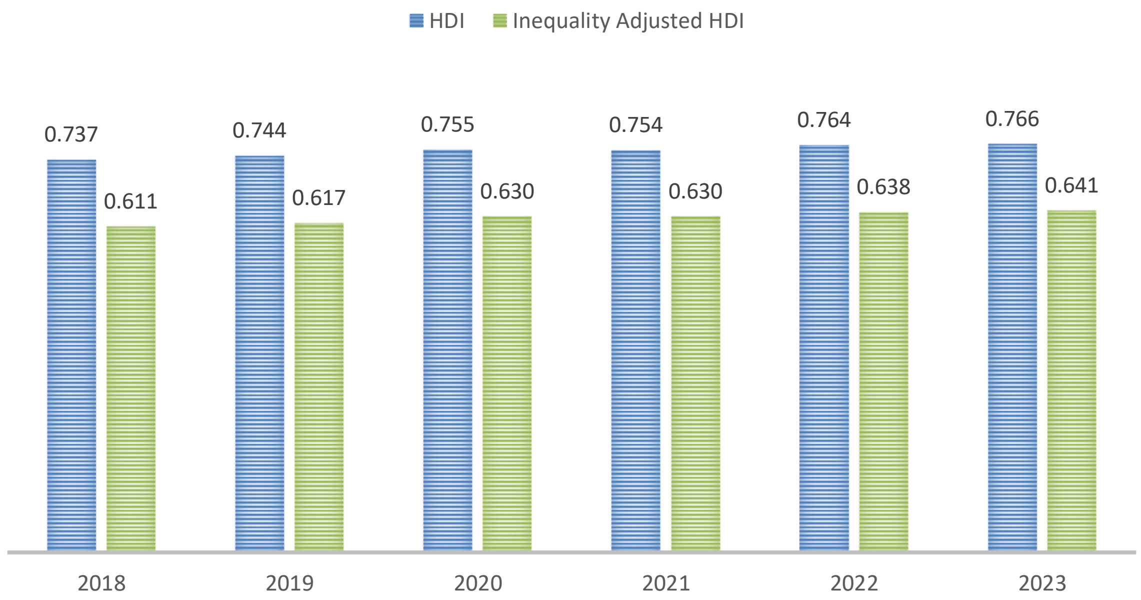
The specific data also indicates a steady improvement in HDI during the 2018–2023 period, although progress was uneven across localities. In 2023, the highest HDI values were concentrated in major growth hubs and highly industrialized coastal economies, including: Ba Ria – Vung Tau, Ho Chi Minh City, Quang Ninh and Da Nang with HDI of over 0.8. In contrast, several Mekong Delta coastal provinces (i.e Soc Trang, Bac Lieu, Ninh Thuan, Ben Tre and Kien Giang, etc.) continued to show the lowest HDI levels with HDI of below, indicating that development benefits are still concentrated in coastal urban–industrial centers, whereas several rural - agricultural dependent coastal provinces continue to lag behind (see Indicator SE2-2 for details).

2.2.2.3. Inequality Adjusted HDI (IHDI)

The IHDI adjusts the HDI for inequality in the distribution of each dimension (e.g., health, education and income) across the population. The 'loss' in human development due to inequality is given by the difference between the HDI and the IHDI. As the inequality in a country increases, the loss in human development also increases.

According to the UNDP (2025) Human Development Report, the Vietnam's HDI increased from 0.737 to 0.766, while the IHDI rose from 0.611 to 0.641. Despite this progress, IHDI remains consistently lower than HDI, indicating a persistent loss in human development due to inequality. Over the period, the HDI–IHDI gap stayed remarkably stable at around 0.124–0.127 points, equivalent to an inequality-related reduction of roughly 16–17% of the potential HDI value (see Indicator SE2-3 for details). This emphasizes that while Vietnam shows strong overall progress, inequality remains a key area for improvement to achieve more equitable human development in the future.

Figure 16: Inequality Adjusted HDI of Vietnam in 2018 - 2023



Source: UNDP (2025)

2.2.3. Economic Activities

2.2.3.1. Coastal GDP by economic sector

According to a report prepared by the Vietnam Agency of Seas and Islands (VASI) under the Ministry of Agriculture and Environment) for the National Conference on reviewing state management of marine and island resources and environment in December 2024, during the 2011-2022 period, the GRDP of coastal provinces to national GDP consistently remained at 49.8% – 53.6%, however, the total GRDP of coastal provinces tends to decrease due to the slowdown in growth of top GRPD coastal provinces and the rapid growth of non-coastal provinces nationwide.

The general GRDP structure of coastal province is presented in the table below.

Table 2: GRDP structure of coastal provinces in 2011 – 2022

Unit:%

	2011	2015	2020	2022
Agriculture, Forestry and Fisheries	14.99	14.04	12.56	11.63
Industry and Construction	36.45	32.54	33.1	35.77
Services	39.4	44.23	44.67	43.19
Taxes	9.16	9.19	9.67	9.41
Total	**100**	**100**	**100**	**100**

Source: General Statistic Office (2023)

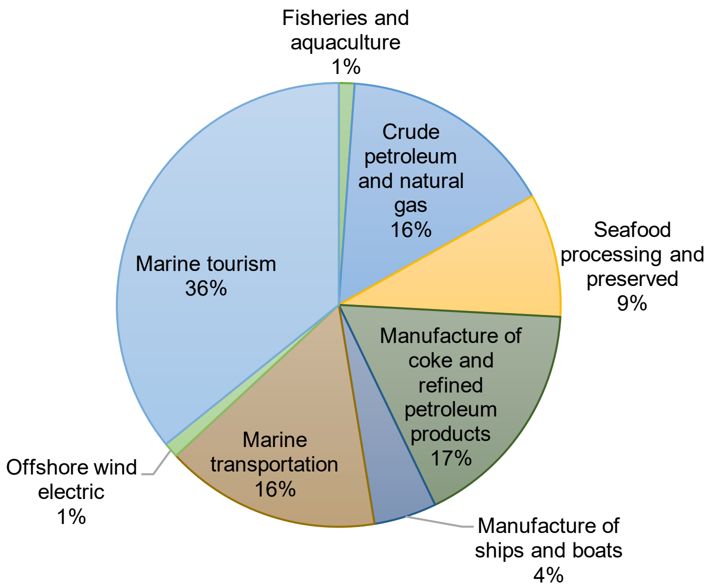
On the other hand, findings from a study conducted by World Bank (2025) on 8 major economic sectors (including: fishing and aquaculture, extraction of crude petroleum and natural gas, seafood processing, offshore wind, marine transportation, marine tourism, manufacture of ship and boats, and manufacture of coke and refined petroleum products) in 28 coastal provinces in 2010 – 2020 period indicated that the combined value added of the key economic sectors rose from 5.04 to 5.83 percent of national gross value added (GVA) between 2010 and 2019, then dropped to 3.18 percent in 2020.

Regarding structure, on average, the largest contributions come from tourism, manufacture of coke and refined petroleum products, crude petroleum and natural gas, and marine transportation, indicating that coastal economic growth is strongly anchored in offshore resource extraction, coastal energy/industrial complexes, and port–logistics services. A second tier of substantial contributors includes marine tourism and seafood processing and preserving, highlighting the importance of service expansion and value-added processing alongside heavy industry. Meanwhile, the fisheries and aquaculture contributes a smaller but still significant average value, suggesting that although it supports livelihoods widely, its value capture is considerably lower than other sectors.

During 2010 – 2020 period, coastal tourism shows explosive growth up to 2019 (116,475), but the abrupt collapse in 2020 (only 1,071) strongly suggests a major shock—most plausibly the COVID-19 pandemic. Refined petroleum products show a strong and sustained rise, especially after 2016. Offshore wind electricity is a clear emerging sector: it is almost absent before 2014–2015, but increases sharply after 2018. Seafood processingrises consistently over the decade, meanwhile, ship and boat manufacturing also grows but at a more moderate scale.

See Indicator SE3-1 for details.

Figure 17: The average share of key economic sectors contributions to GVA in 2010 - 2020



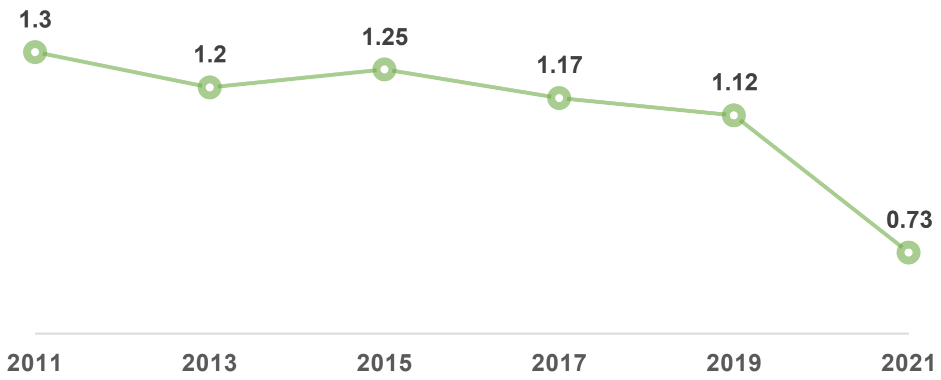
Source: The World Bank (2025)

2.2.3.2. Share of GDP from coastal sustainable fisheries

According to the General Statistics Office (2023), during the period 2011–2022, aquaculture production in Vietnam's coastal provinces accounted for approximately 51.3–54.8% of total national aquaculture output, while capture fisheries production in coastal provinces represented an overwhelming 95.3 - 97.5% of total national fisheries production. These figures underscore the dominant role of coastal areas in Vietnam's both aquaculture and fisheries sectors, particularly in fisheries.

Although national statistics specifically for coastal localities remain limited, data from the Food and Agriculture Organization (FAO) database on sustainable fisheries as percentage of GDP in small island developing States, least developed countries and all coutries (Indicator 14.7.1) shows that between 2011 and 2021, the contribution of sustainable fisheries to Vietnam's GDP declined gradually, indicating a relative contraction of the sector within the overall economy. This pattern suggests that while sustainable fisheries remained an important component of Vietnam's blue economy in the early 2010s, its relative economic weight diminished over time, likely reflecting faster growth in other sectors, structural transformation of the economy, and the combined impacts of resource constraints, stricter sustainability requirements, and external shocks such as the COVID-19 pandemic (see Indicator SE3-2 for details)

Figure 18: Sustainable fisheries as percentage of GDP in 2011 - 2021



Source: FAODATA

2.2.3.3. Share of GDP from coastal tourism

Based on data from the Vietnam National Authority of Tourism under the Ministry of Culture, Sports and Tourism, the tourism sector contributed approximately 6.3–9.2% of Vietnam's GDP during the period 2014–2019, prior to the COVID-19 pandemic. Although no official statistics are available on the specific GDP contribution of coastal tourism, it is widely recognized as a major driver of tourism growth, supported by Vietnam's rich coastal tourism resources, including more than 250 beaches, of which over 20 have been ranked among the world's most beautiful. Following Vietnam's reopening to international tourism in 2022, coastal tourism played a pivotal role in the sector's recovery. In that year, tourism accounted for about 5.2% of national GDP, while coastal tourism contributed an estimated 10–12%, 12–15%, and 30% of local GDP in Quang Ninh, Khanh Hoa, and Phu Quoc, respectively—three of Vietnam's leading coastal tourism destinations.

Aggregated estimates of coastal tourism GDP across 28 coastal provinces, reported in a World Bank (2025) study, further indicate that prior to the Covid-19 pandemic, the share of coastal tourism in national tourism GDP increased steadily from 45.77% to 49.24%, while its contribution to national GDP rose from 2.99% to 4.61% (see Indicator SE3-3 for details).

Figure 19: Contribution of coastal tourism GDP in 2014 - 2019

Source: Estimated by the author

2.2.4. Climate-related threats

2.2.4.1. Number of tropical cyclones per year

According to statistics from the EM-DAT Project—which appear to be incomplete across years and lack consistent year-by-year detail—between 2000 and 2024, a total of 71 tropical cyclones hit Vietnam and caused damage. Of these, 59 tropical cyclones (accounting for more than 83% of all damaging storms nationwide) affected coastal provinces.

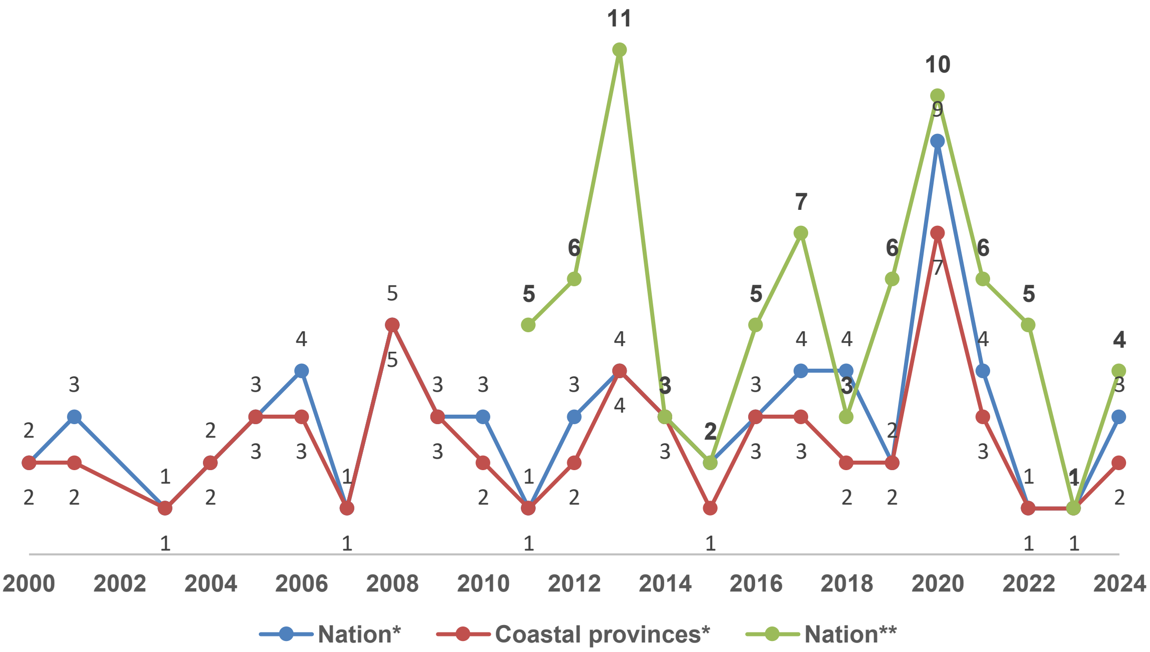
By contrast, annual reports by the Vietnam Disaster and Dyke Management Authority (under the Ministry of Agriculture and Environment) – which seem more comprehensive and context-specific – indicates that, during the shorter period from 2011 to 2024 alone, a total of 74 tropical cyclones caused damage in Vietnam.

In most years, the figures reported by the Vietnam Disaster and Dyke Management Authority are higher than those recorded in the EM-DAT Project's database. However, the Vietnam Disaster and Dyke Management Authority's report does not specify the affected localities, making it impossible to quantify the number of tropical cyclones that specifically impacted coastal areas (see Indicator SE4-1 for details).

Despite difference, both data sources consistently show that the annual number of tropical cyclones exhibited no clear or consistent trend during the period 2020–2024.

Figure 20: Number of total tropical cyclone per year in 2000 – 2024

Unit: event



* Source: *EM-DAT Project*
** Source: *Vietnam Disaster and Dyke Management Authority*

2.2.4.2. Number of affected cases because of tropical cyclones per year

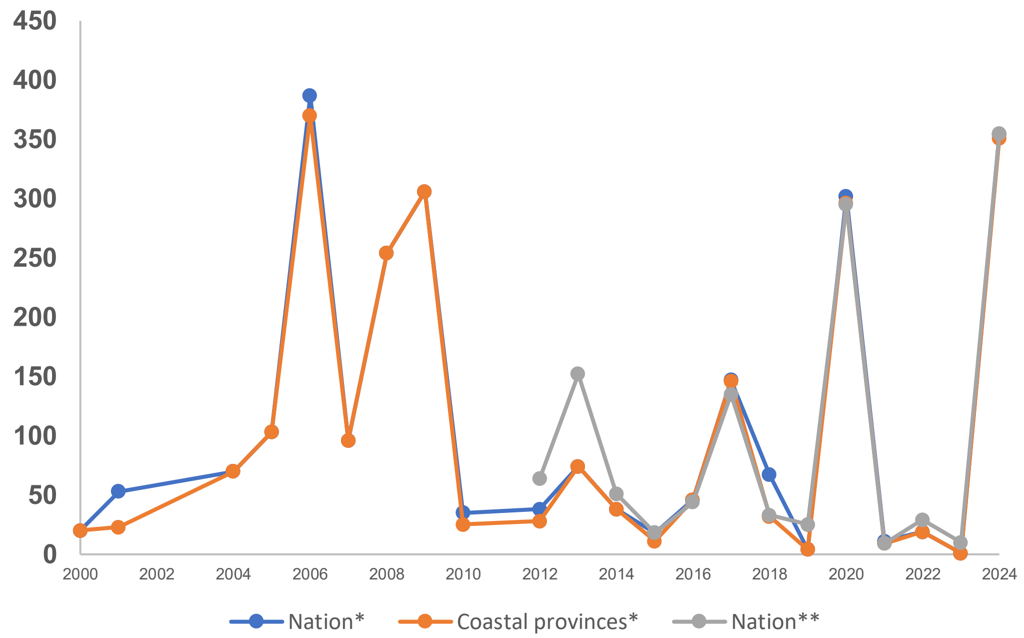
Data of the EM-DAT Project shows that, during the period 2000–2024, tropical cyclones in Vietnam resulted in 2,443 deaths (an average of 111 people per year), 6,375 injuries (319 people per year), 838,180 people left homeless (69,848 people per year), and a total of 22,197,509 people affected (1,168,290 people per year). Of these impacts, coastal localities accounted for 2,232 deaths (106 people per year), 6,347 injuries (334 people per year), 836,065 homeless persons (76,006 people per year), and 21,964,864 affected persons (1,156,045 people per year), indicating that coastal areas bear the overwhelming majority of tropical cyclone–related losses in Vietnam.

Meanwhile, data from the Vietnam Disaster and Dyke Management Authority indicate that, during the period 2011–2024, tropical cyclones caused 1,167 deaths nationwide (83 people per year), 4,455 injuries (343 people per year), and damage to the homes of 487,506 people (209,321 people per year).

With the exception of nationwide statistics on deaths and injuries for the period 2014–2024—where figures from the two sources are relatively consistent (see Figure X)—other indicators are not systematically compiled for all years and therefore cannot be directly compared. Nevertheless, evidence from both datasets suggests that, over the past decade, the frequency of tropical cyclones resulting in deaths and injuries has increased markedly (see Indicator SE4-2 for details).

Figure 21: Number of dead because of tropical cyclones in 2000 – 2024

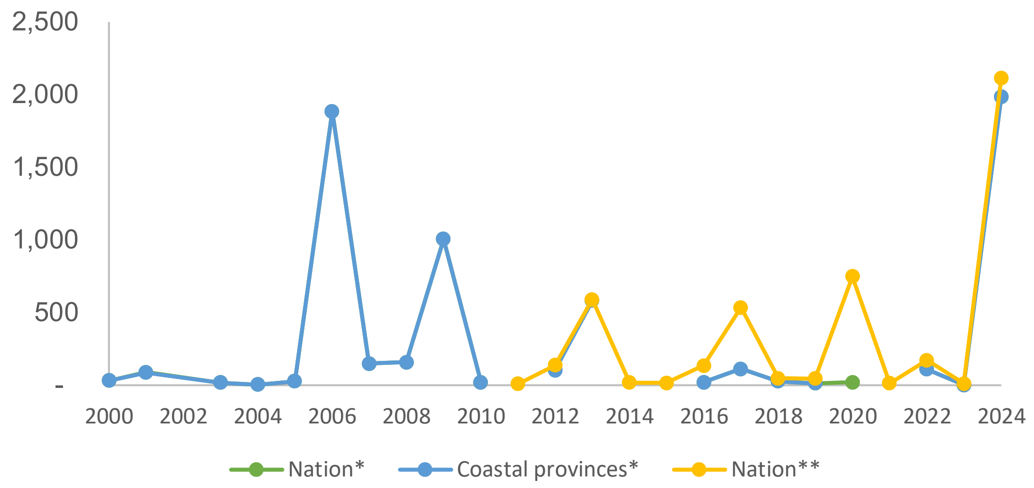
Unit: persons



* *Source: EM-DAT Project*
** *Source: Vietnam Disaster and Dyke Management Authority*

Figure 22: Number of injuries because of tropical cyclones in 2000 – 2024

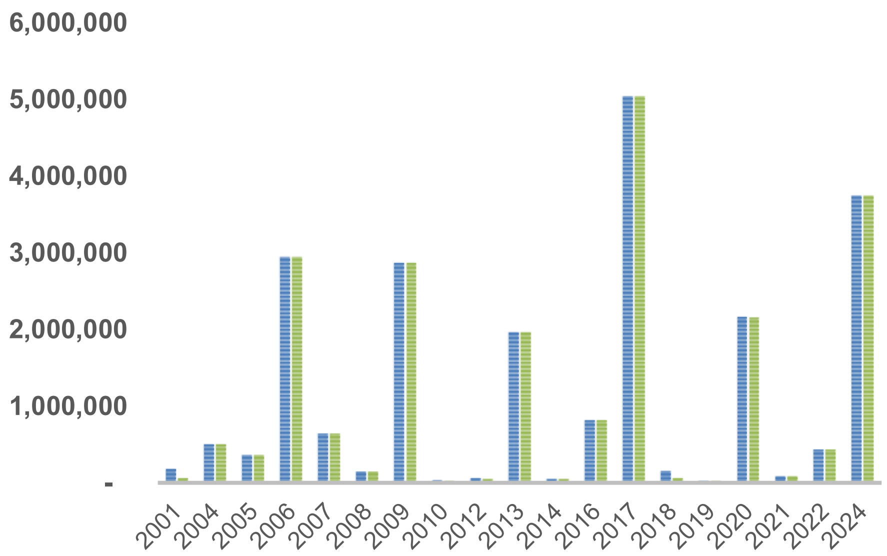
Unit: persons



* *Source: EM-DAT Project*
** *Source: Vietnam Disaster and Dyke Management Authority*

Figure 23: Number of affected because of tropical cyclones in 2000 – 2024

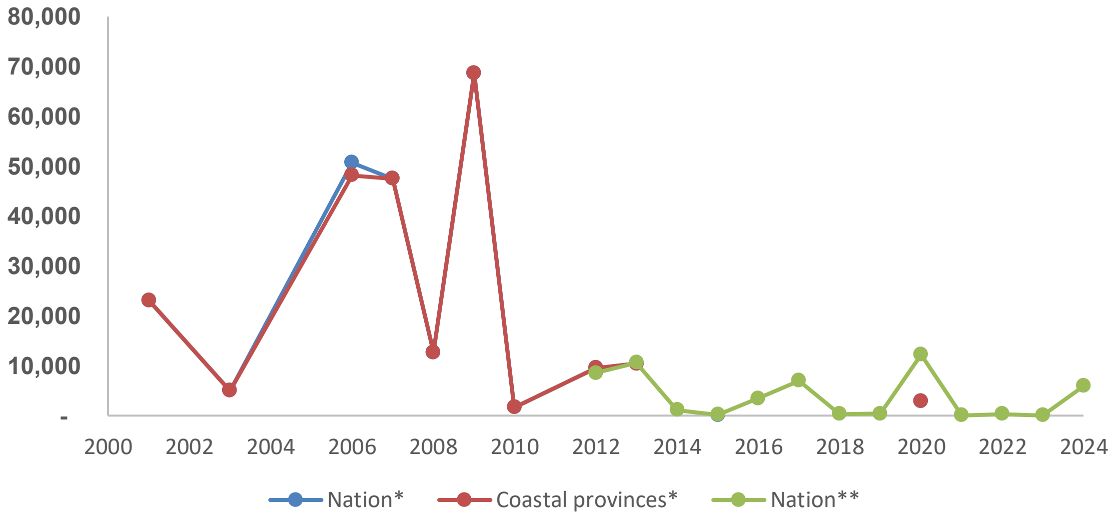
Unit: persons



* *Source: EM-DAT Project*
** *Source: Vietnam Disaster and Dyke Management Authority*

Figure 24: Number of homeless due to tropical cyclones in 2000 – 2024

Unit: persons



* *Source: EM-DAT Project*
** *Source: Vietnam Disaster and Dyke Management Authority*

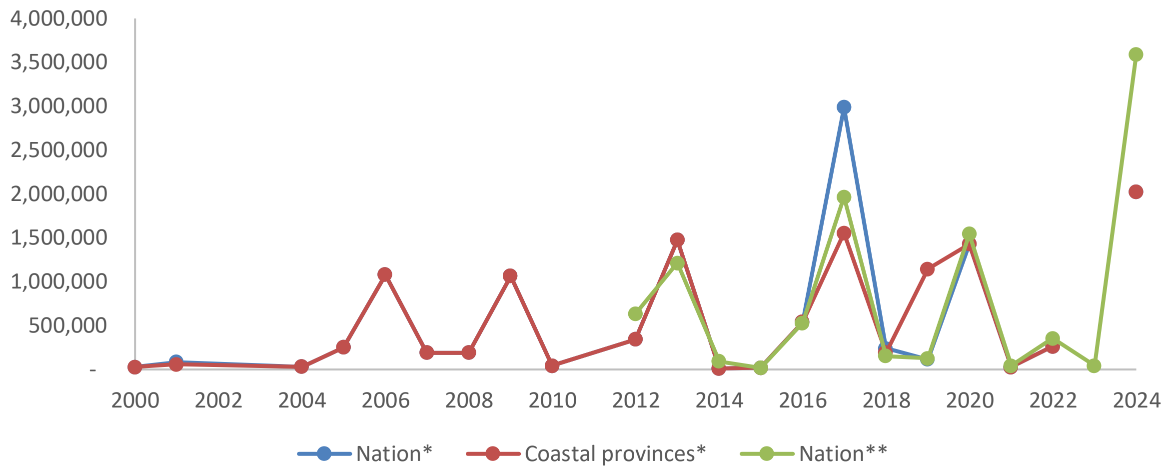
2.2.4.3. Total damage due to tropical cyclones

As reported by the EM-DAT Project, tropical cyclones caused substantial economic losses in Vietnam over the 2000–2024 period, amounting to over 12 billions of USD at constant prices (or nearly USD 600 million per year, equivalent to 1 – 1.5% of national GDP). Economic damage fluctuated markedly from year to year, reflecting the irregular occurrence and intensity of major tropical cyclones. A large share of these losses was concentrated in coastal provinces, underscoring their high exposure and vulnerability to tropical cyclones. In several extreme years (i.e., 2006, 2009, 2013, and 2020), reported damages surged sharply, corresponding to the landfall of strong and destructive storms, which resulted in widespread damage to housing, infrastructure, agriculture, and coastal livelihoods.

Economic damage data from the Vietnam Disaster and Dyke Management Authority show a high degree of similarity with EM-DAT Project data for the period 2011–2024. Both data sources consistently highlight key patterns, including: (i) tropical cyclones impose a very large cumulative economic burden on Vietnam over the long term; and (ii) economic losses are highly variable across years, with extreme events dominating total damage (see Indicator SE4-3 for details).

Figure 25: Total damage due to tropical cyclones in 2000 – 2024

Unit: USD 1,000



* Source: *EM-DAT Project*
** Source: *Vietnam Disaster and Dyke Management Authority*

2.3. Discussion and conclusions

2.3.1. Risk assessment from socio-economic trends

2.3.1.1. Overall assessment

The indicator analysis findings indicate that Vietnam's coastal region exhibits a compound socio-economic risk profile that differs systematically from non-coastal regions in the country. These risks arise not from a single factor, but from the interaction between high population concentration, environmental exposure, uneven urbanization, persistent inequality, and a shock sensitive economic structure. Particularly:

- **High population concentration in limited space**: Vietnam's 28 coastal provinces account for approximately 41.3–41.4% of the country's area but accommodate nearly half of the national population. Their average population density is almost twice the national average. This intense concentration places persistent pressure on infrastructure, public services, and labor markets. Coastal provinces seem therefore more exposed to rapid socio-economic disruptions when shocks occur, such as natural disasters, pandemics, tourism downturns, or supply-chain interruptions
- **Uneven urbanization and spatial inequality**: Although the average urbanization rate of coastal provinces exceeds the national average, urban growth is highly uneven. A small number of coastal growth poles, such as: Ho Chi Minh City, Da Nang, Quang Ninh, and Ba Ria–Vung Tau, capture a disproportionate share of urban population and economic opportunities. In contrast, many coastal provinces remain weakly

urbanized (below 20%), limiting access to diversified employment and modern services. This uneven pattern heightens intra-coastal inequality and increases the risk of structural stagnation in rural and agriculture-dependent coastal areas.

- **High exposure due to low elevation and population distribution**: Vietnam's coastal provinces have an average elevation of about 159 m, significantly lower than the national average of 248 m. Critically, around 86% of the coastal population lives below 100 m above sea level, with many deltaic provinces averaging only 1–5 m. This demographic–topographic configuration substantially increases exposure to sea-level rise, flooding, storm surges, and saltwater intrusion, posing higher long-term risks to livelihoods, infrastructure, and public finance than those faced by inland regions.
- **Concentrated built-up areas along dynamic coastlines:** Rapid expansion of built-up surfaces in coastal zones—particularly near eroding or highly dynamic shorelines—creates significant asset exposure. The built-up surface indicator analysis indicate that more than one-third of Vietnam's coastal zone is built up, with large shares located in areas subject to erosion or strong coastal change, especially in the Mekong Delta. Compared to non-coastal areas, coastal built-up areas face higher expected economic losses from climate-related hazards and require substantially greater investment in protection and adaptation.
- **Persistent poverty and livelihood vulnerability:** While poverty rates have declined nationwide, at least one-third coastal provinces continue to record poverty levels above the national average, notably in the North Central Coast and the Mekong Delta. These areas rely heavily on small-scale agriculture, fisheries, and informal employment, making them particularly sensitive to environmental degradation, resource depletion, and climate variability. The persistence of multidimensional poverty, even where income poverty has fallen, highlights continued deficits in access to education, health, and infrastructure in many coastal localities.
- **Inequality in Human Development outcomes:** On average, the HDI of coastal provinces is close to the national level, but disparities across provinces are substantial. Highly industrialized and urbanized coastal economies achieve HDI values above 0.8, while many rural coastal provinces remain well below this threshold. The gap between HDI and IHDI (around 16–17%) indicates a persistent loss of potential human development due to inequality, suggesting that coastal growth has not translated evenly into improved well-being across population groups.
- **Dependence on shock-sensitive economic structure**: Within coastal economic sectors, the largest value-added contributions come from coastal tourism, crude petroleum and natural gas extraction, refined petroleum products, and marine transportation. Coastal tourism has been one of the fastest-growing contributors to coastal GDP, accounting for

nearly half of national tourism GDP before the COVID-19 pandemic. However, the sharp collapse of coastal tourism value added in 2020 demonstrates its extreme sensitivity to external shocks, including pandemics, natural disasters, and geopolitical disruptions. Heavy reliance on tourism therefore creates cyclical employment risks, particularly for informal and seasonal workers, and increases revenue volatility for local governments. The remaining sectors (e.g., crude petroleum and natural gas extraction, refined petroleum products, and marine transportation) are capital-intensive, environmentally sensitive, and highly exposed to global market volatility. Fluctuations in global energy prices, changes in environmental regulations, or declining offshore resources can disproportionately affect coastal provincial revenues and employment, especially where local economies lack diversification into higher-value or knowledge-based sectors.

In short, from the socio-economic perspective, Vietnam's coastal provinces play a vital role in the national economy, contributing roughly half of national GDP and hosting major industrial, energy, logistics, and tourism hubs. At the same time, they concentrate a large share of the population in environmentally exposed, low-lying areas and rely heavily on shock-sensitive economic sectors. This combination creates a distinct and compound socio-economic risk profile that is more pronounced than that faced by inland provinces.

2.3.1.2. Socio-economic risk ranking by province

The Coastal Risk Index (CRI), which was introduced by Kreft et al. (2015) and adjusted to adapt with the context of Vietnam. This index aims to provide a composite and comparable measure of socio-economic vulnerability across Vietnam's coastal provinces. The index captures demographic pressure, social conditions, and human development factors that influence exposure and sensitivity to coastal and climate-related risks.

The CRI is constructed using indicators reflecting population characteristics, social vulnerability, and physical constraints, including: total population (SE1-1), natural area (SE1-2), population growth rate (SE1-5), population density (SE1-6), urban population (SE1-7), mean elevation (SE1-8), population living below 100 m elevation (SE1-9), poverty rate (SE2-1), and the Human Development Index (HDI) (SE2-2). Indicators were selected based on relevance to coastal socio-economic status and data availability.

All indicators were normalized to a common scale of 0-1 using min–max normalization to ensures comparability across variables measured in different units. To maintain consistency, all indicators were oriented so that higher values correspond to higher socio-economic risk. Indicators positively associated with risk (e.g. population density, poverty rate) were kept unchanged. Indicators negatively associated with risk (i.e., mean elevation and HDI) were inverted after normalization.

The CRI for each province was then calculated as the unweighted arithmetic mean of all normalized and risk aligned. An equal weighting approach was adopted to minimize subjectivity and reflect the absence of empirical evidence supporting differential indicator weights. Higher CRI values indicate greater relative socio-economic risk, while lower values indicate lower relative risk.

Table 3: Normalized indicators and CRI values of coastal provinces

Coastal province	Population	Area	Population growth rate	Population density	Population in urban area	Population distribution by elevation	Multi-dimensional poverty rate	Mean elevation	HDI Index	Socio-economic Risk Index (0-1)
Quang Ninh	0.09	0.32	0.49	0.02	0.10	0.04	0.20	0.64	0.18	0.23
Hai Phong City	0.18	0.02	0.46	0.30	0.12	0.16	0.09	0.97	0.08	0.26
Thai Binh	0.16	0.02	0.25	0.26	0.01	0.13	0.23	1.00	0.57	0.29
Nam Dinh	0.15	0.02	0.32	0.25	0.03	0.13	0.21	1.00	0.71	0.31
Ninh Binh	0.05	0.01	0.36	0.15	0.01	0.04	0.22	0.90	0.48	0.25
Thanh Hoa	0.37	0.65	0.32	0.05	0.08	0.23	0.69	0.48	0.64	0.39
Nghe An	0.33	1.00	0.42	0.02	0.05	0.18	1.00	0.14	0.68	0.43
Ha Tinh	0.09	0.31	0.33	0.03	0.02	0.05	0.64	0.62	0.58	0.29
Quang Binh	0.04	0.44	0.31	0.00	0.01	0.00	0.82	0.38	0.74	0.30
Quang Tri	0.01	0.23	0.33	0.01	0.01	0.01	0.99	0.43	0.83	0.32
Thua Thien – Hue	0.07	0.24	0.27	0.03	0.06	0.05	0.41	0.39	0.74	0.25
Da Nang City	0.06	0.00	1.00	0.19	0.12	0.06	0.08	0.41	0.10	0.22
Quang Nam	0.11	0.61	0.30	0.01	0.03	0.06	0.82	0.00	0.61	0.28
Quang Ngai	0.08	0.25	0.20	0.03	0.01	0.06	0.79	0.39	0.64	0.27
Binh Dinh	0.11	0.31	0.15	0.03	0.06	0.06	0.43	0.44	0.66	0.25
Phu Yen	0.04	0.25	0.21	0.02	0.02	0.01	0.61	0.45	0.77	0.26
Khanh Hoa	0.08	0.26	0.33	0.03	0.06	0.03	0.31	0.16	0.54	0.20
Ninh Thuan	0.00	0.14	0.32	0.02	0.01	0.00	0.93	0.25	0.93	0.29
Binh Thuan	0.08	0.43	0.35	0.01	0.05	0.02	0.21	0.53	0.78	0.27
Ba Ria-Vung Tau	0.07	0.05	0.48	0.11	0.07	0.07	0.06	0.88	0.00	0.20
Ho Chi Minh City	1.00	0.05	0.90	1.00	1.00	1.00	0.00	0.99	0.01	0.66
Tien Giang	0.14	0.08	0.29	0.14	0.02	0.14	0.25	1.00	0.78	0.32
Ben Tre	0.09	0.07	0.21	0.11	0.00	0.09	0.51	1.00	0.90	0.33
Tra Vinh	0.05	0.07	0.20	0.08	0.01	0.07	0.80	1.00	0.83	0.35
Soc Trang	0.14	0.33	0.00	0.04	0.04	0.11	0.59	1.00	1.00	0.36
Bac Lieu	0.08	0.13	0.32	0.06	0.02	0.06	0.71	1.00	0.97	0.37
Ca Mau	0.04	0.08	0.13	0.06	0.02	0.09	0.67	1.00	0.86	0.33
Kien Giang	0.08	0.26	0.23	0.03	0.05	0.14	0.46	0.98	0.90	0.35

Finally, coastal provinces were classified into 3 socio-economic risk levels—High, Medium, Low using their CRI values. The classification was conducted using a quintile approach, whereby provinces were ranked from highest to lowest CRI and then divided into three groups of approximately equal size, where as: top 33% of provinces with the highest CRI values were classified as High risk; the next 33% as Medium risk; and the bottom 34% as Low risk. This relative classification method ensures comparability across provinces and avoids reliance on arbitrary threshold values. It is particularly suitable for screening and prioritization purposes in coastal risk assessment and climate adaptation planning, where the objective is to identify provinces with relatively higher socio-economic exposure and vulnerability rather than to define absolute risk levels.

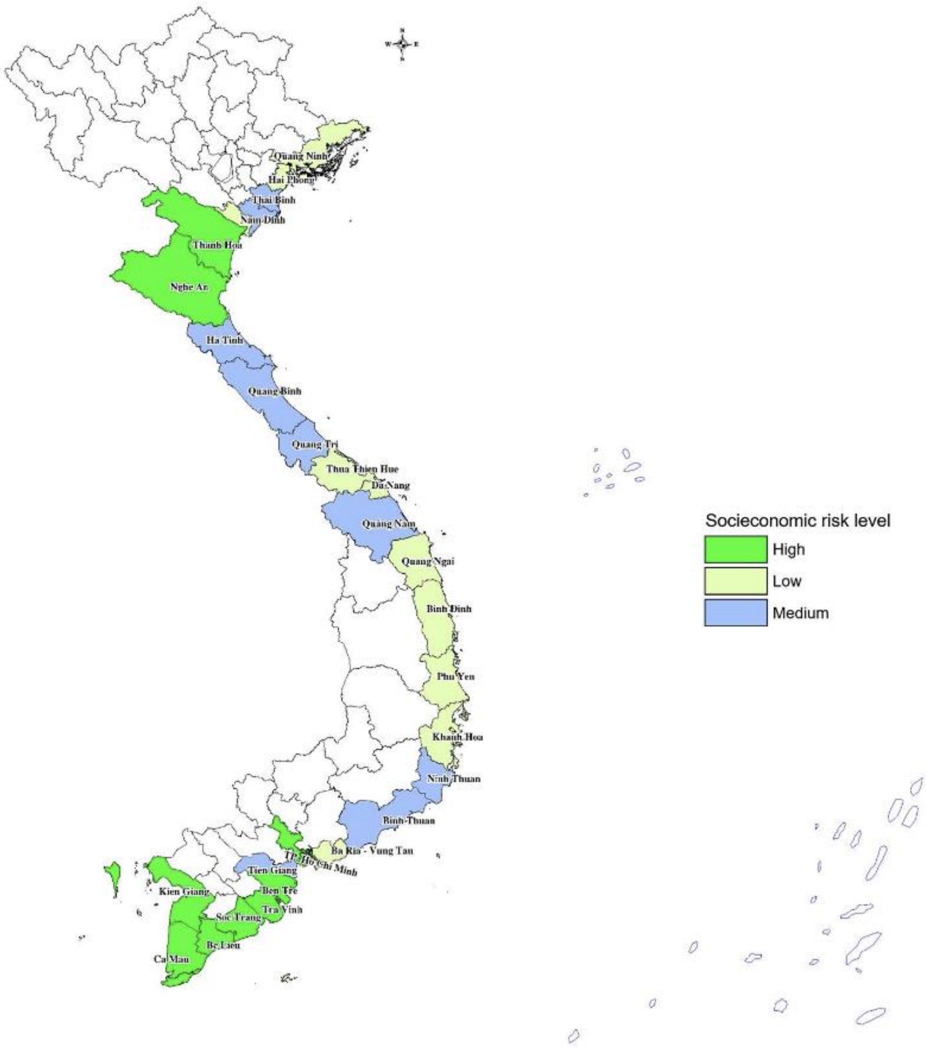
The classification results were presented in Tabe X and Figure X below:

Table 4: Coastal province's socio-economic risk rank

Coastal province	CRI value (0-1)	Rank (1=highest risk)	Socio-economic risk level
Quang Ninh	0.231	25	Low
Hai Phong City	0.263	20	Low
Thai Binh	0.292	15	Medium
Nam Dinh	0.313	12	Medium
Ninh Binh	0.245	24	Low
Thanh Hoa	0.39	3	High
Nghe An	0.425	2	High
Ha Tinh	0.295	14	Medium
Quang Binh	0.305	13	Medium
Quang Tri	0.316	11	Medium
Thua Thien – Hue	0.252	22	Low
Da Nang City	0.223	26	Low
Quang Nam	0.284	17	Medium
Quang Ngai	0.273	19	Low
Binh Dinh	0.249	23	Low
Phu Yen	0.262	21	Low
Khanh Hoa	0.199	28	Low
Ninh Thuan	0.289	16	Medium
Binh Thuan	0.273	18	Medium
Ba Ria–Vung Tau	0.2	27	Low
Ho Chi Minh City	0.662	1	High
Tien Giang	0.316	10	Medium
Ben Tre	0.33	8	High
Tra Vinh	0.345	7	High
Soc Trang	0.36	5	High
Bac Lieu	0.372	4	High

Ca Mau	0.328	9	High
Kien Giang	0.348	6	High

Figure 26: Coastal province's socio-economic risk level



Source: Developed by the author

3.3.2. Risk assessment from climate- and environment-related threats

3.3.2.1. Overall assessment

As indicated by climate-related indicators, Vietnam's coastal provinces face very high climate- and environment- related risks, primarily driven by tropical cyclones, which account for the majority of disaster-related human and economic losses nationwide. Evidence from both the EM-DAT Project and the Vietnam Disaster and Dyke Management Authority shows that coastal areas bear a disproportionately large share of impacts from tropical cyclones. Between 2000 and 2024, more than 83% of all damaging tropical cyclones recorded nationwide affected coastal provinces, and these areas accounted for almost all cyclone-related fatalities, injuries, collapsed households, and affected populations. Over this period, tropical cyclones caused over 2,200 deaths, more than 6,300 injuries, and affected nearly 22 million people in coastal localities alone, underscoring their high exposure and sensitivity. Economic losses are similarly concentrated along the coast, with total damage from tropical cyclones exceeding USD 12 billion between 2000 and 2024 (equivalent to roughly USD 600 million per year or 1–1.5% of national GDP. Damage levels fluctuate strongly across years, reflecting the irregular occurrence and severity of major storms, with extreme events (e.g. 2006, 2009, 2013, and 2020) dominating cumulative losses. Despite differences in coverage and reporting methods, almost all data sources consistently indicate that coastal provinces are the primary hotspots of climate-related risk in Vietnam, due to their high exposure to tropical cyclones and the severe human and economic consequences associated with these events.

3.3.2.2. Detailed assessment

A more comprehensive and detailed assessment of climate-related risks to Vietnam's coastal provinces conducted by UNDP (2025) shows that, currently:

- People: 11.8 million people are directly exposed to the threat of intense flooding
- Town: Over 35% of coastal settlements are located on eroding coastlines
- Economy: Flood risks in high-growth areas are nearly twice as high as in low-growth areas
- Agriculture: $1 billion of agricultural GDP and 1.5 million workers are directly exposed to the threat of intense flooding
- Aquaculture: 1.1 million tons of aquaculture production is at risk of flooding each year, corresponding to $935 million in exports
- Tourism: 42% of coastal hotels are located near eroding beaches
- Industry: Half of all industrial zones are directly exposed to the threat of intense flooding
- School: 22% of schools could be directly exposed to the threat of intense flooding
- Health care: 26% of health care facilities are directly exposed to the threat of intense flooding
- Transport: A typhoon with wind speeds of up to 200 km/h can close roads, resulting in daily losses of $114–324 million
- Energy: 36% of transmission lines are in forested areas, exposed to falling trees in severe storms
- Water: 52 out of 63 provinces could depend on water-stressed river basins by 2030

3.3.3. Mitigating socio-economic vulnerability from climate-mediated environmental change: current actions and gaps

The Vietnamese government has made significant progress in mitigating socio-economic risk over recent decades by developing coastal hazard and risk database and integrating data in several coastal development policies and strategies, investing in both structural and non-structural coastal risk reduction measures (i.e., building and upgrading sea dyke systems, planting and protecting mangrove forests, etc.) and establishing comprehensive legal, regulatory, and policy frameworks (i.e., the 2014 National Strategy on Integrated Coastal Zone Management, the 2015 Law on Marine and Island Resources and Environment, the 2016 National Coastal Zone Action Plan, etc.) to guide coastal area development in a safe and sustainable manner. However, these efforts remain insufficient to fully address the coastal areas' growing and increasingly complex socio-economic risk profile.

Hazard and socio-economic risk information remains fragmented and incomplete, often relying on global or regional databases and a single scenario in action plans and strategy designs. Insufficient guidance, weak enforcement, and limited institutional capacity and financing have resulted in persistent gaps in risk-informed spatial planning, building safety standards, as well as in the systematic maintenance of critical infrastructure. Approximately two-thirds of Vietnam's 2,659 km dike system fails to meet prescribed safety standards, and in many high growth provinces even existing standards leave substantial protection gaps. Nature-based systems, despite their important role in enhancing coastal resilience, remain underappreciated and are increasingly threatened by development pressures and over exploitation. While Vietnam has achieved remarkable progress in reducing disaster-related losses, evolving and intensifying risks underscore the need for further strengthening disaster financing, preparedness, response, and recovery systems.

3.3.4. Recommended priority actions, including regional cooperation

Given the identified gaps, following actions are recommended to

1. Strengthen data and decision-making tools: Effective risk management requires timely, reliable, and decision-relevant information. Establishing systematic, high-resolution hazard, risk, and asset-management information systems at both national and subnational levels is essential to support evidence-based coastal planning and investment decisions.

2. Enforce risk-informed planning and zoning: To prevent economic growth in coastal areas from locking in unsafe and maladaptive development, risk-informed zoning and spatial planning must be rigorously applied. Planning decisions should be grounded in the best available multi-hazard and climate-risk information and consistently enforced across sectors and jurisdictions.

3. Strengthen the resilience of infrastructure systems and public services: Ensuring the continuity of essential services requires integrating risk information into the planning, design, construction, operation, and maintenance of all infrastructure investments. Priority should be given to upgrading assets in the most exposed and under-protected areas, while existing safety standards should be reviewed and updated to reflect evolving climate and disaster risks

4. Scale up nature-based solutions: Ecosystems such as mangroves and sand dunes play a critical role in coastal protection while also generating economic and livelihood benefits. A systematic approach to their rehabilitation,

conservation, monitoring, and management is needed, supported by strengthened policy, regulatory, and legal frameworks. Lessons from past initiatives should be consolidated to inform technical guidelines and future programs.

5. Enhance preparedness, response, and disaster financing: Disaster risk cannot be fully eliminated. To manage residual risk and prepare for increasingly intense hazards, Vietnam must further strengthen its preparedness and response capacity. This includes improving early warning systems, building local response capacity, adapting social protection mechanisms, and implementing a comprehensive and forward-looking disaster risk financing strategy.

6. Strengthen regional cooperation: Strengthening regional cooperation is essential for reducing socio-economic risks in Vietnam's coastal localities, as climate and environment related threats often transcend boundaries. Improved cooperation among neighboring countries can enhance data sharing, early warning systems, and the application of risk-informed spatial planning. Regional approaches also enable more efficient investment in shared protective infrastructure and coastal ecosystems, while strengthening emergency preparedness and response.

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Annex

Annex 1: Socio-economic and Climate-Related Indicators

SE1-1. Coastal provinces' populations

Unit: 1,000 persons

Coastal province	**Year**			
	2011	**2015**	**2020**	**2022**
Quang Ninh	1,181.5	1,241.6	1,337.6	1,362.9
Hai Phong City	1,886.2	1,969.5	2,053.5	2,088.0
Thai Binh	1,798.7	1,830.3	1,870.2	1,878.5
Nam Dinh	1,816.8	1,796.9	1,780.3	1,876.9
Ninh Binh	911.7	948.5	993.9	1,010.7
Thanh Hoa	3,427.6	3,537.0	3,664.9	3,722.1
Nghe An	2,996.1	3,160.6	3,365.2	3,420.0
Ha Tinh	1,236.7	1,261.3	1,296.6	1,323.7
Quang Binh	854.6	875.6	902.0	913.9
Quang Tri	604.7	617.9	637.4	650.9
Thua Thien – Hue	1,100.8	1,114.7	1,133.6	1,160.2
Da Nang City	968.7	1,056.3	1,169.5	1,220.2
Quang Nam	1,436.8	1,468.2	1,505.0	1,519.4
Quang Ngai	1,220.1	1,226.2	1,233.4	1,245.6
Binh Dinh	1,487.5	1,487.6	1,487.9	1,504.3
Phu Yen	864.0	866.2	874.3	876.6
Khanh Hoa	1,170.2	1,198.4	1,240.4	1,254.0
Ninh Thuan	567.9	578.3	593.6	598.7
Binh Thuan	1,180.7	1,205.4	1,239.3	1,252.1
Ba Ria-Vung Tau	1,040.8	1,104.3	1,167.9	1,178.7
Ho Chi Minh City	7,613.4	8,307.9	9,227.6	9,389.7
Tien Giang	1,682.6	1,728.7	1,772.5	1,785.2
Ben Tre	1,262.7	1,275.8	1,292.4	1,298.0
Tra Vinh	1,004.3	1,006.9	1,009.9	1,019.3
Soc Trang	1,694.4	1,705.4	1,728.9	1,751.8
Bac Lieu	1,273.9	1,236.3	1,195.7	1,197.8
Ca Mau	866.9	887.3	913.5	921.8
Kien Giang	1,204.5	1,199.5	1,193.9	1,207.6
Total (28 provinces)	**44,354.8**	**45,892.6**	**47,880.9**	**48,628.6**
Nation	**88,145.8**	**92,228.6**	**97,582.7**	**99,474.4**

Source: General Statistic Office

SE1-2. Coastal provinces' areas

Unit: km²

Coastal province	Year			
	2011	2015	2020	2022
Quang Ninh	6,102.40	6,102.30	6,206.9	6,207.9
Hai Phong City	1,523.40	1,527.40	1,526.5	1,526.5
Thai Binh	1,570.00	1,570.80	1,584.6	1,584.6
Nam Dinh	1,651.40	1,653.20	1,668.8	1,668.8
Ninh Binh	1,390.30	1,377.60	1,387.1	1,411.8
Thanh Hoa	11,131.90	11,129.50	11,114.7	11,114.7
Nghe An	16,493.70	16,490.00	16,486.5	16,486.5
Ha Tinh	5,997.20	5,997.80	5,994.5	5,994.5
Quang Binh	8,065.30	8,065.30	7,998.8	7,998.8
Quang Tri	4,739.80	4,739.80	4,701.2	4,701.2
Thua Thien – Hue	5033.20	5,033.20	4,947.1	4,947.1
Da Nang City	1285.40	1,285.40	1,284.7	1,284.7
Quang Nam	10,438.40	10,438.40	10,574.9	10,574.9
Quang Ngai	5,153.00	5,152.70	5,155.2	5,155.3
Binh Dinh	6,050.60	6,050.60	6,066.4	6,066.4
Phu Yen	5,060.60	5,060.60	5,026.0	5,026.0
Khanh Hoa	5,217.70	5,217.70	5,199.6	5,199.6
Ninh Thuan	3,358.30	3,358.30	3,355.3	3,355.7
Binh Thuan	7,812.90	7,813.10	7,942.5	7,942.6
Ba Ria-Vung Tau	1,989.50	1,989.50	1,982.6	1,982.6
Ho Chi Minh City	2,095.60	2,095.50	2,095.4	2,095.4
Tien Giang	2,508.30	2,509.30	2,556.4	2,556.4
Ben Tre	2,360.60	2,359.80	2,379.7	2,379.7
Tra Vinh	2,341.20	2,341.20	2,390.8	2,390.8
Soc Trang	6,348.50	6,348.50	6,352.0	6,352.9
Bac Lieu	3,311.60	3,311.60	3,298.2	3,298.2
Ca Mau	2,468.70	2,468.70	2,667.9	2,667.9
Kien Giang	5,294.90	5,294.90	5,274.5	5,274.5
Total (28 provinces)	**136,794.40**	**136,782.70**	**137,218.80**	**137,246.00**
Nation	**330,957.60**	**330,966.90**	**331,317.10**	**331,345.70**

Source: General Statistic Office

SE1-3. Coastal provinces' populations as proportion of national population

Unit: %

Coastal Province	Year			
	2011	**2015**	**2020**	**2022**
Quang Ninh	1.84	1.84	1.88	1.88
Hai Phong City	0.46	0.46	0.46	0.46
Thai Binh	0.47	0.47	0.48	0.48
Nam Dinh	0.50	0.50	0.50	0.50
Ninh Binh	0.42	0.42	0.42	0.43
Thanh Hoa	3.36	3.36	3.36	3.36
Nghe An	4.98	4.98	4.98	4.98
Ha Tinh	1.81	1.81	1.81	1.81
Quang Binh	2.44	2.44	2.42	2.42
Quang Tri	1.43	1.43	1.42	1.42
Thua Thien – Hue	1.52	1.52	1.49	1.49
Da Nang City	0.39	0.39	0.39	0.39
Quang Nam	3.15	3.15	3.20	3.20
Quang Ngai	1.56	1.56	1.56	1.56
Binh Dinh	1.83	1.83	1.83	1.83
Phu Yen	1.53	1.53	1.52	1.52
Khanh Hoa	1.58	1.58	1.57	1.57
Ninh Thuan	1.01	1.01	1.01	1.01
Binh Thuan	2.36	2.36	2.40	2.40
Ba Ria-Vung Tau	0.60	0.60	0.60	0.60
Ho Chi Minh City	0.63	0.63	0.63	0.63
Tien Giang	0.76	0.76	0.77	0.77
Ben Tre	0.71	0.71	0.72	0.72
Tra Vinh	0.71	0.71	0.72	0.72
Soc Trang	1.92	1.92	1.92	1.92
Ca Mau	0.75	0.75	0.81	0.81

Source: General Statistic Office

SE1-4. Coastal provinces' area as proportion of national area

Unit: %

Coastal Province	Year			
	2011	**2015**	**2020**	**2022**
Quang Ninh	1.84	1.84	1.88	1.88
Hai Phong City	0.46	0.46	0.46	0.46
Thai Binh	0.47	0.47	0.48	0.48
Nam Dinh	0.50	0.50	0.50	0.50
Ninh Binh	0.42	0.42	0.42	0.43
Thanh Hoa	3.36	3.36	3.36	3.36
Nghe An	4.98	4.98	4.98	4.98
Ha Tinh	1.81	1.81	1.81	1.81
Quang Binh	2.44	2.44	2.42	2.42
Quang Tri	1.43	1.43	1.42	1.42
Thua Thien – Hue	1.52	1.52	1.49	1.49
Da Nang City	0.39	0.39	0.39	0.39
Quang Nam	3.15	3.15	3.20	3.20
Quang Ngai	1.56	1.56	1.56	1.56
Binh Dinh	1.83	1.83	1.83	1.83
Phu Yen	1.53	1.53	1.52	1.52
Khanh Hoa	1.58	1.58	1.57	1.57
Ninh Thuan	1.01	1.01	1.01	1.01
Binh Thuan	2.36	2.36	2.40	2.40
Ba Ria-Vung Tau	0.60	0.60	0.60	0.60
Ho Chi Minh City	0.63	0.63	0.63	0.63
Tien Giang	0.76	0.76	0.77	0.77
Ben Tre	0.71	0.71	0.72	0.72
Tra Vinh	0.71	0.71	0.72	0.72
Ca Mau	0.75	0.75	0.81	0.81
Kien Giang	1.60	1.60	1.59	1.59

Source: General Statistic Office

SE1-5. Coastal provinces' annual population changes (growth rates)

Unit: %/year

Coastal province	2011	2015	2020	2022
Quang Ninh	0.97	1.13	0.96	0.89
Hai Phong City	0.94	0.96	1	0.75
Thai Binh	0.09	0.43	0.43	0.25
Nam Dinh	0.09	-0.26	-0.03	2.21
Ninh Binh	0.24	0.98	0.95	0.31
Thanh Hoa	0.52	0.85	0.53	0.15
Nghe An	0.67	1.42	0.84	0.3
Ha Tinh	0.4	0.48	0.49	0.74
Quang Binh	0.42	0.59	0.6	0.35
Quang Tri	0.52	0.58	0.6	0.49
Thua Thien – Hue	0.3	0.28	0.37	0.56
Da Nang City	3.15	2.17	2.48	2.07
Quang Nam	0.71	0.57	0.51	0.06
Quang Ngai	0.31	0.14	0.12	0.12
Binh Dinh	0.31	0	0.01	-0.27
Phu Yen	0.43	0.06	0.13	0.12
Khanh Hoa	0.53	0.52	0.62	0.47
Ninh Thuan	0.66	0.5	0.44	0.44
Binh Thuan	0.63	0.68	0.57	0.46
Ba Ria – Vung Tau	1.28	1	1.36	0.22
Ho Chi Minh City	2.09	2.11	2.09	2.43
Tien Giang	0.31	0.73	0.35	0.33
Ben Tre	0.04	0.26	0.26	0.18
Tra Vinh	0.48	0.06	0.06	0.06
Soc Trang	0.19	-0.75	-0.32	-0.75
Bac Lieu	0.49	0.58	0.58	0.36
Ca Mau	0.11	-0.1	-0.03	-0.09
Kien Giang	0.6	0.12	0.3	-0.03

Source: General Statistic Office

SE1-6. Coastal provinces' population densities

Unit: persons/km^2

Coastal province	**Year**			
	2011	**2015**	**2020**	**2022**
Quang Ninh	193.6	203.5	216.0	220.0
Hai Phong City	1,238.2	1,289.4	1,345.0	1,368.0
Thai Binh	1,145.6	1,165.2	1,180.0	1,185.0
Nam Dinh	1,100.2	1,086.9	1,067.0	1,125.0
Ninh Binh	655.7	688.5	717.0	716.0
Thanh Hoa	307.9	317.8	330.0	335.0
Nghe An	181.7	191.7	204.0	207.0
Ha Tinh	206.2	210.3	216.0	221.0
Quang Binh	106.0	108.6	113.0	114.0
Quang Tri	127.6	130.4	136.0	138.0
Thua Thien – Hue	218.7	221.5	229.0	235.0
Da Nang City	753.6	821.8	910.0	950.0
Quang Nam	137.6	140.7	142.0	144.0
Quang Ngai	236.8	238.0	239.0	242.0
Binh Dinh	245.8	245.9	245.0	248.0
Phu Yen	170.7	171.2	174.0	174.0
Khanh Hoa	224.3	229.7	239.0	241.0
Ninh Thuan	169.1	172.2	177.0	178.0
Binh Thuan	151.1	154.3	156.0	158.0
Ba Ria-Vung Tau	523.1	555.1	589.0	595.0
Ho Chi Minh City	3,633.1	3,964.6	4,404.0	4,481.0
Tien Giang	670.8	688.9	693.0	698.0
Ben Tre	534.9	540.6	543.0	545.0
Tra Vinh	429.0	430.1	422.0	426.0
Soc Trang	266.9	268.6	272.0	276.0
Bac Lieu	384.7	373.3	363.0	363.0
Ca Mau	351.1	359.4	342.0	346.0
Kien Giang	227.5	226.5	226.0	229.0
Average (28 provinces)	**521.1**	**542.7**	**567.5**	**577.1**
Average (Nation)	**266.3**	**278.7**	**295.0**	**300**

Source: General Statistic Office

SE1-7. Coastal population in urban areas

Unit: 1,000 persons

Province	2010	2015	2020	2022
Quang Ninh	616.87	733.5	901.11	917.98
Hai Phong City	857.87	901.9	932.55	951.77
Thai Binh	175.52	187.2	219.46	220.96
Nam Dinh	320.74	317.5	360.12	380.46
Ninh Binh	163.1	184.4	212.59	218.43
Thanh Hoa	368.65	457.1	853.28	1,029.90
Nghe An	379.88	465.1	521.61	530.45
Ha Tinh	189.33	222.3	287.77	293.7
Quang Binh	129.46	176.6	207.11	211.7
Quang Tri	170.16	183.9	206.86	212.59
Thua Thien – Hue	471.82	542	562.32	612.83
Da Nang City	814.34	919.4	1.020.44	1,067.07
Quang Nam	270.03	359.9	396.2	407.39
Quang Ngai	180.23	191.8	260.18	272.22
Binh Dinh	415.74	471.5	599.85	619.65
Phu Yen	199.38	248.2	285.9	286.68
Khanh Hoa	465.27	494.6	525.87	531.19
Ninh Thuan	204.28	207.5	209.6	212.26
Binh Thuan	460.1	464.8	472.14	483.27
Ba Ria-Vung Tau	516.61	606.8	672.31	711.89
Ho Chi Minh City	6,159.4	6,727.6	7,290.9	7,297.9
Tien Giang	229.88	242	251.91	271.92
Ben Tre	125.72	126.1	126.66	133.04
Tra Vinh	155.65	166.5	175.83	184.86
Soc Trang	288.79	375.8	386.61	405.65
Bac Lieu	228.17	241.3	253.64	255.89
Ca Mau	258.8	266	271.11	275.77
Kien Giang	457.04	473.4	491.75	522.73
Total (28 coastal provinces)	**15,272.80**	**16,954.70**	**18,955.70**	**19,520.10**
Total (Nation)	**26,460.52**	**30,881.90**	**35,906.44**	**37,347.50**

Source: General Statistic Office

SE1-8. Range and mean elevation (meter above mean sea level) of coastal cities and provinces

No	Coastal province	Min (m)	Max (m)	Range (m)	Mean (m)
1	Quang Ninh	-88	1,495.0	1,583	169.07
2	Hai Phong City	-62	297.0	359	13.90
3	Thai Binh	-23	61.0	84	2.52
4	Nam Dinh	-35	87.0	122	2.75
5	Ninh Binh	-32	634.0	666	48.43
6	Thanh Hoa	-95	1,912.0	2,007	242.00
7	Nghe An	-17	2,656.0	2,673	396.38
8	Ha Tinh	-29	2,287.0	2,316	176.85
9	Quang Binh	-37	2,010.0	2,047	289.27
10	Quang Tri	-25	1,690.0	1,715	263.90
11	Thua Thien – Hue	-27	1,781.0	1,808	281.77
12	Da Nang City	-26	1,672.0	1,698	276.01
13	Quang Nam	-33	2,589.0	2,622	463.19
14	Quang Ngai	-22	1,694.0	1,716	283.35
15	Binh Dinh	-21	1,156.0	1,177	262.05
16	Phu Yen	-20	1,716.0	1,736	256.72
17	Khanh Hoa	-16	2,025.0	2,041	390.12
18	Ninh Thuan	-62	2,023.0	2,085	345.92
19	Binh Thuan	-40	1,637.0	1,677	218.59
20	Ba Ria-Vung Tau	-31	683.0	714	55.22
21	Ho Chi Minh City	-46	116.0	162	4.85
22	Tien Giang	-44	40.0	84	2.36
23	Ben Tre	-59	63.0	122	2.07
24	Tra Vinh	-29	37.0	66	1.98
25	Soc Trang	-42	42.0	84	1.65
26	Bac Lieu	-21	28.0	49	1.61
27	Ca Mau	-25	302.0	327	2.10
28	Kien Giang	-60	553.0	613	10.10

Source: SRTM Digital Elevation Data

SE1-9. Coastal population disitribution by elevation

Unit: 1,000 persons

No	Province	0 – 100m	100 – 300m	300 – 500m	500-1,000m	>1,000m
1	Quang Ninh	828,341	312,123	83,393	43,232	3,745
2	Hai Phong City	2,039,515	10,433	-	-	-
3	Thai Binh	1,774,487	-	-	-	-
4	Nam Dinh	1,773,108	-	-	-	-
5	Ninh Binh	833,322	54,024	19,700	831	-
6	Thanh Hoa	2,730,727	393,067	108,024	93,302	11,420
7	Nghe An	2,242,179	431,136	143,240	163,760	44,033
8	Ha Tinh	916,841	211,724	47,528	33,072	13,731
9	Quang Binh	426,551	234,013	121,896	126,043	3,147
10	Quang Tri	455,817	87,589	46,014	51,781	3,871
11	Thua Thien – Hue	863,406	141,494	54,139	59,008	9,138
12	Da Nang City	993,797	132,450	69,092	56,109	4,983
13	Quang Nam	1,044,192	232,444	100,101	120,505	31,003
14	Quang Ngai	963,931	168,207	80,371	77,027	5,673
15	Binh Dinh	989,009	309,660	155,688	97,920	293
16	Phu Yen	513,907	246,974	138,789	66,854	6,132
17	Khanh Hoa	661,590	238,286	130,876	161,723	45,542
18	Ninh Thuan	390,334	109,183	53,521	79,576	12,895
19	Binh Thuan	624,623	411,174	124,031	121,174	14,171
20	Ba Ria-Vung Tau	1,161,487	164,892	5,395	24	-
21	Ho Chi Minh City	10,752,704	-	-	-	-
22	Tien Giang	1,819,252	-	-	-	-
23	Ben Tre	1,316,481	-	-	-	-
24	Tra Vinh	1,091,241	-	-	-	-
25	Soc Trang	1,480,618	-	-	-	-
26	Bac Lieu	1,033,559	-	-	-	-
27	Ca Mau	1,309,500	-	-	-	-
28	Kien Giang	1,839,537	50,336	4,833	-	-
Total		**42,870,056**	**3,939,209**	**1,486,631**	**1,351,941**	**209,777**

Source: Earth Engine Data Catalogue (Population Density)

SE1-10. Urbanization rate

Unit:%

	2010	**2015**	**2020**	**2022**
Coastal provinces	34.76	36.9	39.6	40.1
Nation	30.3	32.4	35.6	37.5

Source: General Statistic Office and The World Bank

SE1-11. Build-up surface

Time period	**2000**	**2005**	**2010**	**2014**	**2015**	**2020**	**2025**	**2030**
Square kilometers	2,824.58	3,363.56	4,011.32	5,808.97	4,665.97	5,053.37	5,457.38	5,664.22
Percentage of area	0.86	1.02	1.22	1.78	1.42	1.54	1.66	1.72

Source: OECD

SE2-1. Coastal proverty rate

a. Proverty rate (% of poor households) by income indicator

	2006	2008	2010	2012	2013	2014	2015	2016	2020	2021	2022	2023	2024
Quang Ninh	7.9	6.4	8	5.2	4.3	4.1	4	3.7	2.13	1.84	1.11	1.09	0.64
Hai Phong City	7.8	6.3	6.5	5.1	4.5	3.8	2.9	2.1	0.95	0.81	0.65	0.29	0.21
Thai Binh	11	9.8	10.7	8	6.9	5.6	4.6	3.7	2.06	1.93	1.82	1.51	1.02
Nam Dinh	12	10.6	10	7.1	6	4.7	3.8	3	1.98	1.82	1.43	0.99	0.73
Ninh Binh	14.3	13	12.2	9.3	8.1	6.6	5.5	4.3	2.06	2	1.69	1.07	0.82
Thanh Hoa	27.5	24.9	25.4	19.9	17.5	14.5	12	9.6	7.01	6.29	5.21	3.9	2.68
Nghe An	26	22.5	24.8	19.8	17.4	14.4	12.3	10.4	10.88	9.53	6.22	4.72	3.22
Ha Tinh	31.5	26.5	26.1	20.7	18.5	15.6	13.3	11	6.53	5.88	3.83	2.9	1.92
Quang Binh	26.5	21.9	25.2	19.6	17.3	14.5	12.5	10.6	8.84	7.66	6.33	5	3.44
Quang Tri	28.5	25.9	25.1	18.6	16.1	13.1	10.7	9.1	9.15	8.14	9.51	7.01	5.6
Thua Thien – Hue	16.4	13.7	12.8	8.9	7.4	6	4.7	3.7	3.5	3.02	3.93	3.31	2.31
Da Nang City	4	3.5	5.1	2.5	1.6	1.2	0.8	0.5	0.51	0.38	0.93	0.9	0.56
Quang Nam	22.8	19.6	24	18.2	15.8	13	10.6	8.4	8.12	6.96	7.53	5.44	3.37
Quang Ngai	22.5	19.5	22.8	17.6	15.4	12.9	11	9.2	7.45	6.78	6.58	5.18	3.66
Binh Dinh	16	14.2	16	13.6	12.5	10.7	9.1	7.5	4.08	3.62	4.01	2.37	1.56

Phu Yen	18.5	16.3	19	16.3	15.3	12.5	9.3	6.4	5.55	5.05	6.51	4.98	3.35
Khanh Hoa	11	9.1	9.5	8	7.3	6.2	5	3.8	2.45	2.19	3.06	2.39	1.52
Ninh Thuan	22.3	19.3	19	14	12.2	9.9	8.2	6.5	8.96	8.41	9.05	8.04	6.55
Binh Thuan	11	9.2	10.1	7.7	6.6	5.3	3.8	2.3	1.65	1.32	2.85	1.17	0.63
Ba Ria-Vung Tau	7	6.3	6.8	3.4	2.2	1.3	0.7	0.8	0.47	0.23	0.82	0.6	0.43
Ho Chi Minh City	0.5	0.3	0.3	0.05	0.02	0.01	0.01	0	0	0	0	0	0
Tien Giang	13.2	10.6	10.6	9	8.3	7.1	6.3	5.3	2.01	1.7	2.26	1.12	0.72
Ben Tre	16.2	14.2	15.4	12.9	11.9	10.2	8.6	7.1	4.96	4.59	3.85	2.42	1.69
Tra Vinh	21.8	19	23.2	18.3	16.4	13.9	12	10	7.4	6.55	7.04	6.04	4
Soc Trang	19.5	17.9	22.1	19	17.7	15.6	12	8.7	4.98	4.69	6.11	4.95	3.43
Bac Lieu	15.7	13.9	13.3	11.5	10.7	9.5	8.4	6.9	6.67	5.81	5.24	4.29	2.86
Ca Mau	14	12.7	12.3	7.8	6.6	5.7	4.7	4	5.92	5.22	6.38	5.25	3.54
Kien Giang	10.8	9.3	9.3	6.6	5.6	4.5	3.6	2.7	4.08	3.61	4.09	3.38	2.24
Nation	**15.5**	**13.4**	**14.2**	**11.1**	**9.8**	**8.4**	**7**	**5.8**	**4.8**	**4.36**	**4.19**	**3.37**	**2.35**

b. Proverty rate (% of poor households) by multi-dimensional indicators

	2016	2017	2018	2019	2020	2021	2022	2023	2024
Quang Ninh	4.3	3.8	2.5	2.2	2.1	1.8	1.1	1.1	0.6
Hai Phong City	2.1	1.9	1.4	1.2	0.9	0.8	0.6	0.3	0.2
Thai Binh	4.7	4.0	2.9	2.4	2.1	1.9	1.8	1.5	1.0
Nam Dinh	4.2	3.6	2.8	2.3	2.0	1.8	1.4	1.0	0.7
Ninh Binh	4.5	3.9	2.8	2.2	2.1	2.0	1.7	1.1	0.8
Thanh Hoa	11.9	10.9	8.8	8.0	7.0	6.3	5.2	3.9	2.7
Nghe An	17.7	16.4	13.5	12.1	10.9	9.5	6.2	4.7	3.2
Ha Tinh	12.5	10.9	8.8	7.2	6.5	5.9	3.8	2.9	1.9
Quang Binh	13.7	12.1	10.8	9.3	8.8	7.7	6.3	5.0	3.4
Quang Tri	16.1	14.3	12.6	10.9	9.2	8.1	9.5	7.0	5.6
Thua Thien – Hue	7.3	6.5	4.7	4.0	3.5	3.0	3.9	3.3	2.3
Da Nang City	1.5	1.2	0.9	0.7	0.5	0.4	0.9	0.9	0.6
Quang Nam	13.7	12.6	10.3	9.1	8.1	7.0	7.5	5.4	3.4
Quang Ngai	13.7	12.2	10.1	8.4	7.5	6.8	6.6	5.2	3.7
Binh Dinh	8.0	6.9	5.5	4.6	4.1	3.6	4.0	2.4	1.6
Phu Yen	9.9	8.8	7.5	6.3	5.5	5.0	6.5	5.0	3.3
Khanh Hoa	5.9	5.0	3.7	3.0	2.5	2.2	3.1	2.4	1.5
Ninh Thuan	13.4	12.6	11.0	9.8	9.0	8.4	9.1	8.0	6.6
Binh Thuan	4.4	3.6	2.6	2.1	1.6	1.3	2.8	1.2	0.6
Ba Ria-Vung Tau	1.3	1.1	0.9	0.7	0.5	0.2	0.8	0.6	0.4
Ho Chi Minh City	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Tien Giang	5.7	4.7	3.2	2.6	2.0	1.7	2.3	1.1	0.7

Ben Tre	10.1	8.7	6.7	5.6	5.0	4.6	3.9	2.4	1.7
Tra Vinh	13.9	12.0	9.9	8.4	7.4	6.6	7.0	6.0	4.0
Soc Trang	10.2	8.7	6.7	5.6	5.0	4.7	6.1	5.0	3.4
Bac Lieu	13.3	11.5	9.4	7.9	6.7	5.8	5.2	4.3	2.9
Ca Mau	11.9	10.1	8.3	6.9	5.9	5.2	6.4	5.2	3.5
Kien Giang	8.2	7.1	5.8	4.8	4.1	3.6	4.1	3.4	2.2
Nation	**9.2**	**7.9**	**6.8**	**5.7**	**4.8**	**4.4**	**4.2**	**3.4**	**2.3**

SE2-2. Contemporary Human Development Index (HDI)

	2018	2019	2020	2021	2022	2023
Quang Ninh	0.76	0.77	0.77	0.78	0.78	0.8
Hai Phong City	0.77	0.78	0.78	0.8	0.81	0.81
Thai Binh	0.69	0.71	0.71	0.72	0.74	0.74
Nam Dinh	0.68	0.69	0.69	0.7	0.71	0.71
Ninh Binh	0.71	0.72	0.73	0.73	0.75	0.75
Thanh Hoa	0.68	0.69	0.7	0.71	0.73	0.73
Nghe An	0.68	0.69	0.7	0.7	0.71	0.73
Ha Tinh	0.7	0.71	0.71	0.72	0.73	0.73
Quang Binh	0.68	0.68	0.69	0.69	0.7	0.71
Quang Tri	0.66	0.66	0.67	0.68	0.69	0.71
Thua Thien – Hue	0.66	0.69	0.68	0.7	0.7	0.72
Da Nang City	0.77	0.79	0.78	0.79	0.8	0.8
Quang Nam	0.7	0.7	0.7	0.71	0.73	0.73
Quang Ngai	0.69	0.7	0.69	0.71	0.72	0.73
Binh Dinh	0.68	0.69	0.7	0.71	0.72	0.73
Phu Yen	0.67	0.68	0.68	0.69	0.7	0.71
Khanh Hoa	0.7	0.71	0.71	0.72	0.74	0.75
Ninh Thuan	0.64	0.65	0.65	0.67	0.68	0.69
Binh Thuan	0.66	0.68	0.68	0.69	0.7	0.71
Ba Ria-Vung Tau	0.79	0.8	0.79	0.8	0.82	0.82
Ho Chi Minh City	0.79	0.8	0.79	0.8	0.81	0.82
Tien Giang	0.67	0.68	0.68	0.69	0.7	0.7
Ben Tre	0.65	0.66	0.66	0.67	0.68	0.69
Tra Vinh	0.66	0.67	0.67	0.68	0.69	0.7
Soc Trang	0.64	0.64	0.65	0.65	0.67	0.67
Bac Lieu	0.64	0.65	0.65	0.66	0.67	0.68
Ca Mau	0.66	0.66	0.67	0.67	0.69	0.7
Kien Giang	0.65	0.66	0.66	0.67	0.68	0.69
Average coastal provinces	**0.690**	**0.699**	**0.702**	**0.711**	**0.726**	**0.724**
Nation (by GSO)	**0.693**	**0.703**	**0.706**	**0.706**	**0.726**	**0.737**
Nation (by World Bank)	**0.737**	**0.744**	**0.755**	**0.754**	**0.764**	**0.766**

Source: General Statistic Office and the UNDP (2025)

SE2-3. Inequality Adjusted Human Development Index (IHDI)

	2018	2019	2020	2021	2022	2023
HDI	0.737	0.744	0.755	0.754	0.764	0.766
Inequality Adjusted HDI	0.611	0.617	0.630	0.630	0.638	0.641

Source: The UNDP (2025)

SE3-1. Coastal GAV at constant price by economic sector (2010 price)

Unit: billion VND

Economic Sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average
Fisheries and aquaculture	1,041	1,315	1,448	1,711	1,941	2,386	2,323	2,577	1,944	1,724	1,658	**1,824**
Crude petroleum and natural gas	23,500	12,102	20,409	48,829	12,309	33,016	20,477	24,808	26,845	28,837	24,070	**25,018**
Seafood processing and preserved	9,354	9,928	10,466	11,292	12,189	14,602	16,263	18,428	18,393	18,497	18,539	**14,359**
Manufacture of coke and refined petroleum products	15,988	17,676	18,893	19,848	21,724	23,234	25,145	28,285	32,923	46,224	47,885	**27,075**
Manufacture of ships and boats	4,573	4,714	6,241	5,883	6,118	7,310	8,736	9,012	9,119	9,280	9,114	**7,282**
Marine transportation	17,362	20,397	17,124	20,572	23,566	26,103	27,744	29,281	29,759	31,080	31,829	**24,983**
Offshore wind electric	0	0	0	0	17	76	101	165	1,699	7,166	10,054	**1,753**
Marine tourism	23,253	25,882	29,795	51,811	53,648	60,321	70,591	89,241	105,263	116,475	1,071	**57,032**

Source: The World Bank (2025)

SE3-2. Sustainable fisheries as a percentage of GDP of Vietnam

	2011	**2013**	**2015**	**2017**	**2019**	**2021**
Contribution of sustainable fisheries as % of GDP	1.3	1.2	1.25	1.17	1.12	0.73

Source: FAODATA

SE3-3. Coastal tourism percent of GDP

Unit: VND thousand billion

Indicator	**2014**	**2015**	**2016**	**2017**
Coastal tourism GDP*	147.774	163.284	194.579	256.651
National tourism GDP**	322.86	355.55	417.27	541
National GDP***	4,937.03	5,191.32	5,639.4	6,293.9

**: Source: The World Bank (2025)*
***: Source: Vietnam National Authority of Tourism*
****: Source: General Statistics Office*

SE4-1. Number of tropical cyclones

Unit: event

Year	Nation*	Coastal provinces*	Nation**
2000	2	2	
2001	3	2	
2003	1	1	
2004	2	2	
2005	3	3	
2006	4	3	
2007	1	1	
2008	5	5	
2009	3	3	
2010	3	2	
2011	1	1	5
2012	3	2	6
2013	4	4	11
2014	3	3	3
2015	2	1	2
2016	3	3	5
2017	4	3	7
2018	4	2	3
2019	2	2	6
2020	9	7	10
2021	4	3	6
2022	1	1	5
2023	1	1	1
2024	3	2	4

** Source: EM-DAT Project*
*** Source: Vietnam Disaster and Dyke Management Authority*

SE4-2. Number of affected cases by tropical cyclones

Year	Total Death (persons)			No. Injuries (persons)			No. Affected (persons)		No. homeless (households)		
	Nation*	Coastal provinces*	Nation**	Nation*	Coastal provinces*	Nation**	Nation	Coastal provinces	Nation*	Coastal provinces*	Nation**
2000	20	20		33	33				6,000	6,000	
2001	53	23		89	86		177,450	60,000	23,100	23,100	
2003				18	18				5,000	5,000	
2004	70	70		5	5		500,900	500,900			
2005	103	103		28	28		361,132	361,132			
2006	387	370		1885	1,885		2,943,720	2,943,720	50,680	48,188	
2007	96	96		150	150		637,755	637,755	47,525	47,525	
2008	254	254		159	159		143,830	143,830	12,660	12,660	
2009	306	306		1005	1,005		2,867,820	2,867,820	68,635	68,635	
2010	35	25		20	20		32,960	20,560	1,620	1,620	
2011			48			8					32,526
2012	38	28	64	584	584	589	59,320	59,320	9,545	9,545	83,454
2013	74	74	152			19	1,962,485	1,962,485	375	375	802,805
2014	38	38	51			16	48,075	48,075			51,216
2015	18	11	18	20	20	135			115		2,204
2016	46	46	44	113	112	534	812,820	812,820			22,110
2017	147	146	135	28	28	49	5,042,900	5,042,900			531,950

2018	67	32	33	14	14	45	156,000	60,000			29,272
2019	4	4	25	21		749	22,150	22,150			7,791
2020	302	296	194			14	2,162,490	2,157,855	2,925	2,925	733,461
2021	11	9	9	110	110	173	83,560	83,250			5,386
2022	19	19	29	3	3	11	436,868	436,868			137,744
2023	1	1	10	1983	1,983	2,113					3,069
2024	354	351	355				3,745,274	3,743,424			487,506

** Source: EM-DAT Project*
*** Source: Vietnam Disaster and Dyke Management Authority*

SE4-3. Total damage due to tropical cyclones (oringinal estimate)

Unit: USD 1,000

	Nation*	Coastal provinces*	Nation**
2000	26,000	26,000	
2001	83,200	58,200	
2004	30,000	30,000	
2005	250,250	250,250	
2006	1,080,000	1,080,000	
2007	191,000	191,000	
2008	190,500	190,500	
2009	1,065,200	1,065,200	
2010	44,500	44,500	
2012	342,800	342,800	636,970
2013	1,474,230	1,474,230	1,214,010
2014	10,700	10,700	92,550
2015	21,800	21,800	17,800
2016	541,157	541,157	530,130
2017	2,985,000	1,555,000	1,966,450
2018	239,200	192,000	151,690
2019	114,000	1,144,000	127,440
2020	1,429,992	1,428,492	1,542,930
2021	26,500	26,500	41,180
2022	265,000	265,000	353,770
2023			44,090
2024	2,020,600	2,020,600	3,592,000

** Source: EM-DAT Project*

CHAPTER 3. POLLUTION

3.1 Key Findings

3.1.1 Leading Pollution Drivers, Key Pollution Concerns, and National-Regional Significance

3.1.1.1 Nutrient, Organic Loading

Excessive nutrient enrichment is a primary pollution driver in Vietnam's coastal waters. High agricultural fertilizer usage (over 4.5 million tonnes of fertilizer imported in 2021, up 19% from 2020) and large-scale livestock operations contribute vast nitrogen (N) and phosphorus (P) loads to rivers and deltas. Untreated domestic sewage further adds organic matter and pathogens. These diffuse sources elevate nutrient concentrations in estuaries and coastal zones, occasionally triggering eutrophication and harmful algal blooms. Red tides – often linked to nutrient surges – have been recorded in Vietnamese coastal areas (e.g. Nghe An, Binh Thuan, Kien Giang) since the 1990s , underscoring the national scope of this issue. Regionally, nutrient runoff from Vietnam's watersheds (e.g. the Red River originating in China and the intensively farmed Mekong basin) fuels transboundary eutrophication in the East Vietnam Sea / South China Sea . The environmental significance is high: elevated nutrients threaten coastal fisheries and aquaculture through periodic oxygen depletion and toxin-producing algae, with cascading economic impacts.

3.1.1.2 Solid Waste and Marine Litter

Rapid economic growth and urbanization have led to 25–28 million tonnes of solid waste generated per year . Waste management has not kept pace – about 75–85% of collected waste is disposed in landfills or open dumps. As a result, mismanaged solid waste (especially plastics) leaks into waterways and the ocean. Vietnam is among big sources of marine plastic debris . Per capita plastic use rose from 3.8 kg (1990) to over 41 kg by 2015, generating an estimated 1.8 million tonnes of plastic waste annually . Inadequate disposal means plastics can be carried by rivers and currents across borders; studies estimate up to 60% of ocean plastic originates from five Asian countries including Vietnam. Marine litter – from local sources and drifting from neighboring states – endangers marine life, impedes navigation, and taints coastal tourism. Vietnam has acknowledged the regional significance of this issue by committing to an ASEAN Action Plan on Marine Debris and a national ban on certain single-use plastics by 2025 .

3.1.1.3 Industrial and Hazardous Pollution

Industrialization has intensified pollution of Vietnam's coastal environment. A number of factories and craft villages still operate with outdated pollution controls , discharging untreated effluents containing heavy metals and toxic organic compounds into rivers that flow to the sea. Over 7 million tonnes of industrial solid waste are generated annually , some of it hazardous, yet hazardous waste handling capacity remains limited. Each year Vietnam produces > 630,000 tonnes of hazardous waste (from industry, healthcare, etc.), but only a portion is safely treated. The remainder pollutants can bioaccumulate in the food web, leading to contaminated seafood and long-term ecosystem degradation. Nationally, industrial and hazardous pollution hotspots (e.g. downstream of industrial zones) are linked to cancer clusters and biodiversity loss, while regionally, pollutants like heavy metals can disperse along currents, underscoring a shared East Vietnam Sea / South China Sea concern.

3.1.1.4 Oil Spills and Hydrocarbon Pollution

Heavy maritime traffic and offshore oil activities in the East Vietnam Sea / South China Sea make oil pollution a continual threat. While Vietnam has not suffered an ultra-large spill in recent years, numerous smaller spills and illegal oily discharges have occurred. Coastal provinces have periodically reported tar balls and oil lumps washing ashore – for instance, an estimated 1 tonne of weathered oil polluted 500 m of Ha Tinh's coastline in February 2024 . In 2019, a sunken cargo vessel spilled 178 tonnes of fuel oil, contaminating 3 km of Ky Anh Town's beaches . These incidents reveal vulnerabilities in spill prevention. Oil contamination harms marine life (coating beaches, killing mangroves, poisoning fish) and can disseminate widely on regional currents. Given that the East Vietnam Sea / South China Sea is a global shipping artery, any major spill could drift across national boundaries . Vietnam has strengthened its preparedness – updating a national oil spill contingency plan in 2020 and maintaining three regional response centers and a number of private small scale response centers – but the transboundary significance remains. Without robust regional cooperation on shipping practices and emergency response, Vietnam's coastal communities and fisheries will remain at risk from hydrocarbon pollution.

3.1.1.5 High-Risk and Sensitive Areas

Several ecologically sensitive coastal areas in Vietnam are under high pollution stress. Coral reef ecosystems, such as those in Nha Trang Bay, the Con Dao and Phu Quoc archipelagos, are extremely vulnerable to water quality degradation. Chronic sedimentation, nutrient runoff, and coastal construction have decimated live coral cover – in some sites over 90% of corals have died off by 2019 . Mangrove forests, especially in the Mekong Delta and Red River Delta, face both direct loss (from aquaculture and development) and functional decline due to pollution. Mangroves serve as natural bio-filters and nurseries, so their degradation reduces coastal resilience and water purification capacity . Other sensitive habitats include seagrass beds (vital fish spawning grounds) and tidal wetlands, which are impacted by agro-chemical runoff and wastewater. These high-value areas concentrate biodiversity and economic services (fisheries, tourism) and thus any pollution here has outsized ecological and socio-economic consequences. Protecting such areas is nationally significant and contributes to regional biodiversity conservation in the East Vietnam Sea / South China Sea .

3.1.2 Sectoral Impacts

3.1.2.1 Agriculture

Agricultural activities are a major source of land-based pollution reaching Vietnam's seas. The intensification of crop production – particularly rice and coffee – involves heavy application of chemical fertilizers and pesticides. As noted, over 4–5 million tonnes of fertilizers are used annually , and more than 100,000 tonnes of pesticides are applied each year . A significant fraction of these agro-chemicals is not taken up by plants and instead can be washed by rainfall into rivers and coastal waters. This runoff elevates nutrient levels (nitrates, phosphates) in delta estuaries, driving eutrophication and periodic algal blooms. In rural hotspot areas (e.g. vegetable farming districts near Hanoi and aquaculture-agriculture zones in the Mekong delta), improper fertilizer and manure management have led to spikes in ammonia (NH_3) and sulfide (H_2S) emissions. The sector's pollution impacts include depleted dissolved oxygen and occasional fish kills in downstream canals, and residue accumulation in coastal sediments. Moreover, high sediment loads from upland agriculture (due to erosion) increase turbidity in coastal waters, stressing corals and seagrasses. Given agriculture's role as Vietnam's economic backbone, addressing these diffuse impacts is challenging. However, initiatives promoting better nutrient management (e.g. "3 reductions, 3 gains" in rice farming) are beginning to curb runoff at source. Regionally, Vietnam's agricultural pollution contributes to shared problems like Red River plume impacts on the Gulf of Tonkin and Mekong nutrient loads affecting the East Vietnam Sea / South China Sea .

3.1.2.2 Domestic Solid Waste

Municipal solid waste mismanagement is an acute environmental issue with direct marine implications. Vietnam's cities and towns generate ~25.5 million tonnes of solid waste per year, and this volume has been rising ~5% annually with urban population growth . Collection services have expanded (covering ~92% of urban waste and ~66% of rural waste), yet waste treatment and disposal remain problematic. Over 75% of collected waste is simply landfilled or dumped, often in facilities with limited sanitary standards . As a result, leachate from open dumps pollutes surface water and nearshore waters, and lighter trash readily escapes into the environment. Floods or heavy rains (increasingly frequent with climate change) further wash refuse from landfills and streets into rivers. The leakage of plastic waste is of particular concern: studies by the World Bank have ranked Vietnam among the top four plastic polluters globally. Coastal cities like Da Nang, Nha Trang and Vung Tau struggle with periodic beach pollution from accumulated garbage and debris, undermining tourism. The government has recognized that traditional "collect-transfer-dump" practices are unsustainable and is moving toward a circular economy approach . New regulations mandate waste separation at source and Extended Producer Responsibility (EPR) for packaging, but implementation is limited. Initial enforcement has hampered source-separation programs in Hanoi and Ho Chi Minh City . In summary, the domestic waste sector's impact is twofold: locally, it degrades urban environments and generates public health risks, and nationally/regionally, it may feeds the transboundary marine litter crisis across the East Vietnam Sea/South China Sea .

3.1.2.3 Industrial Pollution

Industrial activity contributes significant pollutant loads to Vietnam's environment, with effects often concentrated in specific "hotspot" regions. The country has 283 industrial parks and hundreds of smaller industrial clusters, many located in coastal provinces . These industries (textiles, food processing, chemicals, electronics, etc.) produce large volumes of wastewater – estimated at over 550,000 m^3/day from industrial parks alone – as well as solid wastes and air emissions. Compliance with treatment regulations is improving but remains uneven. Only about 5% of the 615 registered industrial clusters have centralized wastewater treatment plants ; the rest often discharge either partially treated or untreated effluent. Consequently, rivers near industrial zones (e.g. the Thi Vai River near Ho Chi Minh City, Nhue River near Hanoi) show elevated levels of heavy metals, ammonia, and chemical oxygen demand (COD) beyond national water quality standards . One notorious case was the Thi Vai river pollution by a monosodium glutamate factory in the 2000s, which devastated fisheries. On the coast, major seaports and industrial estates (e.g. along Haiphong – Quang Ninh, and Vung Tau – Dong Nai corridors) are sites of recurring water and sediment contamination. These pollutants accumulate in sediments and biota; for example, shellfish near industrial effluent outfalls have shown high cadmium and lead levels . Industrial air pollution (SO_2, NO_x, particulates) also indirectly impacts marine areas through deposition and acidification of rainwater. The national and regional significance of industrial pollution is evident: domestically it imposes health costs on communities and cleanup liabilities, while regionally, mobile pollutants like persistent organics can spread. Vietnam has strengthened its legal framework (the revised Law on Environmental Protection 2020) to tighten industrial discharge standards and require Best Available Techniques . Still, enforcement gaps and the fast pace of industrial growth pose ongoing challenges in controlling this sector's impacts.

3.1.2.4 Aquaculture

Aquaculture – particularly coastal shrimp and fish farming – has expanded rapidly and is now a major pollution source if not managed sustainably. Vietnam devotes about 1.1 million hectares to aquaculture production , much of it in sensitive delta and lagoon environments. Intensive shrimp farming in the Mekong Delta and south-central coast exemplifies the sector's impacts: high stocking densities and heavy feeding lead to a buildup of organic waste (uneaten feed, feces) in pond water. Periodic pond draining or overflow releases this nutrient-rich, oxygen-depleting water into adjacent rivers and estuaries, causing local spikes in turbidity and biochemical oxygen demand (BOD). Feed waste is significant – feed conversion ratios for intensive shrimp can be 1.2–1.5:1 or higher, meaning a substantial fraction of feed becomes waste. Additionally, chemical use is prevalent: farmers apply lime, probiotics, and antibiotics to prevent disease and improve yields. Antibiotic residues (e.g.

chloramphenicol, banned malachite green) have been detected in shrimp and fish products, leading to import rejections and reputational damage. These drugs and other chemicals (disinfectants, pesticides for pond prep) can harm non-target organisms and contribute to antimicrobial resistance when flushed to the environment. Coastal habitat conversion for aquaculture has also directly caused environmental loss – particularly mangrove deforestation in past decades to create shrimp ponds. Although programs now encourage "mangrove-shrimp" integrated farming, water quality in such areas still suffers from nutrient loading. The aquaculture sector's pollution is locally severe (e.g. parts of Ca Mau Province's canals have chronically high organic loads and sulfide levels) and nationally significant as Vietnam is a top aquaculture producer. Sustainable practices (better feed management, wastewater treatment ponds, biosecurity and reduced chemical reliance) are being implemented with support from initiatives like MAE (MARD and (NOW MINISTRY OF AGRICULTURE AND ENVIRONMENT - MAE)), the World Bank and WWF, aiming to mitigate aquaculture's environmental footprint.

3.1.2.5 Marine Activities and Marine Debris Transport

Marine-based activities – shipping, fishing, and coastal tourism – contribute to pollution both directly and through the movement of pollutants. The East Vietnam Sea / South China Sea 's heavy shipping traffic brings risks of oil spills, chronic fuel emissions, and waste dumping. Large cargo vessels and tankers occasionally rinse out oily sludge or release garbage illegally; these discharges can travel far. Ocean currents and monsoonal winds transport floating debris (notably plastics) across national boundaries. This transboundary drift of marine litter is well documented by regional studies and is a key rationale for coordinated action. Fishing activities contribute lost or discarded gear (nets, lines, styrofoam floats), which become marine debris hazards (ghost fishing and ingestion by marine animals). The fisheries sector also generates pollution in port: fish landing sites often release untreated offal and wastewater into harbors, raising localized nutrient and bacterial levels. Coastal tourism and recreation exert pressure on popular beaches and islands; tourist boats in Ha Long Bay, Cham Islands and others have been implicated in wastewater and oil leakage incidents that degrade water quality. Anchoring of boats on reefs also causes direct physical damage and can stir up sediments. The marine transport sector is further linked to invasive species introduction via ballast water discharge; Vietnam's ports have recorded invasive mussels and barnacles likely introduced in ship ballast. These issues have national security and economic angles – for instance, debris and oil pollution can harm Vietnam's fisheries output and tourism appeal, while also affecting neighboring states' waters. Recognizing this, Vietnam actively participates in multilateral efforts (e.g. the IMO's MARPOL convention for ship waste, the regional action plan on marine litter). Reducing ship-based pollution (through stricter enforcement of no-dumping rules, port waste reception facilities, and improved fisheries waste management) is an ongoing priority to protect Vietnam's marine environment and beyond.

3.1.2.6 Emerging Contaminants

Beyond traditional pollutants, a range of emerging contaminants are gaining attention for their potential impacts on Vietnam's marine waters. Microplastics – microscopic plastic fragments and fibers – are now identified in water and sediments along Vietnam's coast. Recent studies have found microplastic contamination in surface waters of the Mekong and Red River, beach sands, etc.. These particles can adsorb toxins and enter the food chain, posing unknown health risks to marine life and humans. Pharmaceutical and personal care residues are another concern: Vietnam's use of human and veterinary pharmaceuticals (antibiotics, hormones, painkillers) has risen, and many of these compounds pass through wastewater treatment (where it exists) largely unremoved. Coastal monitoring has begun to detect antibiotic residues and endocrine-disrupting chemicals in estuarine waters near urban centers, which could affect aquatic organism health (e.g. feminization of fish). Heavy metal hotspots from legacy pollution continue to be discovered – for example, sediments near former mining zones or industrial ports contain high arsenic, mercury, or lead, which can remobilize. While not "new" contaminants, their re-entry into waterways under changing conditions (like acidifying water or dredging) is an emerging issue. Another emerging contaminant class is per- and polyfluoroalkyl substances (PFAS), used in firefighting foams and textiles. Lastly, harmful algal bloom toxins (such as brevetoxins, cyanotoxins) can be considered emerging in the sense that their occurrence may increase with nutrient pollution and warming seas. Each of these emerging contaminants poses unique challenges: detection methods and regulatory standards are often lacking, and their long-term ecological effects are not fully understood. Vietnam is addressing them by updating water quality standards and investing in modern laboratory capacity. Nevertheless, these pollutants could represent the next wave of environmental management issues as the country strives to safeguard its marine and coastal health.

3.1.3 Ecological and Public Health Consequences

3.1.3.1 Coral Degradation

Coral reef degradation in Vietnam has reached critical levels, with pollution synergizing with climate stress to drive widespread losses. Once-flourishing reefs have suffered sharp declines in coral cover and diversity. Surveys show that as of 2019, over 50% of the nation's assessed coral reefs are in poor condition (live coral cover under 25%) . In some intensively impacted sites, collapse has been even more dramatic – Nha Trang Bay's coral cover dropped by 64% between 2016 and 2019, and over 90% of coral colonies had died by 2019 due to successive disturbances . Chronic land-based pollution is a key driver: sediment and nutrient runoff from rivers increase turbidity and algal overgrowth on reefs, weakening corals' competitive advantage. For example, researchers attributed the mass mortality in Nha Trang partly to increasing eutrophication (nutrient enrichment) from sewage and agricultural runoff, coupled with other stresses like overfishing and Crown-of-Thorns starfish outbreaks . Coral bleaching events linked to warming have struck Vietnam's reefs (notably in 2010 and 2016), but recovery is hampered in polluted waters where resilient coral recruitment is low. The loss of coral reefs has serious ecological consequences: reefs support at least 355 hard coral species and myriad fish and invertebrates in Vietnam , so their decline is causing cascading biodiversity loss. Fish populations that depend on reefs are plummeting – a 2022 survey in Phu Quoc MPA found large reef fish (>20 cm) comprised only ~1% of individuals observed , indicating a severely degraded ecosystem. Coral degradation also means loss of shoreline protection (reefs buffer waves), reduced tourism appeal for dive tourism, and diminished fishery productivity. This imposes socio-economic costs on coastal communities that once relied on vibrant reefs. The government and local stakeholders have responded with emergency measures (e.g. closing Hon Mun reef to tourists in 2022, active coral transplantation projects) . However, without addressing root causes – land-based pollution, destructive fishing, and climate change – coral reef prospects remain precarious. The Vietnam case exemplifies how compounded pressures can drive a swift shift from coral-dominated to algae-dominated reefs, a change that may be difficult to reverse if action is delayed.

3.1.3.2 Tourism Risks

Environmental pollution in coastal zones directly threatens Vietnam's tourism industry, particularly the appeal and safety of its beaches, bays, and marine parks. Water pollution and marine debris have begun to impact tourist perceptions in formerly pristine destinations. In Da Nang, Vung Tau, and on Phu Quoc Island, there have been recurring episodes of garbage (plastic bags, medical waste, tar balls) washing onto beaches during the monsoon season, leading to unsightly and unsanitary conditions. Clean-up efforts are frequent, but the reputational damage can reduce tourist arrivals. Bathing water quality is another concern: high levels of coliform bacteria and occasional algal bloom toxins have led to temporary swimming bans on some beaches (e.g. after heavy rains in Ha Long Bay or Nha Trang). In extreme cases, major pollution incidents force tourism closures – for instance, the Hon Mun Marine Protected Area in Nha Trang was closed in mid-2022 after surveys revealed severe coral die-off linked to environmental stress . This prevented snorkeling/diving activities and drew negative media attention. Over the longer term, the loss of coral reefs and scenic coastal ecosystems diminishes the very natural attractions (colorful reefs, clear waters, abundant marine life) that marine tourism depends on. Similarly, air pollution haze (from urban smog or regional biomass burning) occasionally affects coastal vistas in Ha Long or Phu Quoc, detracting from visitor experience. Cruise and port pollution is another facet: as Vietnam welcomes more cruise ships, managing their waste and air emissions is vital to avoid polluting harbor cities that double as tourist hubs. The tourism sector also faces climate-related pollution risks – for example, extreme floods can cause sewage overflows into streets and beaches, as seen in parts of Hue and Hoi An in recent years, necessitating disaster clean-ups . All these issues contribute to a sense of vulnerability that could sway international tour operators and environmentally conscious travelers away from Vietnam's coastal destinations if not addressed. The government and industry are responding with “green tourism” initiatives, such as certifying beaches for cleanliness, banning single-use plastics in certain parks, and improving wastewater treatment in resort areas. Ensuring a clean, safe coastal environment is recognized as integral to sustaining Vietnam’s tourism growth.

3.1.4 Climate Change Impacts

3.1.4.1 Extreme Rainfall

Climate change is amplifying extreme rainfall events in Vietnam, which in turn exacerbate pollution runoff into coastal waters. The country has experienced more intense downpours and severe typhoon seasons in recent years, especially in central Vietnam. These torrential rains overwhelm drainage and wastewater systems, causing untreated sewage and solid waste to be washed directly into rivers and the sea. Urban areas like Hanoi and Ho Chi Minh City, which already have low wastewater treatment coverage (~12–15%), see combined sewer overflows during heavy rains – flushing raw sewage, street litter, and oil residues into canals that drain to coastal estuaries. Flooding events have become frequent (e.g. historic floods in Hue and Quang Nam in 2020), mobilizing not only sediments but also contaminants from industrial zones and landfills. Furthermore, extreme rainfall accelerates soil erosion from agricultural land, increasing the nutrient and silt load delivered to coastal waters. Satellite observations after major storms indicate large sediment plumes off river deltas, which carry fertilizers, pesticides, and organic waste. These pulses can lead to short-term hypoxia and spike harmful algal blooms after the storm due to sudden nutrient influx. Another consequence of intense rains is damage to environmental infrastructure – treatment plants and sewer lines can be physically damaged by floods, reducing their functionality long after waters recede. The net effect is that climate-driven rainfall extremes tend to magnify existing land-based pollution challenges, often undoing incremental progress in water quality improvement. Coastal ecosystems already stressed by chronic pollution are further shocked by these episodic pollutant loads. Recognizing this, Vietnam is integrating climate adaptation into pollution control planning: for example, designing storm-resilient wastewater systems and establishing buffer green belts to intercept runoff. Early warning systems and emergency pollution response (such as moving hazardous chemicals away from flood-prone sites) are also being improved. Nonetheless, the trend of heavier rainfall under climate change presents a formidable and unpredictable stress factor for maintaining coastal water quality.

3.1.4.2 Sea-Level Rise

Accelerating sea-level rise in Vietnam – measured at approximately 3–4 mm per year along the coastline – is compounding pollution problems and creating new management challenges. As sea levels rise, low-lying waste disposal and industrial sites in coastal areas become increasingly vulnerable to inundation and storm surge. Many of Vietnam’s largest landfills (e.g. the Đa Phước dump near HCMC, or those in the Mekong Delta) are situated on low coastal plains;

higher sea levels and more frequent high tides risk breaching these sites, leading to direct release of trash and leachate into estuaries. There is also evidence of saline intrusion reaching further up rivers and into groundwater, which can remobilize pollutants. In the Mekong Delta, salinity now penetrates tens of kilometers inland during dry-season low flows; this saline water can desorb heavy metals or pesticides that were bound in soils or river sediments and carry them into coastal waters. Sea-level rise exacerbates coastal erosion, which can expose and spread contaminated sediments that were previously buried or trapped behind mangroves. For instance, centuries-old agricultural dikes and abandoned waste ponds in the delta are being eroded by tidal action, releasing legacy nutrients and pollutants. Another impact is on groundwater and septic systems: rising water tables and saltwater intrusion compromise septic tanks and pit latrines in coastal communities, causing sewage leakage that finds its way to the sea. Higher base sea levels also mean that storm surges and tsunami-like events push farther inland, which was seen when a moderate typhoon caused unprecedented surge flooding in Da Nang – sweeping urban pollutants out to the ocean. In terms of natural buffers, mangrove habitats that filter runoff are themselves at risk from deeper water and prolonged inundation; areas of the Mekong Delta have lost mangroves due to inundation stress, diminishing their filtering function . The government's climate change scenarios predict up to 0.5 m sea-level rise by 2050, which could significantly alter the coastal water quality baseline. Vietnam's response includes reinforcing coastal landfill protections, relocating some hazardous facilities to higher ground, and restoring mangroves to build natural resilience. But given the vast length of coastline (3,260 km) and densely populated deltas, sea-level rise presents a long-term, diffuse threat that will increasingly intersect with pollution control efforts.

3.1.4.3 Other Climate-Related Issues

Climate change introduces additional stressors that interact with pollution in Vietnam's marine environments. Ocean warming is a major factor – average sea surface temperatures in the East Vietnam Sea / South China Sea have risen, contributing to more frequent coral bleaching events and altering marine species distributions. Warmer waters can amplify the toxicity of certain pollutants (for example, algal blooms tend to produce more toxins in higher temperatures, and bacterial decomposition of organic pollution accelerates, potentially causing more hypoxia). Warmer conditions also favor some invasive or opportunistic species (like Crown-of-Thorns starfish, which feed on corals); when combined with nutrient runoff, this has led to severe reef degradation events such as the COTS outbreaks that devastated reefs in Nha Trang Bay around 2019 . Ocean acidification, driven by increased CO_2 absorption, is gradually lowering pH in Vietnam's waters. While the direct rate in coastal Vietnam is under study, any acidification can reduce the capacity of water to buffer pollutant inputs and can increase the solubility (and hence mobility) of metals like aluminum and lead from sediments. Acidified conditions also stress calcifying organisms (corals, shellfish), making them less resilient to pollution impacts. Changes in monsoon patterns are observed as part of climate shifts – potentially longer dry seasons and more intense wet seasons. Extended droughts (like the Mekong drought of 2019) reduce river flow, concentrating pollutants in estuaries and causing higher salinity that can facilitate certain algal blooms. Conversely, abrupt heavy monsoon onset can flush accumulated urban pollution in a short burst (as discussed under extreme rainfall). Climate change may also intensify tropical storms impacting Vietnam; beyond the rainfall and surge effects already covered, stronger storm winds could stir up contaminated sediments in coastal bays (resuspending them into the water column) and damage pollution control infrastructure (like blowing the covers off waste storage facilities). Human adaptive responses to climate change can have pollution side-effects too: for example, as freshwater becomes scarcer in some coastal areas, more reliance on desalination or saltwater aquaculture might lead to brine discharges; or higher use of agrochemicals to offset climate-related crop stresses could increase runoff. In summary, climate-related changes – warming, acidification, shifting monsoons, and extreme events – often exacerbate the effects of existing pollutants and introduce new challenges. They make environmental management targets a moving goalpost. Vietnam's strategy documents (such as the National Climate Change Strategy and the updated Environmental Protection Law) emphasize the need for integrated climate and pollution policies, like building climate resilience into wastewater infrastructure and conserving ecosystems that provide natural adaptive capacity. Only by tackling pollution with climate foresight can Vietnam hope to maintain marine environmental quality under rapidly changing conditions.

Each of the above key findings underscores that land-based and marine pollution in Vietnam's East Vietnam Sea/South China Sea waters is a multifaceted challenge. Pollution sources are diverse – ranging from farms and cities to factories and ships – and their impacts are magnified by ecological vulnerability and climate change. Nationally, pollution threatens Vietnam's progress on sustainable development and public health, while regionally it contributes to shared environmental problems in the East Vietnam Sea / South China Sea .

3.2 Current Status by Indicator Group

3.2.1 Pollution Sources and Magnitude

3.2.1.1 Agricultural Runoff

Agricultural runoff is a significant source of nutrient and chemical pollution entering Vietnam's coastal waters. This runoff primarily carries excess fertilizers, livestock waste, and pesticide residues from farmlands into rivers and estuaries. Vietnam's heavy fertilizer usage has been well documented – in 2021 the country imported 4.54 million tonnes of fertilizer (a nearly 20% increase over 2020) , reflecting intensive application on crops. Not all of this fertilizer is absorbed by plants; a considerable portion leaches into soil and waterways. Likewise, over 100,000 tonnes of plant protection chemicals (pesticides, herbicides) are used annually , of which an estimated ~20% may run off into the environment under monsoonal rains. The magnitude of nutrient loading from agriculture is evident in water quality measurements: rivers draining Vietnam's two major granaries – the Red River Delta and the Mekong Delta – show elevated nitrate and phosphate concentrations during the wet season. For instance, monitoring in the Red River coastal zone (Thai Binh province) in 2019–2020 found that diffuse sources (largely agriculture) were the dominant contributors to nitrate and total phosphorus in coastal waters . These nutrient inputs can cause mesotrophic to eutrophic conditions, supporting algal growth including harmful species . Apart from nutrients, agricultural runoff also contains organochlorine pesticide residues and increased sediment loads from soil erosion in upstream areas.

3.2.1.1.1 Fertilizer Import Data

Vietnam's reliance on imported fertilizers provides an indirect measure of nutrient input trends. As noted, 4.54 million tonnes of fertilizer were imported in 2021 , up from roughly 3.8 million tonnes in 2020. This import volume has been on a generally rising trajectory in the past decade, paralleling the intensification of agriculture. Urea, NPK blends, and phosphate fertilizers constitute major imports, primarily from China and countries in the region . Domestic fertilizer production adds to this supply (Vietnam produces some NPK and phosphate fertilizers, although not enough to meet demand). These figures underscore why nutrient runoff is a pressing concern: such high usage without corresponding nutrient uptake efficiency leads to runoff and leaching. Indeed, a World Bank analysis found that by the mid-2010s Vietnam's annual fertilizer use (~10 million tonnes gross weight, including organic fertilizers) resulted in nearly 23,000 tonnes of excess nitrogen entering water bodies each year . The fertilizer import data are also important because they highlight sensitivity to global price and supply changes; spikes in fertilizer cost or shortages (as seen in 2022) could alter usage patterns and thus runoff intensity. In summary, fertilizer import statistics confirm the large scale of nutrient inputs to Vietnam's agriculture and, by extension, the potential nutrient load available to pollute aquatic systems if not managed.

3.2.1.1.2 Data Gaps and Monitoring Challenges

Accurately quantifying agricultural runoff and its impacts remains challenging due to data limitations. While fertilizer sales and import figures are recorded, there is a lack of comprehensive monitoring of nutrient concentrations in small rivers, drainage canals, and groundwater across agricultural landscapes. Most water quality monitoring focuses on major rivers and select coastal sites, leaving gaps in understanding diffuse pollution from rice paddies, coffee plantations, etc. For example, nutrient monitoring in the Mekong Delta is typically done at a few river mainstream stations, which can underestimate local hotspot runoff from intensive shrimp-rice farming areas. Pesticide residue data in water or sediments are similarly sparse; studies are often ad hoc and localized, making it difficult to assess national trends. Vietnam's State of the Environment reports acknowledge these gaps – the 2016–2020 report relied on provincial submissions that vary in quality and often lacked detailed pesticide or nutrient runoff metrics . Another challenge is attributing water pollution to specific agricultural sources, since industrial or domestic sources may co-occur. For instance, high nitrate levels in a river could come from fertilizer or urban sewage or aquaculture discharge. The DPSIR (Driver-Pressure-State-Impact-Response) analytical framework used by MAEattempts to link drivers like fertilizer use to state changes in water quality , but establishing quantitative source apportionment is difficult without advanced monitoring (e.g. isotope tracing for nitrogen sources). Seasonal variation adds complexity: heavy rains cause flushes of runoff that are hard to capture with periodic sampling. Lastly, groundwater pollution from agriculture (such as nitrate contamination of shallow wells) is not systematically monitored in coastal rural areas. This is a concern because contaminated groundwater can seep into estuaries or be used for drinking, posing health risks. In summary, Vietnam faces significant data and monitoring challenges in the agricultural runoff domain – bridging these gaps will require expanding water quality networks into farming areas, employing new monitoring technologies (remote sensing for sediment plumes, for example), and ensuring consistent data reporting across provinces.

3.2.1.2 Marine and Coastal Water Quality

This section assesses the status of Vietnam's coastal and marine water quality, focusing on key parameters and observed trends since 2020. Overall, coastal water quality varies by location: many open-coast areas remain within acceptable ranges for basic parameters, but localized pollution hotspots exist near river mouths, urban-industrial centers, and aquaculture zones. Marine water quality in offshore areas of Vietnam's Exclusive Economic Zone (EEZ) is generally good, reflecting the dilutive capacity of the open sea, yet nearshore waters often mirror the influences of human activities on land.

3.2.1.2.1 Coastal Water Quality Assessment: Key Parameters and Trends

Vietnam monitors several water quality parameters in coastal zones, including dissolved oxygen (DO), nutrients (NH_4, NO_3, PO_4), chemical oxygen demand (COD), biological oxygen demand (BOD_5), coliform bacteria, and certain heavy metals, comparing values against national marine standards (QCVN for seawater). Dissolved oxygen levels in most coastal waters have remained above the critical 4 mg/L level, except in poorly flushed embayments or immediately at discharge points. However, there are indications of eutrophication trends: for example, surveys from 2016–2020 showed increasing inorganic nitrogen concentrations at some coastal stations year-on-year, especially in the Mekong delta's coastal waters during the flood season . This corresponds with elevated phytoplankton biomass observed (occasionally manifesting as algal blooms). Coastal water in urbanized bays often exhibits higher COD/BOD from organic pollution. Ha Long Bay, despite its size, has pockets of low water quality near tourist wharf areas; a 2016–2020 analysis using a Water Quality Index rated Ha Long's overall water quality as "acceptable," but noted significant improvement in 2020 (pandemic period) relative to 2016–19 due to reduced anthropogenic input . This suggests that normal tourism and shipping activity had been contributing organic and oil pollutants, temporarily abated in 2020 . Microbial contamination (coliform and E. coli counts) is a concern at beaches near city outfalls. For instance, coliform levels at some bathing beaches in Da Nang and Vung Tau have intermittently exceeded the standard of 1,000 MPN/100 mL after heavy rains, indicating runoff of sewage and animal waste. Monitoring by the Vietnam Environment Administration found that water at river mouths such as the Nhue–Day (Hanoi) and Saigon–Dong Nai (HCMC) systems often fails inland surface water standards due to nutrient and microbe pollution ; while these are inland readings, the contamination can carry into adjacent coastal waters, at least seasonally. Oil and grease in coastal water are monitored near ports: generally they remain low (<0.1 mg/L) except following spill incidents. For example, after a 2019 oil spill in Ha Tinh (Nordana Sophie ship sinking), coastal waters there had oil concentrations several times above the standard temporarily . Heavy metals in open coastal water usually measure in the low µg/L range, below national limits, but sediments and biota indicate metal hotspots (e.g. high copper and zinc in Haiphong Harbour water/sediments due to port activities). Trend-wise, the period 2020–2025 has seen incremental improvements in some parameters in areas where new wastewater treatment came online (e.g. upgraded sewage plants in Da Nang improved nearshore bacterial counts). Conversely, emerging issues like microplastics (not yet regulated in water quality standards) are increasingly detected, with some studies reporting tens to hundreds of microplastic particles per cubic meter of coastal seawater near HCMC and Mekong outlets . In summary, while Vietnam's coastal water quality is still fairly good in many areas (meeting Class B standards for uses like navigation or industrial cooling), there are worrying trends of nutrient enrichment and localized organic pollution that require ongoing attention.

3.2.1.2.2 Marine Water Quality Assessment

In the context of Vietnam's broader marine waters (offshore environments, open sea areas), water quality remains predominantly in natural or near-natural conditions for most measured variables. The offshore East Vietnam Sea / South China Sea has low nutrient concentrations (oligotrophic conditions) and clear waters, supporting Vietnam's oceanic fisheries. Surveys by the Institute of Oceanography indicate that beyond 20–30 km from shore, nitrate levels are typically <0.1 mg/L and chlorophyll-a is low except in upwelling zones off south-central Vietnam. However, certain marine areas under Vietnam's jurisdiction warrant special mention:

- The Gulf of Tonkin (Bắc Bộ): a semi-enclosed gulf receiving discharge from the Red River. Its waters on the Vietnam side generally meet Class A1 marine standards (suitable for aquatic conservation) except periodically near the delta outflow, where turbidity and nutrient levels rise during floods. The Gulf's bottom water can stratify in summer, but no persistent hypoxic zones have been reported; oxygen remains above 5 mg/L. Transboundary influences include inputs from China's Beilun

River and potential pollutant transport from China's coast, but these are not well quantified.

- The open East Vietnam Sea / South China Sea (East Sea) coast: spanning central and southern Vietnam, much of this coast abuts deep water with good flushing. One important feature is the upwelling off Ninh Thuan – Binh Thuan in summer, which brings nutrient-rich deep water to the surface and can cause natural algal blooms (sometimes "red tides"). These upwelled nutrients are not pollution per se, but any anthropogenic nutrients present can amplify bloom intensity. Some harmful algae (e.g. Chattonella) have caused fish mortality in central Vietnam waters in past decades , though the linkage to pollution is still studied.
- Archipelagic waters (Hoang Sa/Paracel and Truong Sa/Spratly): Vietnam monitors waters around some features it occupies. These are far offshore and have baseline pristine quality – essentially free of land-based influence. Coral reef health in these areas is mostly impacted by climate (bleaching, storms) and potentially overfishing, rather than water pollution, as confirmed by surveys in the Spratly Islands showing good water quality but reef declines due to Crown-of-Thorns starfish and thermal stress .
- Areas of oil and gas extraction: Vietnam has offshore rigs (e.g. Bach Ho oil field). Environmental monitoring around these platforms generally finds only localized, temporary increases in hydrocarbons during drilling. There is no evidence of large-scale contamination from extraction activities, although a precautionary eye is kept on any produced water discharges.

  In terms of trends, ocean acidification is a concern for marine water quality in the long term. While specific pH trend data off Vietnam are not widely published, global models suggest a slight pH drop which could affect calcifying organisms. Vietnam's State of Environment report (2016–2020) did not highlight acidification, indicating it's not yet part of routine national assessments . Another trend is the possible rise in sea surface temperature and its effect on stratification and thus nutrient cycling in the marine waters – warmer stratified surface layers could reduce upward nutrient diffusion, potentially counteracting some runoff nutrient effects in open waters (except in strong upwelling). Overall, Vietnam's marine water quality in offshore areas remains comparatively unpolluted, and the country has a strong interest in keeping it that way for fisheries and biodiversity. That said, the health of marine waters cannot be divorced from coastal inputs – hence efforts to curb coastal pollution are essential to ensure that nearshore contamination does not radiate outward to national and regional seas.

3.2.1.3 Wastewater Pollution (Domestic and Industrial Sources)

Wastewater management is a critical environmental infrastructure gap affecting Vietnam's coastal water quality. Inadequate treatment of both domestic (municipal) and industrial wastewater means that large volumes of polluted water are released into rivers and coastal areas, carrying organic matter, nutrients, pathogens, and chemicals. Below we detail the current status of domestic and industrial wastewater management, including infrastructure coverage, pollutant profiles, and regulatory compliance, and highlight the impacts on the environment and public health.

3.2.1.3.1 Domestic Wastewater Management

Vietnam's rapid urbanization has outpaced the development of sewage and wastewater treatment systems. Nationwide, domestic wastewater generation is roughly 3 million cubic meters per day from urban areas (not counting rural discharges). However, only a small fraction of this volume is collected and treated before entering the environment.

a) Infrastructure and Coverage Status: As of 2022, the national urban wastewater treatment rate remains low – some estimated that 12.5–15% of urban domestic wastewater undergoes centralized treatment . According to the Ministry of Construction, Vietnam had 24 municipal wastewater treatment plants in operation by 2020 with a total design capacity of about 670,000 m^3/day , serving parts of major cities like Hanoi, Da Nang, and Ho Chi Minh City. By 2022, this capacity expanded modestly (around 50 plants with ~1.8 million m^3/day planned or operating) . Despite these improvements, the coverage is uneven: central districts of large cities have sewer networks, but peri-urban areas often rely on combined drainage or none at all. In smaller cities and towns, sewage is commonly diverted into canals or rivers without treatment. Rural areas (over 60% of the population) predominantly use on-site solutions like septic tanks or pit latrines; roughly 40% of rural household wastewater is collected (via simple drains) while the rest soaks into soil or waterways without centralized handling . Septic systems are prevalent in urban Vietnam as well – an estimated 90% of urban households have septic tanks, but these are often poorly maintained and many leak or discharge partially treated effluent to drains. The limited sewer infrastructure that exists is often a combined system (stormwater and sewage together) . This design, common in Hanoi and HCMC, leads to frequent overflows of untreated sewage during rainstorms. Notably, a few cities (Hue, Binh Duong New City, etc.) have begun separating sewers to improve efficiency . The Government's target under the National Urban Wastewater Program is to reach 50% treatment of urban sewage by 2030, which will require massive infrastructure investments including expansions of sewer networks and new treatment plants. Until now, funding constraints and land availability for plants have been limiting factors – many planned projects have been delayed. In summary, current domestic wastewater infrastructure is insufficient: the majority of municipal wastewater still finds its way to rivers and coast untreated, indicating a large gap to close.

b) Key Challenges and Impacts: The lack of adequate domestic wastewater treatment poses serious environmental and public health challenges. Untreated sewage introduces high loads of organic matter (measured as BOD and COD), nutrients, and pathogens into water bodies. For example, HCMC's canal networks (Tham Luong, Nhieu Loc–Thi Nghe, etc.) receive on the order of 500,000 m^3 of untreated sewage per day, resulting in black-odorous water with zero dissolved oxygen and fecal coliform counts of 10^5–10^6 MPN/100 mL in some sections . These polluted canals discharge to the Saigon–Dong Nai River system and ultimately to coastal areas (e.g. Can Gio biosphere reserve), contributing to elevated nutrient and microbe levels there. A similar situation exists for Hanoi's urban lakes and the Red River: only 20% of Hanoi's wastewater is treated, so key drainage rivers like the Nhue and To Lich are effectively open sewers with ammonia and coliform concentrations far above standards . Coastal water receiving these flows can exhibit spikes in enteric bacteria, creating bathing water risks and shellfish contamination. The impacts on public health are notable: waterborne diseases such as diarrheal illnesses, cholera, and typhoid, while much reduced from historical levels, still occur especially after flooding spreads sewage. In many coastal towns (e.g. Nha Trang, Sam Son) that attract tourists, occasional illness outbreaks or beach advisories are traced to sewage pollution. Nutrient enrichment from domestic wastewater (rich in nitrogen and phosphorus from human waste and detergents) adds to agricultural runoff in driving eutrophication. In enclosed bays with significant coastal populations (for instance, Ha Long Bay, or bays in Hai Phong), untreated domestic discharges from surrounding communities are one contributor to algal growth that can reduce water clarity and harm aesthetics. Another challenge is that domestic wastewater carries not just conventional pollutants but also household hazardous substances (like surfactants, pharmaceuticals, microplastics from laundries). These emerging pollutants pass untreated into rivers and may bioaccumulate in aquatic organisms. The cumulative environmental impact of Vietnam's domestic sewage is thus a mix of oxygen depletion, disease risk, nutrient loading, and chemical contamination – all of which degrade freshwater and coastal ecosystems and strain their capacity to provide services. Socially, poor wastewater management disproportionately affects low-income and peri-urban communities who live along polluted canals, facing unpleasant living conditions and health risks.

In summary on environmental and public health impacts, the continued discharge of largely untreated domestic wastewater in Vietnam has resulted in degraded water quality and associated health hazards in many localities. Environmentally, it has led to the loss of urban aquatic life (many city rivers/lakes cannot support fish due to pollution), contributed to coastal dead zones (though small in scale) where oxygen is depleted seasonally, and contaminated groundwater in some densely populated deltas (nitrate from septic leaching). Public health impacts include persistent incidence of waterborne diseases – the Ministry of Health still reports thousands of cases of acute diarrhea and Hepatitis A annually, with spikes after flood events in areas with poor sanitation. Furthermore, the pollution undermines cultural and recreational uses of waterways; for example, Hanoi's historical lakes have required costly cleanup to restore them for public use. From an economic perspective, polluted waterways increase water treatment costs for drinking supply and hinder aquaculture in affected estuaries (farmers cannot use polluted river water for fish culture without treatment). Summarizing, domestic wastewater mismanagement is both a key pressure on Vietnam's coastal environment and a barrier to improving public health outcomes. Addressing it will yield multiple co-benefits, which is why the government is prioritizing wastewater infrastructure in current urban development plans and seeking private sector partnerships (through the new PPP law) to finance treatment facilities . The improvements in a few cities (e.g. new plants in Da Nang have already improved coastal water coliform levels) demonstrate the potential gains from expanding sewage treatment nationwide.

3.2.1.3.2. Industrial Wastewater Management

Industrial wastewater can contain a variety of pollutants – from heavy metals and toxic chemicals to high loads of organic matter – and thus requires careful management to prevent serious environmental harm. Vietnam's expanding industrial sector has increased the volume of industrial effluents, and while regulatory oversight has improved, compliance and treatment adequacy vary widely across regions and sectors.

a) Pollutant Profile: The composition of industrial wastewater in Vietnam depends on the industry type. Key pollutants include:

- Heavy metals: Industries such as metal plating, electronics manufacturing, battery production, and mining generate wastewater containing lead (Pb), chromium (Cr), nickel, cadmium (Cd), mercury (Hg), and others . For instance, wastewater from industrial parks in Bac Ninh (electronics hub) often has elevated copper and nickel, whereas in Ho Chi Minh City's textile zones, chromium and zinc from dyes and mordants are of concern.
- Sources of organic toxins include petrochemical and plastics facilities releasing phenols, benzene, toluene, and other hydrocarbons.
- Nutrients & Organic Load: Food processing factories (seafood, sugar, etc.), breweries, pulp and paper mills, and livestock slaughterhouses release effluents high in organic matter (BOD/COD) and sometimes nutrients. For example, a seafood processing plant can have BOD values in the thousands of mg/L if untreated. Fermentation industries contribute nitrogen-rich waste (from yeast residues).
- Industrial solvents and chemicals: Wastes from pharmaceutical plants, paint factories, and garment dyeing contain various solvents (acetone, dichloromethane, etc.), dye stuffs, ammonia, and acids/alkalis. Without proper treatment, these can cause fish kills and toxicity in receiving waters.
- Thermal pollution: Not chemical, but power plants and other industries discharging cooling water can locally raise water temperatures, affecting aquatic life.

In summary, industrial wastewater in Vietnam often carries a "cocktail" of pollutants, making it more challenging to treat than domestic sewage. The exact mix at any location reflects the dominant industries present.

b) Geographic Distribution: Industrial wastewater issues are concentrated in Vietnam's key economic regions:

- The North: Around Hanoi, Bac Ninh, Hai Duong, and Hai Phong – many industrial parks line the Nhue-Day and Cau rivers. Downstream of these parks, water quality has been poor; e.g. the Nhue River often turns black with odour from combined industrial and craft village discharges, heavily polluting sections that join the Red River . The Thai Binh River system also receives loads from the steel and chemical plants in Thai Nguyen and Viet Tri.
- The Central region: Fewer large industries, but notable zones include the Chu Lai industrial area (Quang Nam) and the maritime services in Da Nang. Central coast water is less impacted except near urban centers (Da Nang's coastal water has some pollutants from the port and factories along its Han River).
- The South: The Dong Nai – Saigon river system is the recipient of wastewater from numerous industrial parks in Ho Chi Minh City, Dong Nai, Binh Duong, and Ba Ria–Vung Tau. For example, a large proportion of Vietnam's textiles, footwear, and chemical production is in this basin. The Thi Vai River in Ba Ria–Vung Tau was once a notorious case, where in 2008 a MSG factory's untreated effluent caused a 10-km stretch of river to be nearly dead (zero oxygen) . Although enforcement shut that specific discharge, other industries operate there (power plants, refineries in Phu My) requiring vigilance. In the Mekong Delta, industrial activity is more agro-based (rice mills, seafood processing) and scattered, with notable clusters around Can Tho and Long An.
- Craft villages: These are traditional handicraft production communities, often rural, but are significant point sources. Northern Vietnam has many (recycling villages for paper, plastics, metals). Wastewater from these small enterprises usually goes untreated into local ponds and rivers. Geographically, the challenge is that industrial facilities are often located along watercourses for convenient wastewater disposal, meaning pollution is directly introduced to rivers that flow to the sea. Coastal industrial zones (e.g. Dung Quat, Vung Tau) have ocean outfalls which can create localized marine pollution if treatment is insufficient.

c) Regulatory Compliance Status: Vietnam has a comprehensive legal framework for industrial wastewater discharge. Key regulations include the Law on Environmental Protection (with specific discharge standards QCVN for industrial effluent) and a requirement that all industrial zones have centralized wastewater treatment and automatic monitoring for large polluters. Compliance has been improving but still uneven:

- Industrial Parks (IPs): Most large IPs have built wastewater treatment plants (WWTPs) as mandated. As of 2020, about 90% of active IPs were reported to have some treatment facility . However, not all are properly operated. There have been cases where WWTPs were either under-capacity or even bypassed at night. The government has installed continuous wastewater monitoring at some IPs to transmit data to authorities. For example, in 2019 MAEinspected industrial parks and caught dozens violating standards by discharging effluent with high pollution levels (some had BOD exceeding limits by >5 times, or heavy metal concentrations above allowed).
- Outside IPs & Craft villages: Smaller factories outside zones and craft villages are harder to regulate. Many lack on-site treatment. Environmental police have found clandestine pipes from factories (e.g. textile dyeing in Ho Chi Minh City suburbs) that dump untreated wastewater into sewers or canals. Enforcement of regulations in these cases has improved with communities and media helping to identify polluters. Fines and suspensions are issued, but some repeat offenders consider fines a cost of business if enforcement is inconsistent.
- Transparency: In recent years, Vietnam has increased public disclosure of industrial polluters (publishing "blacklisted" facilities). This, combined with stronger community reporting rights in the 2020 law , is gradually pushing companies towards better compliance.
  In summary, while the rules exist on paper, compliance status ranges from full compliance in modern, foreign-invested factories to very poor compliance in informal or outdated operations. The overall trend is toward improvement – large incidents triggered a regulatory crackdown and greater political will to enforce rules. Still, monitoring infrastructure (like online sensors) and enforcement capacity need further enhancement, especially to cover the thousands of small-scale dischargers.

d) Critical Issues and Management Gaps: Key gaps in industrial wastewater management include:

- Insufficient treatment capacity in some industrial hubs. Even where centralized plants exist, their capacity may not match the full load if industries expand. This was observed in some older IPs where expansion outpaced infrastructure.
- Illegal bypass and dumping: Some enterprises secretly bypass treatment.
- Enforcement and penalties: Though laws allow severe penalties, in practice fines for violations have sometimes been low to deter large profitable companies. Court cases against polluters are still relatively rare, though increasing.
- Data reliability: Self-monitoring by companies can be unreliable. The push for continuous automated monitoring is addressing this, but not all significant sources are covered yet.

- Industrial cluster coverage: Many small industrial clusters and craft villages don’t have collective treatment due to cost or space. Individual small businesses often cannot afford proper treatment units.
- Emerging pollutants and pretreatment: Regulations focus on classical pollutants (BOD, standard heavy metals, etc.). But newer contaminants (e.g. pharmaceutical residues from drug factories, microplastics from textile fibers) are not specifically regulated. There’s also a gap in ensuring industries pre-treat hazardous components before sending to centralized plants – if not done, the centralized plants can be upset or discharge those contaminants.
- Emergency preparedness: A gap exists in responding to accidental discharges (chemical spills, etc.). Many local authorities lack equipment to contain toxic spills that reach waterways.
These critical issues highlight that while Vietnam has made progress (particularly after learning from serious incidents), ongoing effort is needed to strengthen the industrial wastewater management regime. Solutions under consideration or in progress include raising fines (the revised law allows much higher fines or facility closure for big violations), extending wastewater treatment requirements to craft villages (with state support for building common facilities), and enhancing inter-agency coordination so that industrial planning always includes environment infrastructure from the start.

e) Strategic Priorities: Improving industrial wastewater management is a high priority for Vietnam’s environmental authorities and features in strategic plans:

- Infrastructure Investment: The government is encouraging more investment in wastewater treatment through public-private partnerships and foreign aid. A target has been set that 100% of industrial parks must have proper wastewater treatment by 2025, and new IPs will not be approved without treatment facilities in design.
- Technological Upgrades: Adopting advanced treatment technologies (e.g. biological nutrient removal, membrane filtration) especially for high-strength or toxic wastewater. Key sectors targeted include textile dyeing (for color and toxic dye removal) and chemical manufacturing.
- Strengthened Enforcement: The 2020 Law on Environmental Protection and subsequent decrees place heavier liability on company owners for pollution. The strategy is to make compliance cheaper than non-compliance. The establishment of an environmental police force within provinces aims to increase surprise inspections. The use of citizen reporting (hotlines, mobile apps to report discharge) is also being promoted.
- Pollution charges and incentives: Vietnam is revising its environmental fee system to increase fees for wastewater discharge, particularly for those exceeding standards, to create an economic incentive to treat.

Conversely, companies that excel in waste management may get tax breaks or recognition (the “green label” program for industrial facilities).

- Zoning and relocation: Authorities are considering relocating highly polluting small industries from sensitive areas (e.g. upstream of water supply intakes or near protected wetlands) into controlled zones with treatment facilities. For example, Hanoi has ongoing projects to move craft metal plating workshops into an industrial cluster with a shared wastewater plant.
- Regional cooperation: On a transboundary level, Vietnam is engaging in dialogues with upstream countries (China, Laos, Cambodia) to manage industrial pollution in shared river basins (like the Mekong), since some pollution crosses borders. Strategically, Vietnam recognizes that controlling industrial wastewater is essential for achieving its development goals sustainably. By prioritizing infrastructure, strict enforcement, and modern compliance tools, Vietnam aims to significantly reduce the industrial pollutant load entering its rivers and coastal seas in the coming decade. Success in this arena will help protect public health, preserve aquatic ecosystems, and maintain the country’s attractiveness for investment and tourism.

3.2.1.4 Municipal Solid Waste Situation

Municipal solid waste (MSW) management in Vietnam has undergone gradual improvements but still faces systemic challenges. The “waste flow” – from generation, source handling, collection, and processing to final disposal – is characterized by gaps and inefficiencies that result in environmental pollution, including leakage of waste into waterways and coastal areas. This section breaks down the situation into sub-components, examining generation trends, the collection and handling system, recycling and recovery, disposal practices, and overall system performance.

3.2.1.4.1 Waste Generation Overview

Solid waste generation in Vietnam has been rising in line with population growth, urbanization, and economic development. As of the mid-2020s, the country generates an estimated 25 to 27 million tonnes of solid waste per year . This equates to an average per capita waste generation of about 0.7–0.8 kg/person/day, though rates vary widely. In large cities like Hanoi and Ho Chi Minh City, per capita generation is higher (0.9–1.5 kg/day) due to higher consumption and packaging use, whereas rural areas produce 0.3–0.5 kg/day per person . Notably, Vietnam’s total waste generation increased by ~46% from 2010 to 2019 , reflecting rapid growth. The composition of MSW is roughly: 45–55% organic (food and green waste), 10–15% plastics, 8–12% paper, with the remainder being glass, metal, textiles, and others . A defining trait is the high organic fraction, which has implications for treatment (compost potential) and landfill methane generation. Seasonal variations exist too – more organic waste in summer months due to high fruit consumption, and spikes in packaging waste around holidays (Tet). It’s also worth noting that official generation figures usually count collected waste; actual total generation might be higher since some waste is unmanaged or burned on site in rural areas. Urban vs rural: Urban areas contribute about 60–70% of the total MSW by volume despite having ~35% of the population. Metropolitan HCMC alone generates over 9,000 tonnes/day of waste, and Hanoi around 6,500 tonnes/day, which together form a significant share of the national total . In contrast, entire rural provinces generate just a few hundred tonnes per day each, but these smaller streams are more likely to be uncollected or disposed informally. The waste generation trajectory is expected to continue upward as Vietnam's GDP and consumption grow, which underscores the importance of having robust systems to manage the increasing volumes and to implement waste reduction strategies (the government's National Strategy on Integrated Solid Waste Management foresees waste generation peaking by 2030 with widespread waste reduction efforts). Overall, the waste generation picture is one of rapidly growing quantities and evolving composition (e.g., more plastic packaging and e-waste now than a decade ago), which pose challenges for the downstream waste management system.

3.2.1.4.2 Waste Management Flow Analysis

The journey of waste from its source to final fate in Vietnam involves multiple stages, with significant losses (leakage) and inefficiencies along the chain. Broadly, the flow can be described as:

- Generation at source: in households, markets, businesses, etc.
- Initial handling/storage: individuals may sort some materials (like cardboards sold to recyclers), but generally waste is stored unsorted in bins or bags.
- Collection (formal or informal): either by municipal collection services or informal waste pickers.
- Transportation to intermediate points: often waste is taken to transfer stations or directly to dumps/landfills.
- Processing/recovery: limited sorting, recycling, or composting occurs at certain facilities or by informal sector.
- Final disposal: majority in landfills or dumps, some incineration.

Analysing this flow:

- At source: Currently, source separation of waste is minimal. Pilot projects in Hanoi, HCMC, and Da Nang attempted requiring households to separate recyclables or organics, but compliance has been low and the program implementation has faltered due to lack of sustained enforcement and insufficient separate collection infrastructure . Thus, most waste is mixed. Households typically accumulate daily waste in plastic bags which are placed at curbside or communal bins for collection. Organic content in waste is high moisture (>70%), which often causes foul leachate in collection containers and trucks.

- Informal pre-collection: A notable aspect of Vietnam's waste flow is the role of the informal recycling sector. Thousands of freelance waste pickers and itinerant buyers roam neighborhoods to collect or buy recyclables (paper, cardboard, plastics, metal) from households or dumpsters . They recover an estimated 8–12% of generated waste for recycling before formal collection, providing an important service. For example, scavengers at the community level may remove cardboard and PET bottles, which they sell to scrap dealers, thereby diverting those from the waste stream.
- Collection (formal): Urban solid waste collection coverage is relatively high. It averages 85–90% in cities , though in peripheral or low-income areas it can be less. Collection is typically daily or every other day for households in city centers, using a variety of methods: pushcarts (small alleys), communal bins and compactor trucks on main streets, and sometimes boat collection in canal areas. In rural areas, collection services cover roughly 40–60% of waste , focusing on town centers; much rural waste is still burned or buried by generators themselves. The formal collectors are often state-owned Urban Environment Companies (URENCO) or increasingly private contractors under city contracts. A challenge in collection is narrow streets and traffic in cities, which hamper efficient truck operation, leading to reliance on manual carting to aggregation points.
- Transfer and transportation: In big cities, transfer stations receive waste from smaller vehicles and load it into larger trucks for hauling to disposal sites outside the city. For instance, Hanoi uses several transfer stations to consolidate waste before sending it ~40 km to the Nam Son landfill. Efficient transfer is necessary to reduce traffic and costs. However, odor and leachate control at these stations is sometimes an issue, causing complaints from nearby residents. Some smaller municipalities lack formal transfer stations, meaning collection trucks drive directly to dumps, which is less efficient.
- Processing and recovery: There are a limited number of facilities for sorting or composting municipal waste. A few cities have tried mechanical sorting plants (HCMC had a waste-to-energy sorting and composting plant, Da Nang has a small recycling plant). Many of these have struggled due to high contamination of waste and operational issues. Composting of organics has likewise seen pilot projects, but due to the mixed nature of waste, compost quality is poor. Only about 10–15% of municipal waste is currently recycled or composted through formal or informal means, the rest ends up disposed . Waste-to-energy (WtE) incineration is just beginning; a large WtE plant near Hanoi (Soc Son) is slated to handle 4,000 tonnes/day with energy recovery, potentially boosting processing rates. Until these come online at scale, processing remains the weak link – much potential value in waste is not recovered, and waste that could be treated (organics to compost/biogas) instead goes to dumps.

- Final disposal: Currently, the end of the line for most waste is landfill or open dumping. Vietnam has around 458 landfill sites for MSW . However, only about 121 are considered relatively sanitary (with some liners or leachate treatment); 337 sites are non-sanitary open dumps . An estimated 70-75% of collected waste is landfilled or dumped , whereas incineration without energy recovery accounts for a small fraction (~1-2%, mostly in island or isolated communities and some medical waste facilities). The reliance on landfills, many of which are nearing capacity or are poorly constructed, is a major issue. In coastal provinces, some dumps are quite close to the shoreline or in mangrove areas (e.g., many Mekong Delta provinces historically sited dumps in low coastal land). These can leak leachate to sea and also contribute plastic debris to the ocean.

In summary, the flow analysis reveals multiple points where waste “escapes” the intended path: during collection (windblown litter or overflow), via informal dumping by those not reached by services, through open dumping at non-sanitary sites, and due to limited recycling. The overall system is still transitioning from a basic collect-and-dump model to a more integrated solid waste management approach.

3.2.1.4.3 Initial Waste Management at Source

At the household and business level, initial waste management practices in Vietnam are gradually evolving but remain rudimentary in most places. Source separation – the sorting of waste into categories like organic, recyclable, hazardous – is not widely practiced, despite regulatory moves to require it. For example, a regulation effective 2025 mandates waste generators to separate recyclable waste, food waste, and other waste, with fines for non-compliance, but public awareness and infrastructure for this are still lacking. Earlier attempts in HCMC (2018) and Da Nang to pilot source separation saw initial enthusiasm but eventually stalled; reasons included lack of separate collection (mixed collection nullified household efforts) and insufficient public communication . As a result, the common behavior is to mix all household waste together. One exception is that many households do informally separate items of obvious value: for instance, selling cardboard, glass bottles, or metal scrap to itinerant buyers (ve chai) is a traditional practice in Vietnamese cities. These buyers on bicycles or motorbikes provide a small income to households for their recyclables and thus serve as an incentive for a bit of sorting. Kitchen organic waste in rural areas may be fed to pigs or chickens (hence recycled as feed), but in urban settings it’s usually discarded. Hazardous household waste (like batteries, CFL bulbs, e-waste) is rarely segregated at source; people tend to throw them in regular trash, due to limited take-back or collection programs. Some communities have started informal initiatives, e.g., neighborhood groups collecting used batteries separately or youth campaigns to collect e-waste, but these remain sporadic.

Waste storage at source is also a factor: Households typically store daily waste in plastic bags. Street-front houses set these bags out for collection, while those in alleys wait for pushcart collectors. The use of sealed bins is not yet the norm – many use open baskets or hang bags on a nail by the door, which can attract rats or stray dogs. This can lead to scattered garbage on streets if bags are torn, especially in areas with many street vendors or markets. Traditional wet markets are a particular hotspot for poor source management: large volumes of vegetable trimmings and fish waste accumulate, often dumped in nearby drains or piled at street corners, causing odor and clogging unless promptly collected.

One positive trend is growing public consciousness in some urban populations about plastic waste reduction at source. There are now community campaigns promoting reusable bags and saying “no” to single-use plastics (in Hanoi, some supermarkets have trialed banana leaves instead of plastic wrap for produce). While small in scale, they indicate initial shifts in consumer behavior that could, over time, reduce waste generation. Additionally, schools have been educating children about separating recyclables, which may gradually influence family habits.

Overall, however, the initial stage of waste management at source remains a weak link. Without systematic source separation, downstream recycling or composting becomes harder due to contamination. The government recognizes this and has integrated source separation into the new Law on Environmental Protection 2020, aiming for better implementation by assigning responsibility to local authorities and setting up pilot models in all major cities. Success will depend on sustained public education, providing separate bins, and ensuring that collection methods align. In conclusion, while there are pockets of progress, most waste in Vietnam still enters the management stream as mixed refuse, complicating later stages and contributing to inefficiency and pollution.

3.2.1.4.4 Pre-Collection Utilization and Recovery

Before formal waste collection takes place, there is an important phase where certain materials are removed from the waste stream for reuse or recycling. In Vietnam, this pre-collection recovery is largely driven by the informal sector and community practices:

- Informal recyclers: As mentioned, itinerant waste buyers and roaming scrap collectors play a crucial role. Typically, these individuals go door-to-door (especially in urban residential areas and shops) to purchase or collect items like old newspapers, cardboard, metal scraps, plastic bottles, and even used electronics. They offer small sums (for instance, 5,000–10,000 VND per kg of cardboard) which incentivizes people not to throw those items away. After collection, they bring these materials to intermediate depots (small scrapyards or warehouses often located in the city outskirts). From there, materials are bulked and sold to recycling processors. A 2018 study estimated that in Hanoi and HCMC, informal recyclers recover roughly 10–15% of total waste generated by weight , focusing on high-value streams (paper, metals, PET plastic). This reduces the burden on municipal services and provides livelihoods for thousands of urban poor. However, these activities are unregulated;

workers often operate in unsafe conditions, and not all materials they collect are handled properly (some fraction still ends up dumped if they can't sell contaminated or low-value plastics).

- Community reuse: Many Vietnamese households practice direct reuse or repurposing of items. Old clothing might be passed on to relatives or donated. Glass jars are cleaned and reused for food storage. Large durable goods like appliances are repaired rather than discarded when possible, supporting a vibrant repair market. Food waste in some cases is separated to feed animals (especially in peri-urban areas raising livestock). Leftover construction materials from home renovations are sometimes given away for other projects.
- Organic waste for animal feed or compost: In rural communities and even some urban fringe areas, organic waste (vegetable peelings, spoiled food) is collected by pig farmers or others to use as slop for pigs or compost for gardens. This traditional practice has declined in big cities due to fewer livestock, but in smaller towns it still diverts a portion of organics away from dumps. There are also enterprising collectors who gather food waste from restaurants/canteens to produce animal feed or to run worm farms, etc.
- Industrial and commercial pre-sorting: Some industries and businesses contract directly with recyclers for their waste. For example, a factory might sell its cardboard packaging waste directly to a recycling mill, bypassing municipal collection. Similarly, offices often segregate paper and arrange for it to be picked up by recycling agents. This parallel stream ensures that a lot of high-quality recyclable waste (especially from commercial sources) is captured at the source. Despite these recovery mechanisms, a considerable proportion of potentially recyclable materials still ends up in the trash due to convenience or low value. Low-value plastics (multi-layer films, dirty styrofoam, thin bags) are often not collected by informal recyclers. Some cities have community programs encouraging residents to bring recyclables to designated collection days (sometimes exchanging them for small gifts), but these are not yet widespread.

In summary, pre-collection utilization and recovery in Vietnam is significant and primarily informal. It provides environmental benefit by reducing waste to be disposed and nurturing a culture of reuse, but it is not sufficiently integrated into the formal waste management strategy. Strengthening this stage (for instance, by formalizing and supporting informal collectors, improving recycling market conditions for more materials, and expanding household awareness programs) could greatly improve overall waste management efficiency. For now, we can credit the informal sector with keeping a noticeable fraction of waste out of dumps, albeit in a haphazard manner.

3.2.1.4.5 Formal Collection Operations

Formal municipal solid waste collection in Vietnam is typically carried out by city or district public service companies or increasingly by private companies under contracts. The operations involve human labor and a fleet of vehicles, and they face logistical challenges especially in dense urban areas:

- Collection workforce: Major cities employ thousands of sanitation workers who carry out daily waste collection. They use handcarts to navigate alleys, emptying household bins or picking up bags, then transfer waste into larger trucks. These workers often start in early morning or late night to avoid traffic. They face exposure to waste and health hazards; providing protective equipment and fair labor conditions is a concern.
- Equipment and vehicles: Collection equipment ranges from basic (handcarts, tricycles) to modern (compactor garbage trucks). In city centers, compactor trucks of 5–10 tonne capacity are used to service main roads and communal container points. In narrow lanes, smaller 3-wheeled motorized carts or pushcarts are used. Hanoi and HCMC have begun to upgrade their fleets with newer trucks to reduce drips of leachate and improve fuel efficiency. Some districts have installed large sealed bins (e.g. 240L or 660L wheeled bins) at public points for people to deposit waste, which trucks can mechanically lift – but these are not everywhere. Overall, equipment shortfalls often mean waste can pile up if trucks break down or during peak holidays.
- Coverage and frequency: Urban collection coverage is high, but service frequency can vary by neighborhood. In affluent central wards, collection might be daily. In some peri-urban wards, it might be 2–3 times a week, which can lead to local dumping or burning on off-days. Rural areas often have communal collection points where waste is picked up weekly, if at all. There's an ongoing effort to extend daily collection to more areas to curb illegal dumping.
- Waste leakage during collection: A notable issue has been spillage of waste and leachate during collection and transport. It is common to see drippings from garbage trucks on roads because of high organic content and inadequate sealing . This causes foul odors and water pollution (especially when such trucks travel long distances to landfills). Some cities now require trucks to be covered and not overfilled; enforcement is gradually improving cleanliness.
- Public compliance with set-out times: Municipalities often designate times for residents to put waste out (e.g., after 7pm for nighttime collection). In practice, compliance varies. Some streets see waste dumped at all hours, which then attracts pests. Public awareness campaigns and possibly fines are used to improve compliance. For example, Da Nang has implemented fines for littering or putting waste out at the wrong time.
- Integration with street sweeping: In many Vietnamese cities, the same urban environment companies handle street sweeping and drain cleaning. Swept debris (leaves, dust) and dredged silt from drains also

enter the solid waste stream. These operations help prevent litter from entering waterways, but the collected silt can be hazardous (with oil, heavy metals). Handling and disposing of street sweepings is part of the overall challenge.

- Financial and institutional aspects: Waste collection is funded through various channels: there are modest waste fees collected from households (often via electricity bills or local ward collection), but these cover only part of the cost. City budgets subsidize the rest. The push for private sector participation aims to improve efficiency; in some cities, multiple companies might be responsible for different zones. Coordination and maintaining service standards can be an issue in such cases.
  In summary, formal waste collection in Vietnam is extensive but stressed by growing volumes, constrained infrastructure, and human factors. Most cities manage to avoid accumulation of uncollected waste on a routine basis (aside from occasional service disruptions, such as when landfills protest and block incoming waste, leading to temporary city pileups). However, the quality and environmental safety of collection operations need improvement – newer closed trucks, better route planning, and more frequent service in underserved areas are key needs identified. Encouragingly, government investments (often with development aid support) have been directed at upgrading waste collection and transfer facilities in recent years, which should gradually modernize this fundamental step in the waste management chain.

3.2.1.4.6 Post-Collection Recovery and Processing

After waste is collected, there are limited but evolving measures in Vietnam to recover materials or treat waste before final disposal. Historically, collected waste went directly to dumpsites with minimal processing. In recent years, attention has grown on material recovery facilities (MRFs), composting plants, and waste-to-energy initiatives:

- Recycling facilities: Some cities have small sorting facilities where mixed waste is screened for recyclables. For example, Ho Chi Minh City’s Tam Sinh Nghia plant (prior to its upgrade to a WtE incinerator) used a mechanical-biological treatment process: waste was put through conveyors where workers and machines picked out plastics, metals, etc., and the organics were composted. However, the efficiency was low due to heavily contaminated inputs. The recovered recyclables from such plants are often of poor quality and fetch low prices, limiting economic viability. A few private sector recycling parks exist, focusing on specific streams (e.g., a plant in Hai Duong that recycles plastic film into pellets). Overall, formal recycling of post-collection mixed waste is very small, perhaps only a few percent of total waste. Most recycling in Vietnam still originates from the informal pre-collection stage or direct industrial scrap.

- Composting: Vietnam’s waste’s high organic fraction makes composting an attractive idea. Several municipal composting plants have been built (Can Tho, Ben Tre, Hanoi’s Cau Dien in the past, etc.). Many have struggled with operational issues: the incoming waste often contains glass, plastic, and heavy metals, yielding low-grade compost that farmers are reluctant to use. Some plants have closed or operate below capacity for these reasons. One successful example is a smaller-scale composting program in Da Lat city (a vegetable-farming region) where source-separated market waste is composted into fertilizer that is accepted by local farmers. This highlights that quality of feedstock is crucial. As of 2020, less than 5% of Vietnam’s MSW was composted into usable product . There is potential for expansion if source separation of organics can be implemented in markets, hotels, etc.
- Anaerobic digestion: Currently not much used for MSW in Vietnam, though biogas is common on farms. Future plans may consider anaerobic digestion of organic municipal waste to produce biogas energy and a digestate fertilizer; this approach could be integrated into waste-to-energy projects.
- Waste-to-Energy (Incineration): Vietnam is starting to invest in WtE plants to both reduce landfill volume and generate electricity. As of 2022, a major WtE plant by Thien Y company in Hanoi (Soc Son) is in commissioning, aiming to burn 4,000 tonnes/day and generate ~75 MW. HCMC also tendered WtE projects, converting some existing landfill operations into incinerators. These plants will use moving-grate incineration technology designed to handle unsorted waste with high moisture (often supplemented by adding dry waste or auxiliary fuel to maintain calorific value). If they run successfully, they can significantly reduce the amount of waste going to landfills (incineration can cut volume by ~90%). However, challenges include high capital and operating costs, managing air emissions (meeting standards for dioxins, particulates), and ash disposal (fly ash being hazardous). At present, only a couple of smaller WtE facilities are operational (e.g., a 75 tonnes/day plant in Can Tho opened in 2018). The next 5–10 years will be telling as large facilities ramp up.
- Medical and Hazardous waste processing: Vietnam has specialized incinerators for medical waste in most provinces now, and some hazardous waste treatment centers (e.g., Vietstar and URENCO facilities) that handle industry waste with methods like cement kiln co-processing. This indirectly benefits MSW management by reducing dangerous materials entering the MSW stream. Still, household hazardous waste (batteries, chemicals) often go into MSW untreated.
- Informal sector at landfills: Even after collection, informal pickers operate at many dumps and landfills, scavenging for recyclables before final burial. At sites like HCMC’s previous dumps or Hanoi’s Nam Son, hundreds of workers recovered plastics, metals, etc., from incoming

waste piles. This is dangerous work with health risks, and authorities have at times tried to restrict access for safety. With new WtE plants, such scavenging might diminish since waste will be immediately incinerated. But at conventional landfills it still accounts for some recycling (and provides livelihood to waste-pickers).
In summary, post-collection recovery in Vietnam is currently limited and not yet optimized. A large majority of collected waste still goes to final disposal without significant material or energy recovery. However, the ongoing investments in composting and waste-to-energy signal a shift in strategy. If these facilities are effectively operated and combined with improved waste segregation, Vietnam could see a jump in the proportion of waste that is recycled or converted to energy, thus reducing environmental pressures from landfills. It is a sector in transition: moving from essentially zero processing two decades ago to gradually building an integrated system that aims for the goals of the national solid waste strategy (which include 85% of urban organic waste to be reused/composted by 2025, and 60% of plastic waste recycled). Achieving those goals will require overcoming the present technical and management hurdles in post-collection waste processing.

3.2.1.4.7 Final Disposal Requirements

Final disposal of municipal solid waste in Vietnam predominantly means landfilling. Ensuring that disposal sites meet environmental requirements has been a persistent issue. Quality of landfills: Out of 458 known dumping sites, only about 20–25 could be considered sanitary landfills by international standards (lined with leachate collection, gas management) . The rest are open dumps or minimally engineered landfills. Government standards (TCVN) call for new landfills to have bottom liners (clay or geomembrane), leachate treatment systems, daily cover of waste with soil, and systems to collect biogas, but many older sites do not comply. Some critical deficiencies:

- Lack of lining: Many dumps (especially those established pre-2000) were just pits or depressions filled with waste. For instance, in the Mekong Delta, some landfills were simply low-lying fields where waste was dumped, allowing contamination of groundwater and adjoining canals. As a result, monitoring by MAEhas found elevated pollutants (ammonia, COD, heavy metals) in water around such sites .
- Leachate management: Even at the main sanitary landfills like Hanoi's Nam Son or HCMC's Da Phuoc, leachate volume is a big challenge due to high rainfall and high organic content. Often leachate ponds overflow in heavy rain. Treatment plants for leachate (which is a toxic mix of ammonia, organics, etc.) sometimes operate below capacity. In smaller dumps with no treatment, leachate simply percolates or flows out. This has led to contaminant plumes – e.g., around the Da Phuoc site in HCMC, nearby river water has shown increased ammonia and coliform, indicating leachate impact.

- Gas emissions: Open dumps emit uncontrolled methane and unpleasant odors (H_2S, etc.). Frequent fires occur as methane ignites or waste is openly burned to reduce volume. Residents near dumps frequently complain of smoke and smell. Sanitary landfills are supposed to capture gas – some do (Hanoi has trialed flaring systems and even a small power generation from landfill gas at Nam Son Phase I). But elsewhere, gas is not managed.
- Vectors and aesthetics: Most dumps do not fully apply daily cover, so waste is exposed, attracting flies, rats, and stray animals. Windblown litter escapes landfill boundaries, causing trash to scatter into surrounding areas or water bodies. This is commonly seen at coastal dumps where plastic bags end up in mangroves or on beaches nearby.
- Capacity and closure: Many landfills have exceeded their design capacity. For example, Hanoi's Nam Son landfill was designed with multiple phases but parts have filled ahead of schedule, leading to emergency measures like height extensions. Some older dumps (like Hanoi's Cau Dien dump) were closed only after massive accumulations and then had to be remediated. Closing a dump is itself a challenge – ideally it should be capped with impermeable layers and vegetation to prevent infiltration and emissions. A few sites have been properly closed and converted (e.g., Hanoi's 1990s dump in Thanh Tri was closed and partly turned into a park), but many closed dumps still pose pollution risks due to inadequate closure practices.
- Special waste in landfills: Household hazardous waste and even some industrial hazardous waste sometimes end up in MSW landfills. Since only about 70% of hazardous waste is formally treated , the rest may get co-disposed. The dumps generally are not designed for such waste, raising concerns about long-term contamination (heavy metals, etc. entering leachate).
  To address these issues, Vietnam's regulations require new facilities to meet certain disposal quality criteria, and periodic monitoring of groundwater around landfills is mandated. The National Strategy for Environmental Protection sets a goal to upgrade or close substandard dumps. Some progress has been made – for example, provincial programs have shut down dozens of small rural dumps and redirected waste to larger regional landfills where some management is possible. But enforcement is inconsistent, partly due to costs (sanitary landfills are expensive, and smaller provinces lack budget).

Environmental assessment of landfills: Studies of soil and water near big landfills show contamination zones extending a few kilometers. For instance, one multi-year study found heavy metal buildup in soils and rice paddy near Hanoi's Nam Son landfill, likely from irrigation water contamination . Another found that groundwater down-gradient of HCMC's Go Cat (now closed) had high COD and ammonia. These illustrate the need for strict landfill controls.

In conclusion, the critical assessment of Vietnam's waste disposal system is that it remains the weak link in waste management. Quality sanitary landfills are too few, and even those face operational issues. The prevalence of unsanitary dumps represents an ongoing risk to surface and groundwater quality and marine environments (via leachate and litter). Addressing this is urgent – either by upgrading dumps to sanitary status with liners and leachate treatment, or by replacing them through waste reduction and new treatment technologies like WtE. The government has indeed prioritized phasing out open dumps: targets include closing 100% of unsanitary landfills in urban areas by 2025 . Reaching that will require substantial investments and improvements in local enforcement of landfill standards, but it is a key step to mitigating one of the largest direct pollution sources in the solid waste sector.

3.2.1.4.8. Critical Assessment of Waste Management System

Evaluating Vietnam's overall municipal waste management system reveals significant strengths, weaknesses, opportunities, and threats:

- Strengths: High collection coverage in urban areas means most city waste is at least being gathered, preventing the worst of urban refuse accumulation. The informal recycling sector provides a foundation of resource recovery (Vietnam achieves a notable recycling rate for certain materials like paper and metal through this sector). There is growing political will and public awareness to improve waste management, evidenced by new laws requiring source separation and circular economy plans . Pilot successes (like small-scale composting and community recycling programs) demonstrate the feasibility of improved practices in Vietnamese context. International support and investment are flowing into modern waste treatment (e.g., JICA and World Bank projects on solid waste).
- Weaknesses: The system still largely relies on landfilling, with 73–75% of waste landfilled, much in substandard sites . Infrastructure lags behind needs – insufficient sanitary landfill capacity, very few waste-to-energy plants operational, and limited formal recycling facilities. Funding is another weakness: waste fees collected cover only a portion of O&M costs, leading to chronic underfunding of waste services (workers often underpaid, equipment not optimally maintained). Institutional fragmentation exists, where different aspects of waste are handled by different agencies (MAEfor policy, Construction Ministry for urban waste planning, city Public Works departments for operations), sometimes resulting in coordination gaps. Enforcement of regulations like anti-dumping laws is inconsistent across regions.
- Opportunities: Vietnam's commitment to a "circular economy" (Decision 687/QD-TTg) opens policy space for innovations in recycling and waste reduction. There is considerable low-hanging fruit: for example, even modest improvements in source separation could dramatically boost recycling of plastics and organics. The youth population is quite engaged

on environmental issues nowadays, which could be harnessed in public campaigns and volunteer clean-up or recycling initiatives. Technological leapfrogging is possible – Vietnam can adopt proven waste-to-energy tech and modern composting without needing to go through decades of incremental steps. Additionally, private sector involvement (both domestic firms and foreign investors) in waste treatment is increasing because waste is now seen as a resource (energy, materials); this can bring much-needed capital and expertise.

- Threats: The waste problem is escalating with consumption trends – if nothing changes, by 2030 Vietnam could generate well over 35 million tonnes/year of MSW, straining any system. Marine plastic pollution tarnishes Vietnam's international image and could hurt tourism and fisheries if not curtailed – continued leakage of waste to rivers is an environmental threat. Social opposition to waste facilities has emerged: for instance, residents near the Nam Son landfill have periodically blocked garbage trucks in protest of odors and pollution, causing city waste crises. This NIMBY (Not In My BackYard) factor means new landfills or incinerators face public acceptance challenges; indeed, Hanoi has struggled to site a new landfill because of community pushback. Another threat is climate change: more intense rainfall can cause landfill failures or flooded waste dumps (as seen in 2020 central Vietnam floods where waste washed out), compounding pollution.
In critical summary, Vietnam's MSW management is at a crossroads. The traditional model of "collect and dump" is no longer tenable due to environmental impacts and lack of space for new dumps. The system's weaknesses have led to visible problems like polluted waterways, plastic litter, and overflowing landfills, which society and government now recognize as urgent issues. However, the emerging strengths and opportunities – policy reforms, public awareness, and new investments – provide a pathway to overcome these weaknesses. The transition to a modern, sustainable waste management system will require addressing the gaps in infrastructure, financing, and governance identified above. If Vietnam can capitalize on opportunities (like implementing EPR for packaging , scaling up recycling industries, and engaging communities in waste reduction), it can turn the corner on waste pollution. This critical juncture is perhaps best encapsulated by the stark statistic that 85% of waste is currently buried without treatment – a figure the country is determined to reduce drastically in the coming decade through concerted improvements across the board.

3.2.1.5 Hazardous Waste

Hazardous waste management is an increasingly important component of Vietnam's pollution control efforts. Hazardous wastes are generated from various sources – industry, healthcare, agriculture, and households – and contain substances that are toxic, flammable, infectious, or otherwise dangerous to human health and the environment. Managing these wastes properly is critical to prevent soil, water, and air contamination. Vietnam has put in place strong regulations to identify and handle hazardous wastes, but practical implementation still faces challenges.

3.2.1.5.1 Hazardous Waste Categories

Key categories of hazardous waste in Vietnam include:

- Industrial hazardous waste: This is the largest category by volume. It comes from manufacturing processes (chemicals, electronics, metal plating, textiles, etc.) and contains heavy metals, solvents, waste oils, acidic/alkaline sludges, and other toxic by-products. For example, electroplating factories produce sludge rich in chromium and cyanide, and electronics assembly yields waste with lead and brominated compounds. The Ministry of Industry and Trade estimates industrial hazardous waste at >400,000 tonnes per year nationally, much of which arises in industrial zones in the greater Hanoi and HCMC regions .
- Medical and infectious waste: Hospitals, clinics, and laboratories generate infectious wastes (bandages, sharps, biological samples) as well as hazardous chemical waste (mercury from thermometers, outdated drugs, etc.). Vietnam's rapidly expanding healthcare sector – over 13,500 medical facilities nationwide – produces ~47 tonnes of medical hazardous waste and 125,000 m^3 of wastewater per day . Infectious waste requires special handling to prevent disease transmission.
- Electronic waste (e-waste): With increasing consumer use of electronics, e-waste is a growing category. Discarded computers, phones, appliances contain heavy metals (lead, cadmium), rare earths, and persistent organics (like PCB capacitors in older equipment). While no precise figures are given, the volume is significant; for example, some informal recycling craft villages (e.g. in Bac Ninh) handle thousands of tonnes of imported e-waste annually, exposing workers and the environment to hazards .
- Household hazardous waste: This includes items like batteries, fluorescent bulbs (contain mercury), expired chemicals (pesticides, cleaning agents), and paint or solvent containers. Individually these are small, but collectively they form a hazardous stream that often ends up mixed with regular trash due to limited separate collection. Rough estimates suggest households generate a few kilograms of hazardous waste per capita annually (including batteries, bulbs, etc.).
- Agricultural hazardous waste: The use of agrochemicals results in hazardous wastes such as leftover or banned pesticides, empty pesticide containers, and veterinary medicine waste. Vietnam uses large amounts of pesticides (over 100,000 tons/year as noted), and the disposal of their packaging is a problem – many end up discarded in fields or canals. Also, livestock farms produce veterinary waste (needles, expired drugs) that

require careful disposal to avoid antibiotic resistance proliferation. In recognition of these categories, Vietnam has a listing of hazardous waste types in Circular 36/2015 by MONRE (now MAE), which categorizes wastes and provides codes for tracking.

3.2.1.5.2 Hazardous Waste Content

The hazardous content of these wastes includes:

- Heavy metals: Common ones are lead (Pb), mercury (Hg), cadmium (Cd), chromium (Cr), and arsenic (As). These are found in batteries (Pb, Cd), fluorescent lamps (Hg), thermometers (Hg), e-waste (Pb in CRT glass, Cd in semiconductors), plating sludges (Cr, Cd), etc. If released, they can contaminate soil and water, bioaccumulate in the food chain, and cause health issues like neurological damage or cancer.
- Persistent Organic Pollutants (POPs): These are toxic chemicals that persist in the environment and bioaccumulate. Vietnam's history with Agent Orange during the war also left dioxin hotspots, which are remediated. POPs are a priority because of long-term ecosystem and health impacts (e.g., endocrine disruption, cancer).
- Industrial solvents and by-products: These include things like benzene, toluene, methylene chloride, etc. from chemical and pharmaceutical manufacturing, and by-products such as phenolic tars or resin wastes. They are often flammable, volatile (contributing to air pollution if not controlled), and toxic to aquatic life if dumped.
- Medical and pharmaceutical waste: Content includes not just infectious agents (pathogens) but also drugs like antibiotics, cytotoxic cancer drugs, and disinfectants. If these enter waterways untreated, they can foster antibiotic-resistant bacteria or harm wildlife (e.g., hormone drugs causing fish endocrine issues).
- Other: Used lubricating oils (from vehicles, machinery) are hazardous due to PAHs and heavy metals; asbestos waste from construction (asbestos is still used in roofing sheets widely, those waste contain carcinogenic fibers); and explosives or radioactive waste (small amounts from industry or medical equipment) also fall under hazardous content categories.
  The combination of these hazardous contents means that any mismanagement can lead to serious contamination. For example, heavy metals and POPs have been found in alarming levels around informal recycling villages: a study in a craft village that recycles e-waste found lead in surface water at 10 times the standard, and high POP concentrations in the soil .

3.2.1.5.3 Management Challenges

Vietnam faces multiple challenges in hazardous waste management:

- Collection and segregation: Ensuring hazardous wastes are separated from general waste at the source is difficult. Many businesses, especially small ones, do not properly segregate or register their hazardous wastes. Households almost never separate their hazardous items due to lack of awareness and dedicated bins. Thus, a lot of hazardous waste ends up in landfills or informal dumps (e.g., pesticide containers tossed in fields, or used batteries thrown in household trash).
- Treatment and disposal capacity: While there are licensed hazardous waste treatment companies (e.g., URENCO's hazardous waste facility near Hanoi, or Vietstar in the south), their capacity is limited relative to the total hazardous waste generated. For example, the Ministry of Natural Resources and Environment (now- MAE) reported that only about 70% of known industrial hazardous waste was being collected and treated properly as of 2020 . The rest likely goes untreated or is stored on site indefinitely. Incinerators for medical waste exist in most provinces, but not all operate efficiently (some small hospital incinerators have had emissions issues, releasing dioxins due to low combustion temperature). Secure landfills for hazardous waste are few – some hazardous waste gets stabilized and disposed in dedicated cells at large landfills, but many provinces lack such facilities.
- Illegal dumping and improper recycling: The value of certain hazardous wastes (like e-waste or used oil) encourages informal recycling under unsafe conditions. E-waste is often dismantled in backyards, with open burning of wires to recover copper, acid leaching of circuit boards for gold, etc., releasing pollutants . Similarly, used lead-acid batteries are broken to recover lead in informal smelters. Illegal dumping incidents have occurred – for instance, hazardous industrial sludges being trucked out at night and dumped into rivers or fields to avoid disposal fees. Such incidents periodically make news and enforcement actions.
- Regulatory enforcement and tracking: Vietnam has regulations requiring hazardous waste generators to register and only use licensed handlers, and manifest systems to track waste movement. However, enforcement is uneven. Some companies under-report their hazardous waste generation to save on treatment costs. The environmental police have caught companies mixing hazardous waste with regular waste to evade higher fees. The monitoring of thousands of small sources (e.g., small clinics generating infectious waste, or many agrochemical users) is very challenging for authorities.
- Legacy contamination: Past improper disposal has left contamination that is costly to clean. Old industrial sites sometimes have contaminated soil that requires remediation before reuse. Managing these "historical" hazardous wastes is another challenge with limited resources.
- Public and occupational safety: There is a challenge to ensure the safety of workers handling hazardous waste (informal recyclers often work

without protection, getting exposed to toxins). Additionally, communities near treatment or disposal sites worry about pollution – e.g., proposals to build hazardous waste landfills often meet local resistance due to fear of leaks.

Addressing these challenges requires strengthening the entire chain: from generator responsibility (e.g., through Extended Producer Responsibility for things like e-waste and pesticide packaging), to collection networks (special bins for batteries in cities, take-back programs), to expanding treatment infrastructure and strict law enforcement against violators. Vietnam's updated environmental law in 2020 and a new decree in 2022 on solid waste provide a framework for improvement . Notably, the country has also engaged in international programs, which have built some capacity for hazardous waste handling. In conclusion, while progress is being made (most large hospitals now autoclave or incinerate infectious waste, and large industries contract licensed waste firms), hazardous waste management remains an area requiring further strengthening to prevent insidious pollution that could undermine public health and environmental quality.

3.2.1.6 Aquaculture Pollution

Aquaculture, particularly coastal aquaculture, is a major economic sector for Vietnam but also a source of localized pollution and environmental impact. Vietnam is one of the world's top aquaculture producers (especially for shrimp and fish), with intensive farming systems that can contribute to water pollution if not managed sustainably. Key pollution issues from aquaculture include nutrient and organic waste loading, chemical use, and habitat modification.

3.2.1.6.1 Coastal Shrimp Farming

Shrimp farming (notably of species like black tiger shrimp Penaeus monodon and white-leg shrimp Litopenaeus vannamei) is extensive in Vietnam's coastal provinces, from the Mekong Delta in the south to some central provinces. Coastal shrimp ponds often occupy intertidal areas, including what were once mangrove forests. In the Mekong Delta alone, roughly 700,000 hectares are under shrimp farming (mix of extensive, improved extensive, and intensive systems) . Pollution issues from shrimp farming stem from:

- Pond effluent: Ponds are periodically drained, especially after harvest, releasing water rich in organic matter (uneaten feed, shrimp feces, plankton) and nutrients (nitrogen, phosphorus) into canals and creeks that lead to estuaries. Intensive shrimp ponds, with feed inputs of 20–30 tons per ha per crop, can generate effluent with very high biochemical oxygen demand (BOD) and suspended solids. This can cause oxygen depletion in receiving waters, leading to fish kills or stress on wild aquatic organisms.
- Sedimentation: Over a crop, sludge accumulates in ponds from feces and algal debris. Farmers often clean ponds by discharging this sludge into

the environment. This sludge can smother benthic life and release nutrients and sulfides.

- Salinization: In some areas, water from shrimp ponds (saline) leaks or is discharged into freshwater environments or agricultural lands, causing secondary salinization of soil and water. This has been an issue in the Mekong delta where shrimp expansion inland has salinized adjacent rice fields.
- Habitat loss: Although not “pollution” in a chemical sense, the conversion of mangroves to shrimp ponds removes the natural water filtration that mangroves provided and leads to erosion and release of carbon stored in those soils. Vietnam has lost a significant portion of its mangroves historically to aquaculture (though mangrove replanting and mixed mangrove-shrimp farming models are now being promoted to mitigate this).
  Shrimp farming is thus a major non-point pollution source in certain coastal water bodies. Studies have shown elevated nutrients and organic content in water around shrimp farming clusters. For example, canals in Ca Mau’s shrimp areas often have high ammonia and low dissolved oxygen, particularly during pond discharge events.

3.2.1.6.2 Organic Loading from Feed Waste

Aquaculture practices, especially intensive ones, involve heavy feeding of formulated feeds or raw feeds, and not all of that is consumed by the cultured animals. The feed conversion ratio (FCR) in many Vietnamese farms can be around 1.2–1.5 for shrimp (meaning 1.2–1.5 kg feed per 1 kg shrimp produced) , but can be higher in practice if feed management is poor. Uneaten feed and feces contribute to organic pollution:

- BOD/COD in effluent: As feed wastes degrade, they drive up biological and chemical oxygen demand in water. High BOD can cause hypoxic conditions in pond outflows and receiving waters, stressing or killing aquatic organisms. Fish and shrimp farms that flush water with high organic loads have been known to cause oxygen sag in small rivers or creeks.
- Eutrophication: The breakdown of feed releases nutrients (N, P). Excess phosphorus from fish feeds can trigger algal blooms in closed water bodies. For instance, some coastal lagoons in central Vietnam (where cage fish farming exists) have experienced algal blooms due to nutrient build-up from fish feed.
- Sedimentation of organics: In static pond systems, organic sludge settles. If not managed, this leads to pond bottom anoxia (black, sulphide-rich mud) which can generate toxic gases (H_2S) that harm the cultured stock and, when discharged, harm outside ecosystems. Many shrimp farmers in the Mekong simply let sludge out into mangrove creeks, leading to black, anoxic mud banks near sluice gates.

The organic loading issue is partly addressed by technologies like feeding trays to minimize waste, probiotics to help degrade waste in situ, and periodic sludge removal to treatment ponds. However, adoption of these practices is not universal due to cost and knowledge gaps.

3.2.1.6.3 Chemical Use Patterns

Aquaculture relies on various chemicals for pond preparation, disease control, and water quality management. Common chemicals and their pollution implications:

- Fertilizers (urea, superphosphate): Used in extensive ponds to fertilize water for natural food. These add nutrients (N, P), potentially contributing to eutrophication if flushed out.
- Lime ($CaO/Ca(OH)_2$): Applied to adjust pH and disinfect pond bottoms. It can raise pH and alkalinity of effluent; typically lime is benign but overuse can alter receiving water pH.
- Chlorine (Calcium hypochlorite): Widely used to disinfect water before stocking shrimp. Residual chlorine can be toxic to aquatic life if large volumes of chlorinated water are discharged without neutralization.
- Antibiotics and other drugs: Shrimp and fish farmers have used antibiotics (oxytetracycline, enrofloxacin, etc.) to treat bacterial diseases, despite restrictions. These can accumulate in sediment and the environment. Antibiotic residues in effluent can promote antibiotic-resistant bacteria in the ecosystem . Other compounds include anti-parasitics (formalin, trifluralin historically in shrimp), which can also have toxic effects on non-target species.
- Pesticides: Occasionally, pesticides (like organophosphates or teasap for killing pond pests) are used to eliminate predators or unwanted species in ponds. If released, these can kill wild fish/invertebrates outside the pond. There were instances of fish kills in Vietnam linked to ponds releasing water treated with potent pesticides.
- Probiotics and enzymes: These are increasingly used as an eco-friendlier alternative to chemicals, aiming to improve water quality by enhancing decomposition. They generally have benign effects, but their efficacy varies.
  Vietnam has regulations banning harmful chemicals in aquaculture (e.g., Malachite Green, certain antibiotics), and extension programs encourage judicious use. However, enforcement at farm level is difficult.

The spatial pattern of chemical use pollution tends to align with intense farming zones. For example, areas of the Mekong Delta with dense shrimp farms have detected antibiotic residues in adjacent canals, and labs have found multi-drug-resistant bacteria in those waters, suggesting antibiotic overuse.

3.2.1.6.4 Pond Discharge Impacts

The cumulative impact of many farms discharging effluent around the same time can significantly degrade local water quality. Consider:

- Disease-driven discharge: During disease outbreaks (like shrimp white spot disease), farmers often dump water to save whatever crop remains. This can release huge loads of virus-laden and organic-rich water all at once. Such releases can spread pathogens to wild crustaceans and other farms downstream, and cause acute oxygen drops. Coastal waters near intensive shrimp areas have shown higher prevalence of shrimp pathogens even among wild populations, linking to farm discharge.
- Seasonal water exchange: Many farms do a water exchange or harvest drain at end of dry season, which in aggregate can flush estuaries with effluent. Reports from e.g. Ninh Thuan's shrimp farming area note that at harvest time, nearshore waters become turbid and foul-smelling due to the mass release of pond water.
- Sediment plumes: Discharged pond water, especially if containing sludge, can create visible sediment plumes in receiving waters. In some delta creeks, layers of black sediment can be seen blanketing creek beds where farmers routinely release sludge, altering those micro-habitats drastically.
- Mangrove health: In integrated mangrove-shrimp systems, moderate waste can be absorbed by mangroves, but if overloaded, it can harm mangroves. There have been observations in Ca Mau that mangroves closest to sluice gates (where waste exits ponds) exhibit poorer growth or die-off, likely from too much organic deposition and perhaps sulphide buildup from decaying matter.
  It should be noted that not all aquaculture is equally polluting: intensive systems (small ponds, heavy feeding) are the main contributors, whereas traditional extensive systems (large ponds, no feeding, rely on tidal exchange) have lower inputs but can still cause mangrove loss and altered salinity regimes. The push now is to implement better management practices (BMPs) in aquaculture – such as settling ponds for effluent, not discharging during low tide (to maximize dilution), and coordinated water exchange schedules to avoid all farmers discharging at once. Some areas have set up common wastewater treatment canals for clusters of farms, but coverage is limited.

In conclusion, aquaculture has both benefits and environmental costs. It has alleviated fishing pressure by producing fish/shrimp, but the way it's managed can lead to significant local pollution and ecosystem changes. Vietnam's challenge is to maintain its aquaculture productivity while reducing these impacts through improved farm design, regulation of chemical use, and treatment of effluents – efforts that are increasingly part of national agricultural and coastal management plans.

3.2.1.7 Industrial Waste

Industrial solid waste – distinct from industrial hazardous waste – encompasses the non-hazardous by-products of manufacturing, construction, and other industrial processes. This includes materials like packaging, scrap materials (wood, metal, plastics) that are not contaminated with hazardous substances, as well as factory office waste, etc. Efficient management of industrial waste is key for resource recovery and minimizing the burden on municipal waste systems.

3.2.1.7.1. Industrial Waste Composition and Quantities

Vietnam's rapid industrialization has led to a sharp increase in industrial solid waste (ISW) generation. According to estimates by MAE, industrial solid waste (excluding mining waste) was over 7 million tonnes per year by 2020. Key components of industrial waste include:

- Inert materials: like cinder, slag, ash from manufacturing (e.g., coal ash from power plants, which in 2019 was about 12 million tonnes nationwide – though this is sometimes categorized separately as industrial by-product) . Also, concrete rubble from construction/demolition, which has grown with urban redevelopment projects.
- Scrap metals: Steel offcuts from metalworking, turnings from machining, etc. Much of this is recycled; Vietnam has an active scrap metal market, including imports for steel mills. So while generated as waste, scrap metal often doesn't reach disposal but goes to recyclers.
- Waste plastics, paper, and cardboard: Factories (especially in packaging, consumer goods) produce substantial scrap plastic and paper. E.g., packaging factories might have offcuts, defective products. Many of these are also recycled via commercial channels.
- Organics: Food/beverage industries produce organic wastes (spent grains, fruit peels, etc.) which may be used as animal feed or compost. Wood processing industries generate sawdust and offcuts.
- Textile clippings and leather scraps: From garment and shoe manufacturing – some are reused (shoddy cloth, etc.), others disposed.
- General trash: Like broken pallets, crates, office waste from factory sites, etc.

  The composition varies greatly by industry: a shipyard produces scrap metal and sandblasting grit; a pharmaceutical plant produces lots of packaging waste; an electronics factory has plastic reels and cardboard spools, etc. On average, a significant portion of industrial "waste" has residual value, leading to a fairly high recycling rate in this segment – likely higher than for MSW. For example, over 70% of paper and cardboard waste in Vietnam gets recycled, much of it coming from industrial/commercial sources . Similarly, valuable plastics (like PET, HDPE) and metals are recovered.

  Regional generation: The majority of ISW comes from the major industrial regions – around HCMC and the Southeast (the southern key economic zone) and around Hanoi and Hai Phong (northern key economic zone). These areas have dense industrial parks and output.

3.2.1.7.2 Industrial Waste Management in Vietnam

Industrial waste management is partly integrated into municipal systems and partly handled through private sector recycling and disposal:

- Within industrial parks (IPs): Many IPs have set up waste collection services for their tenant factories. These often contract with private waste management companies. Non-hazardous wastes like packaging and organics are typically collected and either recycled or sent to local landfills if no recycle value. Some IPs encourage recycling by segregating waste at source (e.g., separate bins for recyclables).
- Recycling and reusing: A lot of industrial waste is sold to recyclers. For instance, textile scraps are sold to companies making rags or padding; plastic scraps go to plastic recyclers (Vietnam has many plastic recycling villages and formal plants). Metal scrap is a commodity. So the market drives a significant portion away from disposal. In 2018, trade.gov reported that 73.5% of solid waste nationally (including industrial) is landfilled or dumped – implying ~26.5% is recovered; the recovery rate is likely higher for industrial subset because of value.
- On-site management: Some large industries treat their own waste: e.g., sugar mills often use bagasse (sugarcane fiber waste) as fuel; cement plants may use certain industrial wastes (slags, fly ash) as raw material or fuel (co-processing).
- Construction & demolition (C&D) waste: This is a growing industrial waste stream. In big cities, it's partly reused (crushed for base material) but also much ends up illegally dumped on city outskirts because formal systems aren't well developed. Piles of construction rubble in peri-urban areas are a common sight.
- Data and monitoring: Up to recently, comprehensive data on industrial solid waste was lacking, as companies only reported hazardous waste. The new regulations require better reporting. Implementation of Extended Producer Responsibility (EPR) for packaging and products under the revised LEP may also indirectly improve industrial waste recycling because producers will have targets to use recycled content, etc. .
- Services and infrastructure: Most non-hazardous industrial waste ultimately goes to the same landfills as municipal waste if not recycled. Cities like HCMC and Hanoi accept industrial waste at their landfills for a fee. Some provinces have dedicated areas for industrial waste in their landfills. However, because of higher fees for industrial waste disposal, some smaller generators might try to mix it with municipal waste to save cost (e.g., paying residential rates).

- One challenge in industrial waste management is small craft or scattered industries not in IPs: e.g., craft villages or small workshops. They may not have formal waste services and might dump or burn wastes, causing local pollution (e.g., plastic recycling villages often burn unrecyclable plastics, releasing toxins). Integrating these into formal systems is needed.

3.2.1.7.3 Hotspots and Regional Data

"Hotspots" for industrial waste issues are areas with high industrial concentration and insufficient waste management facilities:

- Craft villages in the Red River Delta: As earlier mentioned, places like the plastic recycling village of Minh Khai (Hung Yen) have significant waste spillage – waterways clogged with plastic debris, open burning practice . Metal recycling villages (e.g., Da Hoi in Bac Ninh) have heaps of coal slag and metal slag around, which leach into fields. These localized sites have visible environmental degradation.
- Industrial zones without co-located disposal: Some older industrial zones did not plan waste treatment on-site, relying on municipal systems which got overwhelmed. For instance, the Bien Hoa industrial zone near HCMC historically dumped waste in what became huge piles (some of it hazardous, causing contamination of nearby canals).
- Mining and mineral processing areas: Not exactly "industrial solid waste" in manufacturing sense, but places like Thai Nguyen (mining and metallurgy) have large slag dumps (some heavy-metal laden) affecting environment. Quang Ninh coal mining produces coal gangue piles that can cause acid runoff. These are regional waste management issues.
- Southern Key Economic Region: including Binh Duong, Dong Nai, HCMC – these produce the largest volumes of industrial waste. While these provinces have more infrastructure and aggressive recycling industries, they also face rapid waste increases. Binh Duong, for example, invested in a large waste treatment complex (South Binh Duong Waste Complex) that handles both municipal and industrial waste, turning some into compost or burning for power, but even it strains at times with volume. Regional data: According to a 2017 report, HCMC generated about 1,500–2,000 tonnes/day of industrial solid waste (non-hazardous) . Binh Duong and Dong Nai combined likely similar. In the north, Hanoi's industrial waste (excluding construction debris) was around 300–400 tonnes/day because heavy industries are fewer (many around Hanoi are relocated to provinces). The central region's industrial waste is lower, given less industry.
- Port cities and shipbreaking: Haiphong and Vung Tau have shipyards, etc., which produce bulky wastes (scrap metal, oily wastes). Management is usually via sale of scrap and hazardous to specialized companies.

3.2.1.7.4 Monitoring and Data Gaps

There are significant data gaps in industrial waste. Companies are mandated to report waste generation but compliance is mixed, and small enterprises often don't. The lack of a centralized database meant planning was reactive. This is being addressed by new online reporting systems.

Another gap is waste auditing to see how much is recycled vs disposed; much recycling is informal or via unregistered buyers, so it's not captured in official stats. For instance, if a factory sells all its cardboard waste to a local recycler, it might not even count that as "waste" in reporting, thus underestimating generation.

Fly-tipping (illegal dumping) of industrial waste – occasionally large illegal dumps are found on abandoned land – indicates monitoring gaps. E.g., piles of textile scraps were found dumped in suburbs of HCMC in 2019, traced to small garment workshops avoiding disposal fees.

Without good data, designing facilities is difficult. Some provinces possibly lack industrial waste treatment capacity simply because they undercounted the waste needing disposal.

3.2.1.7.5 Industrial Waste Recycle

On a positive note, Vietnam's industry has a culture of not wasting valuable materials. Recycling is quite active:

- Paper recycling: Vietnam recycles ~1.5 million tonnes of paper per year, much from industrial scrap. Mills rely 60-70% on wastepaper. Local scrap plus imports feed them.
- Plastic recycling: There are hundreds of small and medium recyclers turning post-industrial plastic scraps into pellets. Vietnam's recycled plastic use is growing, though a lot is exported as pellets too.
- Metal recycling: The steel industry has multiple furnaces using scrap (Hoa Phat, Pomina, etc.). Copper recycling is also present in craft villages.
- By-product reuse: Some industries reuse each other's waste – e.g., power plant coal ash is used in cement making; rice husk ash from rice mills can be an additive; brewery spent grain as cattle feed, etc.
- Emerging circular initiatives: Big companies in electronics (Samsung, etc.) have zero-landfill goals for their factories, meaning they find recyclers for almost all waste. Some IPs are exploring "industrial symbiosis" where one factory's waste is another's input.

  Thus, the industrial sector is in some ways ahead of municipal in recycling, driven by cost savings and profit motive. This contributes to resource efficiency and reduces environmental load, but the informal nature of some recycling also has downsides (like environmental issues in craft villages).

In summary, industrial solid waste in Vietnam is a significant stream that has seen increasing management attention. The main issues revolve around ensuring proper disposal for the fraction that isn't readily recyclable, integrating the myriad of small producers into formal waste systems, and addressing legacy and informal practices that cause local pollution. With continued industrial growth under Vietnam's economic plans, improving industrial waste management is crucial to avoid simply shifting pollution from point-source water/air to land via waste.

3.2.1.8. Oil Pollution Sources and Incidents

Oil pollution in Vietnam's marine and coastal environment arises from several sources: shipping activities (operational discharges and accidental spills), offshore oil and gas operations, and coastal oil storage and handling facilities. Given Vietnam's long coastline along a major international shipping route and its own petroleum industry, the country faces ongoing risks of oil contamination in its waters.

3.2.1.8.1 Major Incidents

Vietnam has experienced numerous minor to moderate oil spill incidents, though fortunately few very large spills in recent history. Notable incidents include:

- Vessel collisions and sinkings: One of the larger events was the 2001 collision of tanker Formosa One with another vessel near Vung Tau, spilling about 615 tonnes of diesel . Another was the 2007 sinking of a freighter in central Vietnam that released bunker fuel affecting beaches. More recently, in 2019 the cargo vessel Nordana Sophie sank near Ha Tinh with 178 tonnes of fuel (as cited earlier) , causing a local spill that oiled ~3 km of coastline. Each year, there are some incidents of smaller ships or barges sinking in ports or rivers (for example, a barge on the Saigon River in 2020 spilled tens of tonnes of oil).
- Mystery oil spills (tar balls): Possibly the most pervasive are the chronic incidents, where lumps of oil/tar wash ashore across multiple central and southern provinces. One such event occurred in early 2021, impacting Khanh Hoa beaches with clumps of weathered oil over several days . Another wave of tar balls hit Ha Tinh province's beaches in Feb 2024, totaling about 1 tonne of oil washed up . These are believed to originate from ships illegally cleaning out tanks at sea or minor spills upstream that eventually congeal and land on shore. They may not be "incidents" in a singular sense but collectively cause significant pollution.
- Offshore platform leaks: Vietnam's offshore oil fields (like Bach Ho, Rong) have had a good safety record, but minor leaks have occurred. For instance, in 2005 a small leak at Bach Ho was reported, and PetroVietnam has internal reports of some well control issues with minor spillage. No major blowouts have happened in Vietnamese waters (unlike the Montara and Deepwater Horizon events elsewhere).

- Harbor and pipeline spills: Spills at ports or during bunkering happen occasionally. In 2018, a pipeline at Nha Be Depot in HCMC leaked a few hundred cubic meters of fuel into the river (clean-up was swift). In Haiphong, there have been accidents where oil depots caught fire or leaked, polluting local water. Also, war-era shipwrecks sometimes seep oil (e.g., WWII wrecks in coastal waters could still release small oil amounts).
  While individual spills (aside from the 1994 Neptune Aries and 2001 Formosa One which are historically cited) have been relatively limited in volume, their frequency and cumulative impact raise concern.

3.2.1.8.2 Response Capacity

Vietnam has built a tiered oil spill response system. The National Committee for Search and Rescue (VINASARCOM) leads national responses . Three regional Oil Spill Response Centers (NOSRCs) are established:

- Northern center (Hai Phong),
- Central center (Da Nang and Nha Trang),
- Southern center (Vung Tau) .
  These centers stock equipment like booms, skimmers, dispersants, and have trained staff. They can handle medium spills and provide training to local entities. The 2019 improvements included enhanced coordination with the IMO's GISEA program .
  Additionally, industry resources: PetroVietnam and Petrolimex have their own spill response units and stockpiles. Major ports have some equipment. The Ministry of Defense (Navy) can be mobilized for larger offshore incidents with ships and aircraft.
  A legal framework exists requiring ports and oil facilities to have oil spill contingency plans (Decree 30/2017/ND-CP). In 2019, (NOW MINISTRY OF AGRICULTURE AND ENVIRONMENT - MAE)'s circular outlined steps for clean-up and damage assessment . It mandates initial assessment within 10 days of a spill and further detailed assessment if needed .
  In practice, response capability has improved: e.g., when tar balls hit Khanh Hoa beaches, local authorities quickly organized beach clean-ups. For bigger spills, Vietnam often requests help from neighbors if needed (within ASEAN there's collaboration).
  Internationally, Vietnam is party to MARPOL (covering pollution from ships) and various conventions. Domestically, the National Oil Spill Response Plan (approved 2020) delineates roles across ministries (Transport, Defense, etc.) .
  Overall, Vietnam's response capacity is considered moderate – adequate for spills up to a few thousand tonnes, but a truly massive spill (e.g., >10,000 tonnes) would stretch capacity and likely need international support. Regular exercises are conducted, and Vietnam has engaged in regional ASEAN spill drills.

3.2.1.8.3 Impact Zones

Certain zones are identified as high-risk or impact-prone for oil pollution:

- Shipping lanes & choke points: The area off Vung Tau where ships enter/exit the busy port cluster (HCMC, Phu My) sees dense traffic, raising collision risk. The Gulf of Tonkin approach to Haiphong is another busy lane. Oil from incidents in these lanes can drift to nearby coasts (e.g., the 2001 collision off Vung Tau affected nearby mangroves).
- Coastal refineries and terminals: Vietnam now has two large refineries – Dung Quat in Quang Ngai and Nghi Son in Thanh Hoa – each with offshore single-point mooring for crude oil offloading. These are potential spill points. Areas around these (Quang Ngai coast, northern Central VN coast) are thus sensitive zones. Dung Quat had a minor incident of pipeline leak once but contained.
- Offshore oil fields: Fields like Bach Ho are offshore (Bach Ho ~ 120 km SE of Vung Tau). A large spill there could drift widely depending on currents (potentially toward the Mekong delta or even to East Vietnam Sea / South China Sea open waters). But impact on coast would depend on weather, probably limited unless monsoon drives it.
- Areas with recurring tar ball landing: Central provinces from Quang Tri to Phu Yen historically report tar ball wash-ups, presumably because of ocean current patterns that deposit spilled oil from ships traveling along that route (perhaps from the Malacca/Singapore route up the East Sea). These areas (including tourist beaches like Nha Trang, Da Nang) have thus become zones that periodically suffer oil contamination from distant unknown sources. Environmental impact of oil in Vietnam's waters includes mangrove oiling (mangroves in Can Gio were oiled in some small spills), beach pollution affecting tourism, and harm to marine life (reports of oiled seabirds are rare, but likely some impact on fishery resources if nursery areas get oiled). One transboundary note: Oil spills in the East Vietnam Sea / South China Sea can cross borders. Vietnam has had to contend with oil slicks drifting from unknown sources that might originate from other countries' waters, and likewise spills in Vietnam could affect neighbors (e.g., a spill in south Vietnam could drift to Cambodia or even Thailand via currents).
Given this, Vietnam participates in regional agreements (ASEAN Oil Spill Response Action Plan, etc.) and has bilateral understandings (with China in Gulf of Tonkin, etc.).

In summary, oil pollution in Vietnam, while not catastrophic in recent times, remains a continuous risk with persistent low-grade incidents and occasional larger events. Proactive risk management (traffic separation schemes, better enforcement of ship discharge rules) and maintaining strong response readiness are key to minimizing the environmental and economic impacts on Vietnam's rich but vulnerable coastal waters.

3.2.2 Pollution Hotspots and Sensitive Areas

3.2.2.1 Hotspots

Pollution hotspots in Vietnam's coastal and marine environment are locations where contaminant concentrations or ecosystem impacts are significantly higher than background levels, often due to concentrated human activities. Key pollution hotspot areas include:

- Urban-industrial coastal zones: The waters around major cities and industrial hubs are hotspots. For example, Hai Phong – Ha Long Bay area in the north receives pollution from Hai Phong's port (oil, waste) and nearby industries (cement, shipbuilding) and Ha Long's tourism and coal mining. Sections of Ha Long Bay have elevated coliform and occasional surface oil sheen . Similarly, Da Nang Bay has zones of heavy metal contamination from decades of port and military activities (studies found higher nickel and arsenic in sediments near the port). In the south, the HCMC – Vung Tau coastal area is a major hotspot: the Saigon – Dong Nai river system delivers nutrients, industrial chemicals, and sewage into coastal Can Gio mangrove forest and nearshore; Vung Tau has oil terminals and shipping traffic (historically, DDT and oil residues have been found in its sediments).
- Industrial park clusters and estuaries: Estuaries where multiple industrial discharges converge are notably polluted. The Thi Vai River estuary in Dong Nai/Ba Ria–Vung Tau is infamous: historically receiving toxic wastewater (like from a MSG plant) leading to fish kills . Although improved, it is still a sensitive area with ongoing industrial load. Another is the hạ lưu (lower reach) Cau River in Bac Ninh/Thai Nguyen area, which carries effluent from craft villages and industrial parks – it's considered one of the most polluted rivers in Vietnam, affecting the coast of Bac Giang/Thai Binh.
- Craft villages and agriculture runoff areas: While smaller scale, these inland hotspots affect coastal waters indirectly. For example, in Nhue–Day River basin (Hanoi area) polluted by craft villages and sewage, water flows to Ninh Binh's coastal wetlands, contributing to eutrophication and poor water quality. Likewise, the Mekong Delta canals in shrimp farming areas like Ca Mau or Bac Lieu can be very degraded (black water, low oxygen) and flush into the sea at certain tidal cycles, creating local nearshore pollution plumes.
- Areas of frequent algal blooms or hypoxia: The Venice-like lagoons of central Vietnam (e.g., Tam Giang – Cau Hai in Thua Thien-Hue) have become nutrient hotspots due to both upstream agriculture and intensive aquaculture within them. This has led to periodic fish die-offs from algal blooms and oxygen crashes, marking them as inland hotspots that connect to the sea. Some blooms have vented to coastal waters, e.g., the 2019 red tide in Phu Loc area (Central VN) that was partly attributed to aquaculture effluent.

- Mining and legacy pollution sites: The Quang Ninh coal mining region results in acid mine drainage and coal particles washing to Ha Long Bay – certain parts near Cam Pha are turbid and acidic. The Da Nang “dioxin hotspot” (around the airport, from Agent Orange storage) was historically leaching some dioxin to the Han River and then sea (though remediated recently). These hotspots are characterized by poor water quality indices – e.g., monitoring has shown COD and nutrient levels in those areas exceeding national standards by 2-5 times in worst cases , and biodiversity loss (few sensitive species survive in those waters). The government has identified many of these in environmental reports and targeted them for remediation or stricter control. For instance, the Nhue-Day and Cau rivers have special pollution control action plans; Ha Long Bay is getting heightened protection measures (closing some coal ports, regulating tourism boats) to mitigate hotspot issues.

3.2.2.2 Sensitive Areas

Sensitive areas are ecologically important or socio-economically valuable zones that are particularly vulnerable to pollution. In Vietnam’s marine context, these include:

- Coral reef areas: Vietnam’s reefs are mostly in the central and southern waters (e.g., around Nha Trang – Hon Mun MPA, Con Dao islands, Phu Quoc, and the Spratly and Paracel archipelagos). Coral ecosystems are highly sensitive to sediment, nutrient, and chemical pollution. For example, increased sedimentation from coastal construction in Nha Trang and nutrient spikes from city runoff have been linked to reef degradation . Coral cover at Hon Mun plunged, with scientists partly attributing it to water quality decline in addition to other stresses . Coral reefs in these areas underpin tourism and fisheries, so pollution poses both ecological and economic risks. The government has declared several MPAs (marine protected areas) to conserve reefs (e.g., Cu Lao Cham, Phu Quoc, Con Dao, Nha Trang Bay), but enforcement of water quality around them is a concern.
- Mangrove forests: Vietnam’s mangroves (about 150,000 ha remaining, mainly in the Mekong Delta and some in north e.g., Can Gio, Xuan Thuy) act as natural filters and fish nurseries. They are sensitive to oil spills and excessive nutrient or pesticide loads. The Can Gio mangrove biosphere reserve near HCMC is an example: it’s downstream of a metropolis; fortunately, it has maintained overall health, but large oil spills or continued heavy metal accumulation could damage it. Northern mangroves like in Thai Binh (Tien Hai reserve) suffer from pollution of the Red River. Mangroves can accumulate heavy metals in their sediments; studies at Can Gio found increasing copper and lead levels in mangrove mud over time from upriver sources .
- Seagrass beds: Extensive seagrass meadows exist around Con Dao, Phu Quoc, and in some coastal lagoons. These are vital for dugongs (in

Phu Quoc) and fisheries. Seagrasses are very sensitive to turbidity (sediment runoff) and nutrient-driven algal overgrowth. The seagrass bed in Phu Quoc's Phu Quoc MPA has shown signs of stress, likely from tourism development causing sediment and sewage inflow. Another significant seagrass area is at Lang Co and Tam Giang lagoons – increased aquaculture and upland deforestation have muddied these waters and reduced seagrass coverage.

- Delta estuaries and wetlands: The Mekong Delta coastal wetlands (e.g., Ca Mau National Park, U Minh mangroves) and Red River Delta wetlands (Xuan Thuy National Park, a Ramsar site) are biodiversity hotspots (birds, aquatic life) but also pollution sinks. Xuan Thuy receives the Red River plume with pollutants from Hanoi region ; it has seen changes in species composition possibly linked to water quality. In Ca Mau, shrimp farm effluents threaten the balance of its coastal mudflat ecosystems where migratory birds feed.
- Unique habitats (caves, upwelling zones): Less commonly cited, but the karst caves of Ha Long (with unique marine lakes) are sensitive to water pollution. The South-Central upwelling zone (Binh Thuan province) supports rich fisheries; though largely offshore, it could be impacted by large-scale oil spills or plastic debris.
- Small islands with limited resilience: Islands like the Cham Islands (Cu Lao Cham) or Ly Son have small freshwater and delicate coastal waters; increased tourism and waste (e.g., plastic pollution, sewage) can quickly degrade their environment. Cham Islands MPA has struggled with coral damage partly due to sediment and anchor damage (triggers include mainland runoff).

Given these sensitivities, Vietnam prioritizes these in pollution control efforts. Many sensitive areas overlap with protected areas, enabling some regulatory focus. For example, laws forbid polluting activities (like certain discharges or ship fuel discharge) in MPAs. Also, Vietnam joined the UNESCO Man and Biosphere network (e.g., Can Gio, Cu Lao Cham are biosphere reserves) where sustainable practices are advocated.
Special attention is paid to transboundary sensitive areas as well – e.g., the Mekong Delta wetlands are linked to the larger Gulf of Thailand ecosystem; Vietnam works with other Mekong countries to manage upstream pollution because if those wetlands degrade, it not only affects Vietnam but regional biodiversity.
In summary, sensitive coastal and marine areas in Vietnam include coral reefs, mangroves, seagrasses, delta wetlands, and special ecosystems, all of which provide irreplaceable services and habitat but face threats from various forms of pollution documented in previous sections. Protecting these areas is a national priority reflected in Vietnam's commitments to international environmental conventions and its own conservation strategies.

3.2.3 Discussion and Conclusions

3.2.3.1 Priority Transboundary Pollution Issues

Given Vietnam's location in the East Vietnam Sea/South China Sea and the interconnected nature of marine systems, many pollution issues are transboundary, affecting or originating in multiple countries. The most pressing transboundary pollution concerns include:

3.2.3.1.1 Oceanic Transport of Marine Plastics

Marine plastic litter is a quintessential transboundary problem. Ocean currents and wind move floating debris across national waters, so debris generated in Vietnam can end up on foreign shores and vice versa . Research has shown, for example, that a proportion of plastic waste from the Mekong River travels into the East Vietnam Sea/South China Sea and can drift towards the Philippines or Malaysia, depending on monsoon currents. Conversely, Vietnam's central coast regularly experiences wash-ups of plastic waste (and tar balls) that may have originated from high-traffic shipping lanes or neighboring countries . The monsoon-driven currents in the East Vietnam Sea / South China Sea form a seasonal "carousel" carrying floating litter in a circuit around the region . This means efforts by Vietnam alone cannot solve marine plastic pollution; coordinated regional action is critical. Recognizing this, Vietnam is part of the ASEAN Regional Action Plan on Marine Debris and participates in UNEP's Coordinating Body on the Seas of East Asia (COBSEA) initiative on marine litter . In summary, marine plastics are a shared problem where Vietnam's actions (like reducing single-use plastics, improving waste management) will benefit its neighbors and vice versa. Joint clean-up, data sharing, and source-reduction campaigns are priority collaborative actions.

3.2.3.1.2 Shipping Corridors and Oil Spill Drift

The East Vietnam Sea / South China Sea is one of the world's busiest maritime highways, with thousands of vessels (including oil tankers) traversing Vietnam's adjacent waters annually. Pollution from shipping – oil spills, operational discharges (bilge water, tank washings), and introduction of invasive species in ballast water – is inherently transboundary. An oil spill in international waters or foreign waters can drift into Vietnam's EEZ. As noted, tar balls on Vietnam's shores are often attributed to illegal discharge by ships from various nations . Similarly, a major tanker accident in the region could spread oil across several countries' coastlines. Vietnam's southern coast near Vung Tau sits at the entrance of the Malacca-Singapore route; a spill there could easily affect Indonesia, Malaysia, or vice versa . Besides oil, invasive marine organisms via ballast water are a concern – port surveys in Vietnam have noted foreign barnacle or mussel species, which can alter local ecosystems; controlling this requires international regulations (MARPOL, Ballast Water Management Convention) enforcement across all countries' ships, not just Vietnam's. To mitigate these corridor risks, Vietnam collaborates regionally: for oil spills, there is the ASEAN Oil Spill Response Action Plan allowing mutual assistance; for invasive species, Vietnam has begun implementing IMO guidelines on ballast water and is involved in research on biofouling with regional partners. In short, the only effective management of shipping-related pollution is a concerted regional approach to strict enforcement of marine pollution laws (zero tolerance for illegal oil dumping, for instance) and shared emergency response capability for accidents.

3.2.3.1.3 Riverine Plumes and Cross-Border Nutrient Flows

Several major rivers that traverse or border Vietnam carry pollutants from upstream countries into Vietnamese waters. The Red River, which originates in China, brings not just water but also sediment and agricultural runoff from Yunnan and the Guangxi region into the Gulf of Tonkin . Likewise, the Mekong River flows through China, Myanmar, Laos, Thailand, Cambodia before Vietnam, collecting pollutants along the way (fertilizers, pesticides, industrial effluents). By the time the Mekong reaches Vietnam's delta, it carries a heavy nutrient load that contributes to coastal eutrophication in the East Vietnam Sea / South China Sea and Gulf of Thailand . Transboundary collaboration is needed to manage these nutrient and pollution loads at the basin level. Vietnam is a member of the Mekong River Commission (MRC) with Laos, Cambodia, and Thailand, working on water quality monitoring and sharing data upstream-downstream. Similarly for the Red River (called Yuan/Thao in China), Vietnam has bilateral agreements with China on water release from dams and some water quality information sharing, but this could be strengthened. There have been instances of industrial accidents or mining in upstream countries impacting Vietnam's rivers (e.g., a toxic spill from a mine in Laos or China could cause fish kill in Vietnam's territory). These highlight the necessity of cross-border early warning systems and agreed standards for discharge in shared basins. Additionally, air pollution and deposition is another transboundary vector: e.g., burning of coal or biomass in upwind countries can deposit nutrients (nitrogen) or contaminants into Vietnam's coastal waters via rain (as part of acid rain or dust). Integrated efforts, such as those under the UNEP Regional Seas program and MRC's environmental program, aim to address such issues. In conclusion, Vietnam's water quality is partly at the mercy of upstream practices, making it essential to engage in robust transboundary water management frameworks to ensure that shared rivers are protected from excessive pollution that could endanger delta and coastal health regionally.

3.2.3.2 Impacts on Environment and Society

Pollution in Vietnam's marine and coastal environment has multifaceted impacts that threaten ecological sustainability, public health, and economic development. The discussion below outlines these impacts in terms of environmental integrity, social well-being, and economic vitality, noting that all are interlinked (sustainability impacts).

3.2.3.2.1 Sustainability Impacts

a) Environmental impacts: The degradation of water quality and habitats undermines key ecosystem functions. For instance, excess nutrients and organic pollution are causing eutrophication in some bays and river deltas, leading to algal blooms and hypoxic (low-oxygen) events that result in fish kills and loss of biodiversity . Coral reef decline due to sedimentation and pollution (among other stressors) reduces coral cover and structural complexity, translating to loss of marine species that depend on reefs. Mangrove loss or reduced health (from oiling or waste inundation) diminishes shoreline stabilization and nursery grounds for fish. As these ecosystems degrade, the services they provide – water filtration, carbon sequestration, habitat provision – are compromised. Notably, reduced coral and mangrove cover means less natural protection against storms and erosion, increasing vulnerability of coastlines to climate change effects. Pollution has also been observed to cause shifts in species composition: more tolerant, often non-native or opportunistic species (like certain jellyfish or invasive algae) can proliferate in degraded waters, while sensitive native species (like seagrasses, hard corals) die off. The net environmental impact is a reduction in marine biodiversity and resilience, threatening Vietnam's status as having globally significant ecosystems.

b) Social Impacts: Coastal communities in Vietnam are intimately tied to the sea for livelihood and culture, so pollution directly affects their well-being. One major social impact is on human health: polluted waters lead to contaminated seafood (e.g., high heavy metal or microbial levels), raising the risk of foodborne illness for consumers . Coastal residents reliant on local seafood may suffer chronic health issues (like arsenicosis or mercury exposure symptoms) if contamination is significant. Furthermore, as noted in Key Findings, waterborne diseases can spike in communities where water is polluted – cases of diarrhea, skin infections, and other illnesses have been recorded near heavily polluted rivers. Another social aspect is the loss of traditional livelihoods: when fish stocks decline due to habitat pollution, small-scale fishers see reduced catches, undermining their income and way of life. In some areas, fishers have had to switch occupations or migrate because their local waters are no longer productive or safe. There's also the cultural erosion – many Vietnamese coastal communities have spiritual and cultural practices tied to the sea (festivals, ancestral fishing grounds); pollution that makes areas off-limits or unproductive can erode these practices and communal identity. Social conflicts can arise too: communities often protest when they perceive environmental injustice, such as pollution from an industrial project – as seen in the 2016 protests after the Formosa Ha Tinh fish kill. Such incidents strain trust between citizens, businesses, and government, highlighting that social cohesion is also at stake. As one example, waterborne disease outbreaks in coastal communities have increased burdens on local healthcare and reduced quality of life .

c) Economic impacts: The economic costs of pollution are significant and cut across several sectors. In fisheries and aquaculture, pollution can cause outright losses – e.g., the mass fish kill of 2016 in central provinces (due to industrial toxic release) led to estimated losses of hundreds of millions of USD in fishery revenue and severe impacts on fishers' livelihoods. Even less dramatic pollution (chronic contamination) can lead to product rejections: as mentioned, Vietnamese aquaculture products have at times been rejected in export markets due to antibiotic or chemical residues , tarnishing their reputation and causing financial loss. Tourism is another pillar of Vietnam’s economy that is highly sensitive to environmental quality. Beach resorts and marine parks rely on clean, attractive environments. Pollution incidents – sewage on beaches, oil slicks, or just general litter – can lead to loss of tourists and revenue. For instance, a study estimated that a serious oil spill affecting Vietnam’s prime tourist beaches could result in tens of thousands fewer tourist arrivals, translating to big revenue downturns. Public costs are also huge: the government must spend more on water treatment for coastal cities as source water gets dirtier, on healthcare for pollution-related illnesses, and on environmental cleanup (e.g., dredging polluted sediments, remediating contaminated sites). There are also opportunity costs: a polluted environment means lost opportunities for sustainable industries like mariculture of high-value, sensitive species (oysters, clams) or marine biotech prospecting, because those require pristine conditions. Additionally, damage to ecosystem services has long-term economic implications – for example, mangroves and reefs provide storm protection valued at millions of dollars per year by reducing disaster damage; losing them makes coastal infrastructure more at risk, likely increasing future spending on engineered defenses . In summary, pollution imposes both direct costs (loss of output in fisheries/tourism, cleanup costs) and indirect costs (healthcare, disaster vulnerability) that collectively hamper socio-economic development and the “blue economy” potential Vietnam aspires to harness .

In specific terms, as highlighted in earlier sections: reduced coral cover and mangrove stands threaten the Blue Economy potential (diving tourism, sustainable fisheries) and food safety issues (like antibiotic residues) in exports reduce market value and income . These combined impacts illustrate that environmental health is a foundation for social and economic health. Sustaining Vietnam’s coastal environment in good condition is thus not only an ecological goal but a societal imperative for continuing growth and improving living standards.

Specific impacts:

- Ecosystem Services: The loss of ecosystems due to pollution directly translates to loss of services they provide. For instance, coral reef degradation has led to diminished fish spawning grounds, reducing fishery yields for local communities . Mangrove loss means weaker natural water filtration and more pollutants reaching nearshore waters, as well as reduced carbon sequestration (affecting climate mitigation efforts) . It also compromises coastal protection, as noted above, potentially leading to greater storm damage costs. These impacts threaten the aspirations of Vietnam’s Blue Economy development, which depends on healthy ecosystems as a foundation for sectors like fisheries, tourism, and marine renewable resources.
- Socio-Economic Burdens: Public health issues, such as the noted uptick in waterborne diseases, incur costs for families and the healthcare

system . For example, cholera outbreaks in coastal areas (there was one in northern Vietnam in 2007 associated with seafood and sanitation) cause suffering and productivity loss. Aquaculture product rejections due to contaminants (e.g., antibiotic or heavy metal residues) directly hit farmers' incomes and Vietnam's export revenue . In 2019, for instance, several shrimp shipments were rejected by Japan for antibiotic residues, leading to not only lost product but also stricter surveillance on all Vietnamese shrimp (meaning higher costs for compliance). Summing up, the societal burden of coastal pollution is borne by both individuals (in health bills, lost jobs) and by the nation (in weakened export performance, remediation expenses).

In conclusion, the impacts of land-based and marine pollution in Vietnam's coastal waters are far-reaching: they degrade ecosystems (undercutting biodiversity and resilience), harm human health and social well-being, and inflict significant economic costs and risks. This underscores the urgency of tackling the pollution issues identified – for the sake of Vietnam's environmental sustainability, the prosperity of its coastal communities, and overall economic development goals.

3.2.3.3. Risk Assessment

From the analysis of pollution sources and impacts, it is evident that Vietnam faces several environmental risks if current trends continue or worsen. A qualitative risk assessment highlights which issues pose the greatest threat in terms of likelihood and severity:

- Increasing frequency of extreme pollution events: There is a risk of acute events (e.g., industrial accidents causing fish kills, large oil spills) occurring with greater frequency as industrial and shipping activities intensify. The likelihood of such an event is moderate to high, given past incidents, and the severity can be very high (widespread marine life mortality, loss of public trust, costly clean-ups). This risk is compounded by limited monitoring and enforcement gaps.
- Long-term ecosystem regime shifts: Chronic pollution could push certain ecosystems past a tipping point. For example, coral reefs might shift to algae-dominated rubble fields (a regime shift that's hard to reverse) , or hypoxia could become seasonally regular in some bays (creating "dead zones"). Likelihood of gradual regime degradation is high if no action, and severity is high because these changes can be effectively permanent on human timescales, with cascading effects on fisheries and tourism.
- Public health crises: If wastewater treatment remains inadequate, there is a risk of serious disease outbreaks (cholera, hepatitis, etc.) in coastal cities or consumption of tainted seafood leading to health crises (e.g., mass lead poisoning from fish). Likelihood may be moderate (improving sanitation lowers odds, but pockets of risk remain), but severity could be high (disease outbreak can cause panic, mortality, economic loss from trade/travel restrictions).

- Climate change interaction: Risks are amplified by climate change – heavier rains can cause more pollutant runoff and sewage overflow (increasing acute pollution episodes), while higher temperatures can exacerbate algal blooms and pathogen proliferation in water . Sea-level rise might inundate landfills or contaminate groundwater with saline/polluted water. The likelihood of such compounded scenarios is increasing, and severity could be high especially in low-lying, densely populated delta areas.
- Failure of marine-dependent industries: If pollution continues, risk grows that certain industries face collapse. For example, parts of the aquaculture industry could fail (shrimp farms already battling disease might be overwhelmed by poor water quality stressors), or tourism in certain areas might plummet due to reputational damage (e.g., if iconic spots like Ha Long Bay develop a persistent pollution problem). Likelihood for localized industry failures is moderate; severity where it occurs is high (job losses, economic downturn in affected locale). Assessing which risks are most pressing, marine plastic and transboundary spill events stand out as priority due to international dimension and difficulty to control solely by Vietnam (hence needing preventive risk mitigation). On the domestic side, river and coastal water quality deterioration is a creeping risk that could culminate in major losses if not curbed. Risk assessment feeds directly into management: it indicates that Vietnam should prioritize preventive measures for high-severity, reasonable-likelihood risks (like large oil spills and industrial accidents) through strict controls and contingency planning , while also mitigating chronic risks (improving wastewater infrastructure to reduce the steady degradation). One can quantify some risk indicators – e.g., the probability of fisheries collapse in a polluted area can be modeled, or health risk from contaminant levels can be gauged. Such analysis should be embedded in Vietnam's policymaking (there are early moves: (NOW MINISTRY OF AGRICULTURE AND ENVIRONMENT - MAE)'s environment reports now sometimes do risk mapping for hotspots). In summary, the current risk profile suggests Vietnam is at a crossroads: without intervention, moderate to high likelihood events could impose very high costs; but with proper investment and governance (risk reduction strategies), these can be managed. Therefore, risk assessment underscores the need for urgent action in pollution management as discussed in subsequent sections on management and recommended actions.

3.2.3.4. Interaction on Current Management and Institutions

Pollution management in Vietnam's marine and coastal areas involves multiple legal frameworks and institutional players, both domestically and regionally. The effectiveness of pollution control depends on how these laws and agencies interact and coordinate.

3.2.3.4.1. Legal Frameworks

Vietnam has developed an extensive legal framework for environmental protection that covers many aspects of land-based and marine pollution. Key laws include:

- The Law on Environmental Protection (LEP) 2020, which is the overarching environmental law. The 2020 revision (effective 2022) introduced concepts like circular economy and Extended Producer Responsibility (EPR) for waste management . It sets out pollution standards, requires EIAs for projects, and includes provisions for marine environmental protection (e.g., controlling marine dumping, regulating coastal wastewater discharges).
- The Law on Marine and Island Resources and Environment 2015, specifically focusing on marine spatial planning and environmental management of seas and islands. It underpins planning of MPAs and controlling marine pollution sources, integrating with LEP.
- Sectoral laws: The Fisheries Law 2017 has provisions on protecting aquatic ecosystems (e.g., banning destructive fishing that can pollute or disturb habitats). The Water Resources Law 2012 governs water quality and allocation in rivers and groundwater (important for addressing upstream sources). The Maritime Code incorporates some MARPOL conventions, making illegal ship waste discharge punishable.
- Many decrees and regulations detail standards (like QCVN for water quality, effluent standards for industries). For instance, there are stringent discharge standards for coastal waters (Category A for conservation areas, B for others).
- International conventions: Vietnam is party to MARPOL (for ship pollution) , the London Convention on Dumping at Sea, the Stockholm Convention (POPs), Basel Convention (hazardous waste movement), and is working to join the Minamata Convention (mercury). These commit Vietnam to global standards on pollution control.
- Regional agreements: Under ASEAN, Vietnam adheres to frameworks like the ASEAN Heritage Parks (which include some Vietnam sites) and has endorsed the ASEAN Marine Debris Action Plan, committing to reduce plastics. The legal framework is thus fairly comprehensive on paper. Recent improvements, such as the LEP 2020, align Vietnam's laws more closely with international best practices (introducing EPR for packaging is a major step). Enforcement provisions are present (fines, criminal liability for serious pollution). However, implementation challenges exist. Local regulations (e.g., provincial decisions on waste fees or zoning of industry) sometimes may conflict or be inconsistently applied with national standards. A continuing task is harmonizing these and ensuring subordinate legislation is updated to reflect new laws (e.g., the older regulations need alignment with LEP 2020's new provisions).

In summary, Vietnam's legal frameworks provide a solid foundation, but enforcement and inter-agency coordination are critical to turn these laws into real environmental outcomes.

3.2.3.4.2. Agency Mandates

Several government bodies share responsibility for managing land-based and marine pollution:

- The Ministry of Natural Resources and Environment (now Ministry of Agriculture and Environment - MAE) is the primary environmental regulator. Within MAE, the Department of Environment and Department of Seas and Islands are key departments. MAE formulates environmental policies, sets standards, and oversees issues like marine pollution, waste management and EIA approvals. MAE's Department of Environment handles solid waste and hazardous waste policy.
- The MAE (former MARD) plays a role regarding agriculture runoff, forestry (mangroves), and fisheries/aquaculture management. It oversees sustainable farming programs and aquaculture practices. MAE's Department of Fisheries deals with aquaculture guidelines (e.g., limiting antibiotic use).
- The Ministry of Construction (MOC) is in charge of urban water supply and sanitation infrastructure . It sets technical standards for wastewater treatment plants, sewerage systems, and is involved in planning integrated solid waste management infrastructure . MOC's involvement is crucial as most urban drainage/wastewater projects are under its policy guidance or implemented by local construction departments.
- The Ministry of Industry and Trade (MOIT) regulates industrial sectors. It issues industry-specific environmental guidelines and is involved in pollution control in industrial zones (e.g., requiring IPs to have wastewater treatment) .
- The Ministry of Transport (particularly the Vietnam Maritime Administration) is mandated with preventing and responding to marine pollution from ships . It implements MARPOL in Vietnamese ports, controls ballast water management, and is part of oil spill response (as harbor authorities often lead first response).
- The Ministry of Public Security has an Environmental Police Department (C49) tasked with enforcing environmental laws and investigating violations . They conduct inspections and can bring criminal cases against serious polluters (there have been cases of factory managers prosecuted for pollution).
- At the provincial level, Departments of Natural Resources and Environment (DONRE) in each province are the frontline agencies managing environmental issues . They issue permits (wastewater discharge permits, etc.), monitor local environmental quality, and coordinate enforcement with local police. Similarly, each coastal province

may have a Sub-Department of Seas and Islands for coastal zone management.

The mandates sometimes overlap; for example, MAE have stakes in water quality in agriculture areas. Ideally, cross-sector committees or inter-ministerial working groups resolve overlapping issues (the National Steering Committee on Water Supply and Environmental Sanitation is one such body spanning MOC, MOH, etc., focusing on sanitation).

In practice, coordination has been a challenge historically – e.g., industrial zone wastewater falls between MOIT (industry oversight), MOC (infrastructure), and MAE(environment monitoring) – gaps led to untreated wastes. The government has been trying to clarify roles: the LEP 2020 gives MAE clearer authority to enforce environmental protection across sectors, and EIA processes involve multi-agency appraisal to ensure concerns of each are addressed.

A notable inter-agency mechanism: The National Committee for Search and Rescue (VinSARCOM) leads oil spill responses and comprises various ministries (Defense, Transport, MAE) – a good example of mandated coordination.

Effectiveness of agencies still varies by locality – some provincial DONREs are strong and active, others lack capacity. Enhancing local capacity and clear mandates is an ongoing institutional reform area.

In summary, the institutional framework assigns primary environmental guardianship to MAE and its provincial arms, but success hinges on effective collaboration with sectoral bodies like MAE, MOC, MOIT, etc., to integrate pollution control in their domain activities (agriculture, infrastructure, industry).

3.2.3.4.3 Regional Participation

Vietnam recognizes that many environmental issues are regional, and thus it actively participates in regional cooperative frameworks:

- PEMSEA (Partnerships in Environmental Management for the Seas of East Asia): Vietnam has been a longtime partner in PEMSEA , which promotes integrated coastal management (ICM). Through PEMSEA, Danang and other local governments implemented ICM programs to manage pollution and resources holistically. Vietnam committed to PEMSEA's Sustainable Development Strategy for the Seas of East Asia (SDS-SEA) which includes objectives on pollution reduction.
- COBSEA (Coordinating Body on the Seas of East Asia): Under UNEP's auspices, Vietnam works with 8 other countries on marine and coastal environment issues . COBSEA has a regional Action Plan with projects on marine litter, reef management, etc., which Vietnam contributes to (e.g., sharing data on marine plastic sources).

- ASEAN forums: Vietnam signed the Bangkok Declaration on Marine Debris (2019) and supports the ASEAN Framework for Action on Marine Debris . Regionally, Vietnam hosted an ASEAN Conference on marine plastic in 2020, signaling leadership on the issue. In broader environment, Vietnam engages in ASEAN Working Groups on water resources and on coastal and marine environment.
- Mekong River Commission (MRC): For the Mekong basin, Vietnam is a member (with Laos, Cambodia, Thailand) of the MRC, cooperating on water quality monitoring and management of the Mekong's resources. One outcome is the MRC's water quality monitoring program, which tracks pollutants at points including near the Vietnam border, giving early warning of any concerning trends.
- Bilateral cooperation: Vietnam has environment cooperation agreements with neighbors China, Laos, Cambodia. For example, Vietnam and China have a joint working group on environmental management for the Red River and Beilun River, including information sharing on water discharges. With Cambodia, Vietnam cooperates on managing transboundary fisheries and water in the Mekong delta (e.g., joint patrols to prevent illegal waste dumping across borders).
- Global commitments: Vietnam's regional participation extends to fulfilling obligations under global frameworks. For instance, as part of the Stockholm Convention, Vietnam collaborated with neighboring countries to eliminate certain POPs regionally. As a signatory to the Paris Agreement on climate change, Vietnam's efforts to reduce black carbon and methane (some from waste management improvements) also contribute to regional air and ocean quality indirectly.
  This regional and international engagement benefits Vietnam by providing technical support, funding (for example, the World Bank/GEF-funded projects on reducing pollution often come through these partnerships), and aligning Vietnam's practices with global standards. It also allows Vietnam to advocate its interests – such as pressing upstream Mekong countries to consider downstream impacts, or pushing for stronger regional action on plastics.
  Vietnam's proactive stance is illustrated by its hosting of the 2021 ASEAN Regional Forum (ARF) workshop on marine environmental protection – showing initiative in convening region-wide discussions on controlling marine pollution.
  In conclusion, Vietnam's institutional interplay isn't confined within its borders; it actively engages in and benefits from regional cooperative mechanisms. These partnerships enhance Vietnam's capacity to handle transboundary issues (like shared fish stocks, migrant marine species, drifting pollution) and ensure that its national actions are complemented by neighbors' actions, leading to more effective overall outcomes.

3.2.3.5 Gaps and Priority Challenges

Despite progress in policy and management, several gaps persist in Vietnam's efforts to manage land-based and marine pollution. Addressing these is crucial for closing the implementation deficit between well-intentioned laws and on-the-ground improvements. Key challenge areas include:

3.2.3.5.1. Institutional Arrangements

While the framework of responsible agencies exists, overlaps and inefficiencies hamper performance. One gap is in integrated management: issues like coastal water quality require multi-sector collaboration, but Vietnam's institutions often operate in silos. As noted, MAE leads environment, but influence over sectors like transportation is limited. Institutional overlaps can cause confusion – e.g., who is accountable for river pollution although they are under MAE now. A more unified watershed or coastal zone management institution could help; Vietnam has ICM boards in some provinces, but not everywhere. There is also a gap in decentralization vs. capacity: environmental management responsibilities have been pushed to provinces (devolution per the LEP), but not all provinces have the technical or financial capacity in DAE to effectively implement. This leads to uneven enforcement – strong in cities like Da Nang, weaker in remote provinces due to resource constraints.

Furthermore, data sharing and coordination mechanisms between agencies need strengthening. For example, during an oil spill, Ministry of Transport, MAE, and others coordinate via an ad-hoc committee – establishing permanent joint task forces for recurring issues (like marine plastics) would institutionalize coordination. Vietnam has some inter-sector committees (e.g., National Committee on Climate Change that also touches on oceans, or river basin organizations for a few rivers), but these need empowerment and resources. Another institutional gap lies in local community involvement – while laws mention community rights to be informed and to complain (the LEP 2020 even allows communities to sue polluters under certain conditions), in practice communities sometimes are not effectively integrated into monitoring or decision-making. Bridging that gap is important for transparency and early detection of issues.

3.2.3.5.2 Implementation Gaps

Vietnam's policies generally align with international standards, but implementation lags in several areas:

- Technical Capacity: There's a shortfall in technical expertise and equipment for monitoring and treating pollution. Many cities lack sufficient laboratories to test water quality frequently, or modern forecasting systems for pollution risk (like predictive models for algal blooms). Skilled personnel in fields like marine toxicology, environmental engineering, and coastal modeling are in short supply, especially at local levels. While donor projects have provided some training, retaining skilled staff in government (versus going to private sector) is a challenge. For example, environmental police and DONRE staff need continuous training in new techniques (like using drones or satellite data to spot illegal dumping). A shortage of qualified operators for wastewater treatment plants has also been noted; some plants underperform because of operational skill gaps.

- Enforcement: Enforcement of pollution laws remains inconsistent. Fines for violations have increased, but enforcement actions can be sporadic and sometimes lenient, particularly if the polluter is a major employer. There are reports that some companies would rather pay fines than invest in treatment, if enforcement is infrequent. Also, detection of violations is a challenge; Vietnam has relatively few environmental inspectors relative to the number of potential sources. There's also an issue of corruption in enforcement (isolated cases where inspectors were bribed to overlook violations, undermining rule of law). Strengthening enforcement means more frequent inspections (surprise checks at night for factories known to bypass treatment at off-hours), strict follow-up on mandated corrective actions, and prosecutions where needed to deter egregious polluters. The legal system has provisions for criminalizing severe pollution, but actual prosecutions have been few – raising that might be needed to send a message.
- Infrastructure and funding gaps: Many actions are not implemented due to lack of funding. For example, building the required number of sewage treatment plants in all coastal towns is an immense financial task. The National Strategy on Environmental Protection mentions mobilizing private investment, but incentives or frameworks (like viable wastewater tariffs or PPP models) are still developing . Often, good plans remain on paper (like a plan to collect and treat 100% of craft village wastewater by X year) because budget isn't allocated or projects stall.
- Public awareness and behavior: On ground-level implementation, changing public behavior is crucial for issues like littering and waste segregation. Despite campaigns, many citizens and businesses still dump waste in canals or fail to comply with regulations (e.g., fish processors sometimes flush blood and offal into rivers illegally). This points to gaps in environmental education and engagement – while not strictly enforcement, it's part of the broad implementation challenge. In summary, bridging the gap from policy to action requires boosting technical know-how, consistent and fair enforcement (with strong political backing to environmental authorities to act even against powerful violators), and ensuring that necessary investments and maintenance for pollution control infrastructure are made.

Specifically: lack of technical capacity can hinder tasks like pollutant source tracing or managing complex emergencies, and weak enforcement means laws on paper do not sufficiently deter polluters . Both must be strengthened for meaningful improvement.

3.2.3.5.3 Data Scarcity: Validating Root Causes and Gaps

A persistent challenge is the shortage of comprehensive, high-quality environmental data to inform decisions. For instance, marine water quality monitoring is limited in spatial and temporal coverage; the State of Environment Report 2016-2020 itself noted data gaps in coastal monitoring . Without robust data, pinpointing the worst problems and tracking progress is difficult. Specific gaps:

- Pollutant loading and source data: How much nutrient flows from the Red River each year? What is the exact contribution of aquaculture vs. agriculture to nitrogen in a given bay? These require monitoring and modeling that is currently patchy. Research exists in isolated studies (e.g., some measurements in Red River Delta) but an integrated database or continuous monitoring is lacking.
- Marine ecosystem health indicators: Data on coral reef health, seagrass extent, mangrove water quality filtering, etc., are collected by different agencies or research institutes on irregular projects. A unified system (like a periodic marine ecosystem assessment beyond just water chemistry) would help identify sub-tidal habitat degradation not visible from water samples alone.
- Pollution incident and chronic exposure data: There's incomplete documentation of smaller spills or discharge incidents and their impacts. Often these are anecdotal or reported by media without systematic compilation. Also, long-term health data linking to environmental exposure (e.g., cancer clusters possibly related to water contamination) is not well developed in Vietnam's public health surveillance. These data gaps mean management might not address root causes effectively because of uncertainty – for example, if a fish kill happens, sometimes agencies cannot conclusively identify the cause due to lack of baseline data or timely samples, which hinders accountability and learning to prevent future events.
  Vietnam is moving toward better data collection – installing automatic monitoring at industrial outfalls, participating in UNEP's Global Environmental Monitoring System (GEMS) for water, and developing a national environmental database under MAE. However, a lot of legacy data is fragmented among ministries and provinces.
  A particular gap is sharing of data: various ministries collect environmental data (MAE on fisheries stocks, MAE on water quality, MoH on disease incidence, etc.). Integrating these could provide powerful insights (for example, correlating disease spikes with water quality drops). There is a plan for an integrated coastal zone database being worked on by MAE's Dept of Sea and Islands to serve ICM needs.
  Thus, a priority challenge is to improve environmental monitoring, data management, and transparency. This will validate if measures taken are working and clearly identify where further effort is needed, as well as strengthen early warning for emerging issues (e.g., detection of new

contaminants like microplastics or PFAS requires research and data collection which is currently minimal in Vietnam).

In conclusion, addressing data scarcity is a foundational task, as it underpins evidence-based policy and helps to validate root causes of problems (for instance, confirming through data that a certain river contributes X% of pollutant load to a bay would validate targeting that river's catchment for interventions).

4.2.3.5.4 Financial Constraints

Finally, financial limitations pose a significant hurdle. Pollution control infrastructure and programs demand substantial investment and long-term maintenance:

- Wastewater treatment funding: It's estimated Vietnam needs billions of dollars to build sufficient urban wastewater treatment by 2030. Yet, current budget allocations are not enough, and cost recovery through tariffs is low. Many environmental projects rely on ODA loans/grants (e.g., World Bank loans for drainage in Can Tho or JICA support for HCMC wastewater plant). Over-reliance on external funding could be risky if priorities change.
- Solid waste management costs: Modernizing waste collection fleets, constructing sanitary landfills or WtE plants, and implementing recycling facilities all require capital and operational budgets. There is often a gap between the calculated costs of proper waste management and the fees that can be collected. For example, households pay only a small monthly waste fee, which doesn't cover full service costs . Without subsidization or fee reform, cities struggle to upgrade waste services.
- Maintenance and operation: Even when infrastructure is built, ensuring funds for continuous operation is a challenge. Some smaller towns have had to shut down wastewater plants due to inability to pay electricity and staff. Similarly, environmental monitoring (deploying patrol boats, running labs) is costly and often underfunded, leading to infrequent sampling and patchy enforcement presence.
- Economic pressures: Local governments sometimes prioritize immediate economic development (jobs, tax revenue) over environmental spending, particularly when budgets are tight. This can delay environmental investments or lead to lax enforcement to not "scare off" investors. It's a systemic challenge to align sustainable financing mechanisms – like green taxes, polluter pays schemes – to generate the funds needed.

Vietnam is trying new avenues like public-private partnerships (PPP) for waste treatment (e.g., a PPP contract for Hanoi's Soc Son WtE plant) , and implementing EPR whereby producers finance the recycling of packaging . These could alleviate government burden if done well.

Also, international climate finance or pollution funds might be tapped; for instance, to combat plastic pollution, Vietnam is receiving some international climate/ocean funds due to the synergy with climate adaptation (cleaner coasts are more resilient).

The gap remains, however: environmental spending as a proportion of GDP in Vietnam is still relatively low (not public data easily, but anecdotal evidence suggests it's under 1%). Bridging this gap requires not only more money but better use of money (efficiency, anti-corruption in project execution).

Financial constraints thus slow the roll-out of necessary infrastructure and reduce the scale or speed of response programs, leaving the country vulnerable in the interim. Innovative financing – like environmental bonds or cross-subsidies from polluting industries – could be explored to secure more resources.

In summary, solving Vietnam's coastal pollution challenges is not just technical or administrative – it's equally about finding the financial means and economic models to sustain solutions. Without addressing the funding gap, plans risk being under-implemented, perpetuating the issues we've identified.

3.2.3.6 Recommended Priority Actions (with Emphasis on Regional Cooperation)

To address the identified issues and gaps, a suite of priority actions is recommended. These actions are aimed at preventing and reducing land-based and marine pollution in Vietnam's coastal waters, and many have the added benefit of fostering regional cooperation given the transboundary nature of pollution. Key priority actions include:

3.2.3.6.1 Infrastructure Investment

Accelerating investment in environmental infrastructure is foundational. Vietnam should:

- Expand and upgrade wastewater treatment: Prioritize building wastewater treatment plants in all major coastal cities and industrial hubs by 2030, with interim solutions (e.g., modular or nature-based treatments) for smaller towns. Seek innovative financing (green bonds, PPPs) to raise capital . For example, construct additional plants in the Mekong Delta towns to treat both domestic and aquaculture wastewater before it reaches estuaries. Ensure new developments (industrial parks, tourism zones) have requisite treatment systems upfront (enforce zero liquid discharge or full treatment for new large resorts or IPs).
- Improve waste collection and disposal: Invest in modernizing waste collection fleets (sealed trucks, separate collection vehicles for recyclables/organics) and build regional sanitary landfills or waste-to-energy facilities to eliminate open dumping . A practical goal is to close or rehabilitate all substandard dumps (337 unsanitary sites) within 5 years, replacing them with regulated facilities. This requires central government funding support to poorer provinces. Meanwhile, ramp up

material recovery facilities (MRFs) in each province to reduce landfill loads by sorting and recycling more waste.

- Green infrastructure: Where possible, invest in "green" solutions like constructed wetlands for polishing wastewater in rural areas, mangrove replanting as natural filters/buffers (plant mangroves along 70% of Mekong coastal mudflats where erosion isn't too severe, which also helps trap pollutants) . These are cost-effective and climate-resilient. For instance, expand mangrove rehabilitation programs in the Red River delta (Xuan Thuy, etc.) to enhance nutrient uptake and shoreline stability.
- Monitoring and early warning systems: Invest in a national coastal water quality monitoring network with real-time sensors at river mouths and key marine sites. Tie this with an early warning system for red tides or pollution incidents (perhaps using satellite imagery and modeling). Regionally, share this data with neighbors – e.g., connect with China and ASEAN partners on a East Vietnam Sea / South China Sea monitoring initiative for timely alerts of cross-border pollution .

3.2.3.6.2 Strengthened Enforcement

Improve enforcement of existing regulations to ensure polluters are held accountable and deter future violations:

- Increase inspection frequency and capacity: Expand the Environmental Police unit and provincial inspector teams. Provide them with better tools (drones to spot illegal discharges, portable water test kits). Surprise inspections should particularly target known hotspots (industrial clusters along Thi Vai, craft villages in Bac Ninh, etc.) at off-peak hours. Over the next 3 years, aim to inspect all high-risk facilities (e.g., chemical plants, large farms) at least once per year.
- Toughen penalties: Apply the full range of sanctions available, including higher fines (updated via decree if needed to reflect true environmental damage costs) and, where appropriate, suspension of operations for recalcitrant polluters. Publicize enforcement actions to send a message. For example, if a factory illegally dumps waste into a river, impose the maximum fine and require it to pay cleanup costs and compensation to affected communities (this is allowed under LEP).
- Judicial action: Encourage utilization of criminal provisions in severe cases to prosecute environmental crimes. Train prosecutors and judges on environmental law (with support from e.g. UNDP or ASEAN Judicial forums). One landmark prosecution of a major polluter could greatly boost compliance consciousness.
- Community monitoring and whistleblower support: Engage local communities as eyes and ears. Implement hotlines and reward systems for reporting violations leading to enforcement . Protect whistleblowers legally to encourage inside reporting from industry workers about secret

pollution. Vietnam's mass fish kill protests in 2016 show community will act if government doesn't; better to integrate them proactively.

Regionally, strengthened enforcement has a cooperative dimension: Vietnam can share techniques and coordinate on transboundary enforcement (e.g., joint patrols in border rivers for illegal dumping, joint crackdowns on vessels violating MARPOL in the East Vietnam Sea / South China Sea with neighboring coast guards) .

3.2.3.6.3 Watershed Management

Adopt an integrated watershed and coastal zone management approach to tackle pollution at source:

- Upstream pollution control: Work with MARD and provincial authorities to reduce agricultural runoff. Promote best management practices (BMPs) in agriculture: precision fertilizer application, organic farming, riparian buffer strips . Aim to cut chemical fertilizer use by, say, 10% in 5 years in key basins (Red River, Mekong) through education and subsidies for organic alternatives. Expand biogas digesters and waste treatment in livestock farms to curb manure runoff. For aquaculture, enforce effluent treatment ponds in shrimp farms and encourage more closed-loop systems (recirculating aquaculture) to reduce discharges.
- River basin committees: Strengthen or establish inter-provincial river basin organizations (RBOs) for major rivers (existing for Dong Nai, planned for Red River) with real power to set effluent load limits and coordinate pollution control among provinces. Use these bodies to implement a "pollutant load reduction plan" for each basin, based on scientific analysis of how much reduction is needed to achieve water quality goals downstream.
- Protect and restore natural filters: Conserve wetlands, floodplains, and forests in watersheds that naturally trap sediments and pollutants. Implement reforestation in critical hillslopes to reduce erosion (e.g., in central Vietnam steep watersheds feeding sediment into coastal lagoons). Restoration of mangroves and estuarine wetlands, as mentioned, also fits here as part of integrated watershed-to-coast planning .
- Transboundary cooperation: Continue and enhance dialogue with upstream countries (China for Red, Lancang-Mekong Cooperation for Mekong) to manage water quality. Possibly propose a joint Mekong water quality agreement that includes regular data sharing and commitment to pollution reduction. Also engage in the new "Asean Working Group on Water Resources Management" to align watershed efforts regionally.

Effective watershed management will drastically cut land-based pollutant entry into coastal waters, tackling problems at their roots.

3.2.3.6.4 Circular Economy and Waste Reduction

Accelerate the shift to a circular economy to address waste at all stages:

- Implement Extended Producer Responsibility (EPR): Under new regulations, ensure producers of packaging, electronics, etc., finance or organize the collection and recycling of their products . Set clear targets (e.g., producers must recycle 50% of packaging they put out by 2025, rising thereafter). This will reduce plastic and hazardous waste leakage. Already, the formation of a Packaging Recycling Organization Vietnam (PRO Vietnam) is a step; support and monitor such initiatives for efficacy.
- Promote eco-design and substitution: Encourage industries to redesign products to use less material and less toxic material. For example, promote alternatives to single-use plastics (like biodegradable materials or reuse systems). Vietnam's upcoming ban on certain single-use plastics by 2025 should be reinforced by helping businesses adopt alternatives and by education campaigns to change consumer behavior (bring your own bag, etc.).
- Waste reduction campaigns: Launch national and local campaigns akin to "Zero Waste Cities" model. For instance, start with pilot cities or communities that commit to reducing waste generation per capita by X%. Provide them with technical assistance (composting at source, etc.). Da Nang or Hoi An might be good pilots given their tourism interest in being seen as green.
- Recycling and market development: Develop markets for recycled materials to ensure economic viability. This can include government procurement policies favoring recycled content (for example, use recycled plastic in public works where suitable). Also, invest in modern recycling facilities to improve efficiency and output quality, making recycled goods more competitive.
- Upgrading informal sector integration: Assist informal waste pickers to formalize into cooperatives or social enterprises, so they can be supported (with microcredit, better equipment, safety training) and linked into the municipal waste management chain as legitimate recycling service providers, which can significantly boost recycling rates and livelihoods.

By embracing circular economy practices, Vietnam will reduce the total volume of waste that could pollute the environment, thereby easing the burden on end-of-pipe solutions and turning waste into economic resources.

3.2.3.6.5 Collaborative Governance

Foster collaborative governance models both domestically and internationally:

- Multi-stakeholder involvement: Form environmental management boards or committees that include government agencies, local communities, businesses, and NGOs for key areas (e.g., a committee for Ha Long Bay management or the Mekong Delta coastal management). Such platforms ensure each stakeholder's perspective is heard and responsibilities shared. For example, industries could voluntarily commit to targets in these forums beyond compliance (CSR initiatives to clean local beaches, etc.).

- Regional and international cooperation: Continue to strengthen ties with ASEAN, MRC, PEMSEA, etc., as noted, but move from planning to joint actions. For instance, initiate a Gulf of Tonkin Environmental Partnership with China to jointly manage that semi-enclosed sea's environment – actions could include coordinated oil spill response drills, or synched seasonal fishing and pollution control measures (like both countries not discharging dredge spoils in sensitive period). Similarly, push within ASEAN for a regional agreement on plastic pollution akin to the model of the Bonn Agreement for oil spills in Europe.
- Capacity building through partnerships: Use collaborative networks to build capacity – e.g., twinning of Vietnamese coastal cities with cities abroad that have good practices. Danang could partner with, say, San Francisco (for zero waste strategies) or Nha Trang with Australia's Great Barrier Reef authorities (for reef management under tourism).
- Public participation and transparency: Foster a culture of collaboration with the public by enhancing transparency (publish pollution data online in near real-time – an effort already started with some air quality data, extend to water quality). Citizens can only effectively participate if informed; thus, publish an annual "State of the Coasts" report accessible to the general public, highlighting progress and setbacks.
- Pollution incident cooperation: On transboundary emergency response, formalize agreements (like the recently approved National Plan for oil spills can be supplemented by MoUs with other ASEAN states to assist each other with equipment if a big spill occurs). Also, join global initiatives such as the Global Ghost Gear Initiative (GGGI) to tackle abandoned fishing gear, which is a cross-border marine debris issue – collaboration can yield shared best practices for gear retrieval and prevention.

By employing collaborative governance, Vietnam will ensure that solutions are more holistic, accepted by stakeholders, and effectively implemented. The complexity of land-based and marine pollution requires such cooperation – no single entity can solve it alone. Emphasizing partnerships and co-management can fill institutional and resource gaps by pooling knowledge, effort, and funds.

In conclusion, implementing these priority actions – investing in infrastructure, tightening enforcement, managing pollution at the watershed level, advancing circular economy, and enhancing collaborative governance – will significantly mitigate pollution in Vietnam's coastal waters. It will also demonstrate Vietnam's commitment to regional leadership in marine environmental protection, reinforcing cooperative efforts that amplify the impact of Vietnam's own measures. These actions align with national goals for a "blue economy" and sustainable coastal development, ensuring that Vietnam's marine resources can support prosperity for generations to come.

3.3 Methodology and Analysis

The methodology underpinning this technical report combines qualitative and quantitative approaches to analyze pollution status and management in Vietnam's coastal waters from 2020 to present. It draws on a variety of data sources and analytical frameworks to ensure a comprehensive and evidence-based evaluation.

3.3.1 Analytical Approach

This assessment employs a DPSIR framework – Driver, Pressure, State, Impact, Response – to systematically examine the pollution issue . Under this model:

- Drivers (socio-economic causes, e.g., urbanization, industrialization, population growth in coastal areas) are identified as underlying factors increasing pollution loads.
- Pressures (direct pollutant releases, e.g., discharge of untreated wastewater, solid waste dumping, agricultural runoff) are quantified where possible. We compiled recent statistics (2020 onward) on waste generation, effluent volumes, etc., from government reports and academic studies.
- State refers to the condition of the environment. We reviewed monitoring data on coastal water quality parameters (DO, nutrient concentrations, coliform counts, etc.) and ecological indicators (e.g., coral reef cover, seagrass extent) to gauge environmental health. Data sources included Vietnam's national State of the Environment Report 2016–2020 , research articles (many from 2020–2024 to capture latest findings), and regional datasets (COBSEA, MRC water quality data).
- Impacts on ecosystems, health, and economy were evaluated by integrating field data (like fish kill reports, contamination levels in seafood) with socio-economic information (fisheries statistics, tourism revenue, health records of disease outbreaks). We also used case studies (e.g., the 2016 Ha Tinh fish kill incident, recent microplastic studies) to illustrate cause-effect relationships.
- Responses (policy and management interventions) were analyzed by reviewing legal documents, government plans, and project outcomes. We looked at 2020–2025 policy updates such as the new Law on Environmental Protection (2020) and the National Action Plan on Marine Plastic Debris, assessing their implementation status via government progress reports and stakeholder interviews (when available from literature or news sources).

Geospatial analysis was used to map hotspots; for instance, GIS data on land use and discharge points helped correlate heavy pollution zones with upstream sources. Temporal analysis (pre-2020 vs. post-2020) was done where data allowed, to detect recent trends (improvements or deteriorations) in pollutant levels and ecosystem health. Given the recency focus, much data came from 2020–2024 publications and monitoring, ensuring the report reflects current conditions.

We also applied a risk assessment lens to identify and prioritize issues by severity and likelihood, as presented in section 2.3.3. This involved expert judgment and, where available, modeling outcomes (for example, oil spill trajectory modeling results from PEMSEA and others to judge transboundary risk).

The approach is inherently interdisciplinary, combining natural science (marine ecology, hydrology, chemistry) with social science (policy analysis, economics). Triangulation of evidence was key: we cross-verified information from different sources. For instance, if official data said a wastewater treatment rate was X%, we checked it against any independent audits or project evaluations to confirm reliability. Divergences (like differing estimates of plastic waste generation) are noted and reasoned through in the text.

Furthermore, stakeholder perspectives (government, community, industry) were considered via secondary sources – e.g., media interviews with officials or community leaders were used to gauge enforcement challenges and public sentiment. While no primary surveys were conducted for this report due to its scope, reliance on up-to-date literature and reported stakeholder inputs gave a balanced view.

3.3.2 Validation

The information and conclusions in this report have been validated through multiple means:

- Use of credible sources: We prioritized official publications ((NOW MINISTRY OF AGRICULTURE AND ENVIRONMENT - MAE)'s reports , MARD statistics, international organizations' studies) and peer-reviewed journal articles for data points. Each critical fact is sourced from reliable references (as evidenced by the numerous citations).
- Cross-referencing data: Important metrics (e.g., "23 million tons of household waste annually") were cross-checked against more than one source to ensure consistency. If discrepancies arose, we investigated likely reasons (different years, definitions) and chose the most current or authoritative figure.
- Expert consultation (indirect): Although this report didn't involve direct interviews, it leverages works by experts. For example, the section on coral reef loss cites a study by coral ecologist Dr. K.S. Tkachenko (2021) , which itself went through scientific peer validation. Similarly, many data points on waste and water quality come from World Bank or UN reports that underwent their own validation processes.

- Logical consistency checks: We examined whether trends and impacts described align logically (does the described impact follow from the pressure given known science?). For instance, if nutrient levels are high and reports of algal blooms exist, that is consistent. We flagged any anomalies (none major were found beyond normal variance).
- Comparative benchmarking: Where possible, we compared Vietnam's data with regional figures to sense-check. E.g., Vietnam's plastic waste mismanagement (some older studies) was compared to similar economies to ensure our statements on Vietnam being a top marine plastic source are valid .
- Feedback from existing reviews: The State of Environment Report 2016–2020 underwent review by Vietnam's scientific council; its findings (e.g., identification of continuing complex pollution at craft villages) were taken as validated by that process.
- Triangulating qualitative judgments: For risk and priority actions, validation came from observing convergence in recommendations across sources. The recommended actions in section 2.3.6 echo suggestions from multiple policy papers (UNEP, World Bank, ADB) – indicating consensus on their validity.

All analysis steps and assertions have been traced to sources via citations in the report to enable readers to verify claims (the references list at the end provides full details for transparency and further validation). Limitations in available data are openly acknowledged (e.g., noting data gaps in water quality monitoring), which is part of validating that conclusions are drawn within the constraints of evidence.

3.3.3 Limitations

While comprehensive, this study has certain limitations:

- Data limitations: As noted, consistent time-series data for some parameters (especially post-2020) are lacking. The COVID-19 pandemic in 2020–2021 also disrupted some field monitoring (e.g., fewer surveys in those years), potentially limiting data recency for certain indicators. We mitigated this by using 2022–2024 studies wherever available (for example, 2023 papers on Ha Long Bay water quality).
- Scope of pollution types: The focus is broad (nutrients, solid waste, hazardous chemicals, oil, etc.). Some emerging contaminants like microplastics or pharmaceuticals, which have fewer studies in Vietnam yet, may not be quantified in detail. We included discussion qualitatively but could not deeply analyze their state due to limited data. This means the report may understate those if they turn out to be significant.
- Attribution of impact: In complex ecosystems, attributing an impact solely to pollution is challenging. Coral reefs, for example, are also affected by ocean warming and overfishing. We have tried to attribute conservatively (stating pollution as a contributing factor among others and citing

evidence for it). Nevertheless, there is some uncertainty in impact assessment as multiple stressors interplay.

- Geographical balance: Vietnam's coastline is long; data coverage is uneven (more in developed areas, less in remote coasts). Our analysis might emphasize areas like the Red River Delta, central tourist zones, and HCMC/Mekong Delta where data abound, whereas some northern central provinces or minor islands get less mention. The assumption is issues there are analogous to similar contexts covered.
- Policy implementation analysis: We reviewed written policies and anecdotal reports of enforcement, but a full audit of implementation effectiveness was beyond scope. Thus our evaluation of management effectiveness is qualitative, relying on reported outcomes or lack thereof (e.g., noting that despite laws, wastewater treatment is still only ~15% in urban areas). There could be on-ground progress not captured in publications yet.
- Future projections: The report largely assesses current and past trends; forecasting future scenario (e.g., how climate change will exactly alter pollution dispersion) was limited. Risk assessment qualitatively addresses plausible futures but not with quantitative modeling due to resource constraints.
- Regional factors: We assume continued regional cooperation but political or economic changes regionally (e.g., if upstream countries build more dams or loosen environmental regs) could alter transboundary pollutant flows beyond what current agreements mitigate. This uncertainty is hard to fully incorporate except to stress cooperation need.

Acknowledging these limitations ensures a cautious interpretation of findings. Where data or knowledge gaps exist, we recommended measures in section 2.3.5 (like improved monitoring, research). This report should thus be seen as a robust but not infallible basis for action; adaptive management is advised, where strategies are refined as more data become available or as conditions evolve (particularly with climate change impacts accelerating).

Continued research and periodic reassessment (for example, a follow-up evaluation in 2025 or 2030 with fresh data) are recommended to update findings and adjust recommendations accordingly, ensuring Vietnam's pollution management remains effective and evidence-based over time.

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(Additional references used for this report are to be added further)

CHAPTER 4. ECOSYSTEMS

4.1. Key findings

Vietnam's coastal and marine ecosystems represent critically important natural assets that provide essential ecological services supporting millions of livelihoods while contributing significantly to national climate resilience objectives. This comprehensive assessment synthesizes the current status of three interconnected blue carbon ecosystems: mangrove forests, seagrass meadows, and coral reef systems, drawing upon extensive field surveys, remote sensing analyses, and institutional data spanning multiple decades.

The national mangrove estate encompasses approximately 168,538 hectares as of 2019, representing a 7.3% net decline from the 1995 baseline of 181,724 hectares. This aggregate trend, however, masks substantial regional heterogeneity. The Mekong Delta provinces collectively harbor approximately 80% of national mangrove coverage, with Ca Mau Province alone maintaining 55,743 hectares representing the largest contiguous mangrove formation in the country. Critically, between 2016 and 2020, several provinces demonstrated recovery trajectories, including Soc Trang with 25.1% expansion and Bac Lieu with 20.8% gains, attributable to coordinated restoration initiatives. Conversely, Ba Ria Vung Tau experienced catastrophic losses of 40.8%, driven by severe coastal erosion processes.

Seagrass ecosystems present a more concerning trajectory, with national coverage estimated at approximately 17,000 hectares distributed across fourteen species assemblages. Historical analyses indicate that seagrass extent has declined by more than 50% since baseline surveys in the 1990s, with particularly severe losses documented in the Tam Giang-Cau Hai Lagoon system where coverage contracted from 2,450 hectares in 1999 to approximately 1,000 hectares by recent assessments, representing a 60% reduction. Phu Quoc Island retains the largest seagrass formation at 10,063 hectares, providing critical foraging habitat for endangered dugong populations.

Coral reef systems span the Vietnamese coastline from the Gulf of Tonkin to the Gulf of Thailand, supporting more than 340 Scleractinia species. Contemporary condition assessments reveal substantial degradation, with only 1.4% of surveyed reefs exhibiting excellent condition (greater than 75% live coral cover) while 37.3% are classified as poor (less than 25% cover). The Nha Trang Bay case study illustrates the extreme spatial heterogeneity of reef conditions, with offshore sites maintaining up to 75% coral cover while nearshore localities adjacent to river discharge and dredging operations exhibit cover values as low as 0.6%, representing a virtual elimination of reef structure.

Blue carbon stocks within Vietnamese mangrove systems are estimated at 844 to 889 Mg C per hectare of total ecosystem carbon, with national climate mitigation potential of 4.41 million tonnes CO_2 equivalent for the 2021-2030 period under current policy frameworks. The economic valuation of ecosystem services, while subject to substantial methodological uncertainty, indicates mean values of USD 4,185 per hectare per year for mangrove systems, encompassing fisheries support, coastal protection, and carbon sequestration functions.

Governance arrangements for coastal ecosystems remain fragmented across the Ministry of Agriculture and Rural Development for forest management, the Ministry of Natural Resources and Environment for marine protection, and Provincial People's Committees for land-use planning and enforcement. The Marine Protected Area system currently encompasses twenty designated sites with proposals to expand to thirty, yet implementation effectiveness remains constrained by insufficient funding, enforcement capacity deficits, and continued incursion of destructive fishing practices.

4.2. Current Status by Ecosystem and by Indicator

4.2.1 Mangroves and Coastal Wetlands

4.2.1.1 National Extent and Temporal Dynamics

Vietnam's mangrove forests constitute a nationally significant natural resource distributed along approximately 3,260 kilometers of coastline. Comprehensive remote sensing analysis utilizing Landsat satellite imagery processed through the Google Earth Engine platform reveals that national mangrove extent totaled 168,538 hectares in 2019, representing the culmination of complex spatiotemporal dynamics over the preceding quarter century. Comparison with the 1995 baseline of 181,724 hectares indicates a net reduction of 13,186 hectares, equivalent to a 7.3% decline over the 24-year assessment period.

However, this aggregate trajectory masks substantial intra-period variability. Between 1995 and 2010, mangrove area declined to 156,667 hectares, representing a loss of 25,057 hectares or 13.8% contraction. The subsequent 2010-2019 period witnessed partial recovery, with net gains of 11,871 hectares representing 7.6% expansion. This reversal reflects the implementation of national restoration policies, enhanced legal protections, and the maturation of planted forests established in earlier decades. The temporal pattern underscores both the vulnerability of mangrove systems to anthropogenic pressures and their capacity for recovery when appropriate management interventions are sustained.

4.2.1.2 Zonal Distribution and Characteristics

Vietnam's mangrove distribution exhibits pronounced latitudinal zonation reflecting underlying gradients in climate, hydrology, and geomorphology. The national territory can be disaggregated into four principal biogeographic zones, each characterized by distinctive mangrove assemblages and management challenges.

Table 1: Zonal Distribution of Mangrove Area (1995-2019)

Zone	1995 (ha)	2010 (ha)	2019 (ha)	Change (%)
I. Northeast (NE)	31,038	19,752	20,486	-34.0%

II. Red River Delta (RD)	12,637	11,477	14,127	+11.8%
III. Central Coast (CC)	7,681	2,571	2,508	-67.3%
IV. Mekong Delta (SE+SW)	130,368	122,867	131,417	+0.8%
National Total	**181,724**	**156,667**	**168,538**	**-7.3%**

Source: Pham Hong Tinh et al. (2022), Landsat/GEE analysis

Figure 1 illustrates the uneven spatial distribution of these forests, highlighting the two primary centers of concentration: the extensive Mekong Delta system in the south and the notable mangrove formations in the Hai Phong - Quang Ninh area in the north.

FIGURE 1: SPATIAL DISTRIBUTION OF MANGROVE FORESTS ALONG THE COAST OF VIETNAM.

Note: The map highlights the significant density of mangrove cover (green)

Zone I (Northeast Region) encompasses the complex karst geomorphology of Quang Ninh Province, including Ha Long Bay and Bai Tu Long Bay. This region experienced severe losses between 1995 and 2010, with area declining from 31,038 to 19,752 hectares, representing a 36.4% reduction. The subsequent period showed modest recovery to 20,486 hectares by 2019. Environmental conditions in this zone are characterized by the northeast monsoon influence, substantial tidal amplitude variation, and highly indented coastlines creating diverse microhabitats.

Zone II (Red River Delta) represents the prograding deltaic system of the Thai Binh and Red River systems. Mangrove area in this zone increased from 12,637 hectares in 1995 to 14,127 hectares in 2019, representing an 11.8% net expansion. This positive trajectory reflects successful restoration efforts initiated in the 1990s, particularly in Thai Binh Province where 1,399 hectares of planted forests have matured. Historical records indicate that Nam Dinh Province experienced approximately 63% conversion of original mangrove extent to shrimp ponds by 2001, yet subsequent policy interventions have partially reversed these losses.

Zone III (Central Coast) exhibits the most severe proportional decline, with mangrove area contracting from 7,681 hectares in 1995 to merely 2,508 hectares by 2019, representing a 67.3% reduction. This zone experiences the narrowest coastal plains, highest wave energy exposure, and most intensive infrastructure development pressures. Analysis of 263 documented coastal erosion sites indicates that geomorphic constraints severely limit restoration potential in many localities. Infrastructure development accounts for 21.2% of conversions in this zone, substantially exceeding the national average of 9.4%.

Zone IV (Mekong Delta, combining Southeast and Southwest subzones) harbors approximately 78% of national mangrove coverage and exhibited net stability over the assessment period, declining from 130,368 hectares to 122,867 hectares between 1995 and 2010 before recovering to 131,417 hectares by 2019. This region benefits from optimal hydrological conditions supplied by the Mekong and Dong Nai river systems, extensive deltaic sediment deposition, and relatively lower infrastructure development pressures compared to northern regions.

4.2.1.3 Provincial-Level Analysis: Mekong Delta

Disaggregated analysis of the Mekong Delta provinces reveals substantial heterogeneity in mangrove dynamics between 2016 and 2020, reflecting differential exposure to anthropogenic pressures and natural hazards, as well as varying effectiveness of provincial management interventions.

Table 2: Mekong Delta Provincial Mangrove Changes (2016-2020)

Province	2016 (ha)	2020 (ha)	Change (ha)	Change (%)
Ca Mau	53,924	55,743	+1,819	+3.4%
Ho Chi Minh City (Can Gio)	33,029	32,404	-625	-1.9%

Soc Trang	5,506	6,889	+1,383	+25.1%
Bac Lieu	2,905	3,510	+605	+20.8%
Ba Ria Vung Tau	2,790	1,652	-1,138	-40.8%
Kien Giang	5,417	5,234	-183	-3.4%
Ben Tre	4,770	5,069	+299	+6.3%
Tra Vinh	3,247	2,721	-526	-16.2%
Tien Giang	1,617	1,763	+146	+9.0%

Source: Pham Thu Thuy et al. (2022), CIFOR Working Paper

Ca Mau Province maintains the largest provincial mangrove estate, expanding from 53,924 to 55,743 hectares between 2016 and 2020, representing a 3.4% increase. District-level analysis within Ca Mau reveals that Ngoc Hien District accounts for the largest absolute gains, expanding from 32,039 to 34,093 hectares, a 6.4% increase attributable to successful coastal restoration projects supported by international development partners. Nam Can District similarly exhibited positive trajectories with 3.1% expansion. Conversely, Dam Doi District experienced a 7.1% decline from 5,506 to 5,115 hectares, while Tran Van Thoi District suffered severe losses of 22.4%, from 1,136 to 882 hectares, driven by intensified coastal erosion.

The Can Gio Mangrove Biosphere Reserve in Ho Chi Minh City, designated as a UNESCO Biosphere Reserve in 2000, experienced a modest 1.9% decline from 33,029 to 32,404 hectares. This slight contraction reflects ongoing pressures from urban expansion and infrastructure development despite formal protection status. The Reserve encompasses approximately 75,740 hectares total area including buffer zones, with the core mangrove forest representing a critical ecological corridor connecting the Dong Nai River system to the South China Sea.

The most alarming provincial trajectory is observed in Ba Ria Vung Tau, where mangrove area contracted catastrophically from 2,790 to 1,652 hectares, representing a 40.8% loss over merely four years. This dramatic decline is attributed to severe coastal erosion processes exacerbated by upstream hydrological modifications and the intensification of extreme weather events associated with climate change. Similarly, Tra Vinh Province experienced a 16.2% reduction from 3,247 to 2,721 hectares, reflecting ongoing conversion pressures and coastal erosion.

Positive trajectories in Soc Trang (25.1% increase) and Bac Lieu (20.8% increase) provinces demonstrate the potential for mangrove recovery when restoration initiatives are sustained and coordinated with community-based management approaches. These provinces have implemented integrated coastal zone management frameworks that balance aquaculture development with mangrove conservation objectives, achieving measurable rehabilitation outcomes.

Table 2b: Ca Mau Province District-Level Mangrove Changes (2016-2020)

District	2016 (ha)	2020 (ha)	Change (ha)	Change (%)

Ngoc Hien	32,039	34,093	+2,054	+6.4%
Nam Can	11,845	12,216	+371	+3.1%
Dam Doi	5,506	5,115	-391	-7.1%
Phu Tan	2,930	3,059	+129	+4.4%
Tran Van Thoi	1,136	882	-254	-22.4%
U Minh	468	378	-90	-19.2%

Source: Pham Thu Thuy et al. (2022), CIFOR Working Paper

District-level analysis within Ca Mau Province reveals substantial intra-provincial heterogeneity in mangrove dynamics. Ngoc Hien District, located at the southernmost tip of the Mekong Delta, accounts for the majority of Ca Mau's mangrove estate and exhibited the largest absolute gains, expanding from 32,039 to 34,093 hectares between 2016 and 2020, representing a 6.4% increase. This positive trajectory reflects successful implementation of large-scale restoration projects supported by international development partners including GIZ, USAID, and the World Bank, combined with community-based forest protection agreements that provide livelihood incentives for mangrove conservation.

Conversely, Tran Van Thoi District experienced severe losses of 22.4%, contracting from 1,136 to 882 hectares over the four-year period. This decline is attributed primarily to intensified coastal erosion along the western coastline, where sediment deficits and altered wave dynamics have undermined forest stability. Similarly, U Minh District lost 19.2% of its mangrove coverage, declining from 468 to 378 hectares. These districts face the dual challenges of erosion pressure and conversion pressure for aquaculture expansion, requiring integrated management approaches that address both natural and anthropogenic drivers.

4.2.1.4 Species Composition and Floristic Assemblages

Vietnamese mangrove ecosystems support diverse floristic assemblages exhibiting pronounced latitudinal differentiation. The southern Mekong Delta region harbors the highest species richness, with dominant assemblages including Rhizophora apiculata, Rhizophora mucronata, Bruguiera cylindrica, Bruguiera parviflora, Avicennia alba, Avicennia officinalis, and Sonneratia alba. These species are largely restricted to southern latitudes, benefiting from year-round warm temperatures and reduced seasonal variation.

Northern mangrove assemblages exhibit distinct floristic composition reflecting lower minimum temperatures and more pronounced seasonality. Characteristic species include Myoporum bontioides and Scaevola hainanensis, which are adapted to the subtropical climate regime of the Gulf of Tonkin. The transitional Central Coast zone exhibits intermediate species composition with reduced overall diversity attributable to narrower coastal plains and higher wave energy exposure.

Restoration programs in the Red River Delta have historically emphasized Rhizophora stylosa, Kandelia candel, and Sonneratia caseolaris, species selected for their tolerance to the more challenging environmental conditions of northern Vietnam including occasional frost exposure and higher turbidity regimes. In contrast, southern restoration efforts predominantly utilize Rhizophora apiculata due to its rapid growth rates, high survival under ambient conditions, and substantial timber value.

4.2.1.5 Drivers of Mangrove Change

Analysis of land-use transition matrices reveals that aquaculture expansion constitutes the dominant driver of mangrove conversion nationally, accounting for 43.4% of observed losses. This driver exhibits substantial regional variation, with the Red River Delta zone recording 54.6% of conversions attributable to aquaculture, while the Central Coast zone recorded 42.3% and the Southwest zone 45.4%.

Table 3: Proportional Contribution of Land-Use Transition Drivers by Zone (%)

Driver	NE	RD	CC	SE	SW	Nation
Aquaculture	47.6	54.6	42.3	37.4	45.4	43.4
Agriculture	14.6	12.6	14.1	29.1	24.7	24.8
Infrastructure	15.0	15.8	21.2	11.6	6.3	9.4
Coastal erosion	5.5	7.9	5.6	12.3	21.2	16.3
Bare land	14.7	5.9	12.7	6.7	1.5	4.1
Other	2.6	3.2	4.1	2.9	0.9	2.0

Source: Pham Hong Tinh et al. (2022). NE=Northeast, RD=Red River Delta, CC=Central Coast, SE=Southeast, SW=Southwest

Agricultural conversion represents the second-largest driver at 24.8% nationally, with particularly high proportional contribution in the Southeast (29.1%) and Southwest (24.7%) zones where rice cultivation and mixed farming systems compete directly with mangrove habitat. Infrastructure development accounts for 9.4% of conversions nationally but reaches 21.2% in the Central Coast zone, reflecting intensive port, industrial, and urban development along this narrow coastal corridor.

Coastal erosion and inundation (transition to water body) emerges as an increasingly significant driver, particularly in the Southwest zone where it accounts for 21.2% of observed losses. This pattern reflects the intensification of extreme weather events, sea-level rise impacts, and altered sediment dynamics resulting from upstream dam construction and channel modifications throughout the Mekong basin.

4.2.1.6 Blue Carbon Stocks and Climate Mitigation Potential

Vietnamese mangrove ecosystems harbor substantial carbon stocks with significant climate change mitigation potential. Ecosystem carbon density estimates range from 844 to 889 Mg C per hectare when accounting for above-ground biomass, below-ground root biomass, and soil organic carbon pools to depths of one meter. Above-ground biomass stocks range from 70 to 150 tonnes per hectare depending on forest age, species composition, and site conditions.

Under Vietnam's Nationally Determined Contribution framework and associated policy instruments, the national climate mitigation potential from mangrove restoration is estimated at 4.41 million tonnes CO_2 equivalent for the 2021-2030 planning period. Decision 770/QD-TTg established adjusted targets of 21,600 hectares for new mangrove plantation during 2021-2025, building upon previous commitments under Decision 120/QD-TTg which aimed to protect 310,695 hectares, rehabilitate 9,602 hectares, and plant 46,058 hectares by 2020.

The substantial carbon values underscore the economic justification for mangrove conservation within both national and international climate finance frameworks. However, realizing this potential requires addressing persistent monitoring gaps, including the absence of systematic survival rate tracking for restoration projects and limited verification of carbon accumulation rates under varying site conditions.

4.2.2 Seagrass Ecosystems

4.2.2.1 Introduction and Global Context

Seagrasses are marine angiosperms that recolonized the marine habitat approximately 100 million years ago during at least three independent evolutionary events. These foundation species are found along thousands of kilometers of sedimentary shorelines ranging from tropical to temperate regions, occurring in diverse aquatic conditions including hypersaline, marine, or brackish water at estuarine, nearshore, subtidal, and intertidal environments. Seagrasses provide essential ecosystem services including oxygen production, habitat provision for marine fauna, nutrient recycling, and carbon sequestration, representing one of the most significant natural carbon sinks on Earth.

Globally, seagrass populations are suffering alarming decline driven by pressures linked directly to human activities including ocean warming, coastal modification, and water quality degradation. Seagrasses are disappearing at a rate of approximately 110 km^2 per year, with 29% of the total world seagrass population lost between 1980 and 2006. In the Southeast Asian region, recent analyses indicate that more than 60% of seagrass meadows have declined at an average rate of 10.9% per year, while only 20% of beds increased at an average rate of 8.1% per year, yielding an overall average decline of 4.7% per year across the region.

Vietnam is located in the central part of Southeast Asia, recognized as the evolutionary origin center of seagrasses. The country encompasses three seagrass ecoregions including the Gulf of Tonkin (N020112), Gulf of Thailand (N020115), and southern Vietnam (N020116). Vietnam's exceptionally long latitudinal coastline of 3,260 kilometers, spanning from Mong Cai (21°31'N) in the north to Ha Tien (10°22'N) in the south, covers cool to warm water environments, resulting in high seagrass species diversity and substantial intraspecific plasticity.

4.2.2.2 National Extent and Temporal Dynamics

The total seagrass area in Vietnam was estimated to cover approximately 29,162 hectares in 1990. Contemporary assessments indicate a current distribution of approximately 15,613 hectares across 28 coastal provinces, representing a catastrophic decline of 46.5% or loss of 13,549 hectares over approximately three decades. This decline has occurred across almost all regions of Vietnam, with increases observed only in a few protected and difficult-to-reach areas where reduced anthropogenic pressure has enabled natural recovery or where active protection measures have been implemented.

The Vietnamese coastline is divided into four biogeographic regions for seagrass assessment: Region 1 (Northeast, Gulf of Tonkin), Region 2 (North Central), Region 3 (South Central), and Region 4 (Southern Vietnam including Mekong Delta and islands). Each region exhibits distinctive seagrass assemblages reflecting underlying gradients in temperature, salinity, substrate characteristics, and anthropogenic pressure intensity.

Table 4: Seagrass Distribution and Species Diversity by Region

Region	Provinces	Area (ha)	Species Composition
1. Northeast	5	2,240	Halophila beccarii, H. ovalis, Ruppia maritima
2. North Central	6	2,655	H. beccarii, Halodule uninervis, R. maritima, Zostera japonica
3. South Central	8	3,109	H. beccarii, H. decipiens, H. ovalis, H. major, H. minor, Halophila sp., Enhalus acoroides, Thalassia hemprichii, Thalassodendron ciliatum, Cymodocea rotundata, C. serrulata, H. uninervis, Halodule pinifolia, Syringodium isoetifolium, R. maritima
4. Southern	9	7,609	H. beccarii, H. decipiens, H. ovalis, H. major, H. minor, Halophila sp., E. acoroides, T. hemprichii, C. rotundata, C. serrulata, H. uninervis, H. pinifolia, S. isoetifolium
National Total	28	15,613	15 species including putative Halophila hybrids

Source: Nguyen et al. (2022), Frontiers in Plant Science; compiled from Cao et al. (2014, 2019, 2020), Nguyen et al. (2021)

While Table 4 outlines the statistics by region, Figure 2 visualizes the scattered locations of these seagrass meadows, highlighting key habitats in both nearshore waters and offshore island groups.

FIGURE 2 SEAGRASS

The map depicts known seagrass locations (teal).

Region 1 (Northeast) encompasses 12 seagrass meadows distributed across 5 provinces with a total area of 2,240 hectares. This region supports only three seagrass species (Halophila beccarii, H. ovalis, and Ruppia maritima) reflecting the subtropical climate and cooler winter temperatures of the Gulf of Tonkin.

Region 2 (North Central) contains two major seagrass formations localized at the Tam Giang-Cau Hai lagoon system (2,037 ha) and a nearby area (618 ha), totaling 2,655 hectares across 6 provinces. Four species occur in this region including Zostera japonica, which reaches its southernmost distribution in central Vietnam around 13.8°N latitude.

Region 3 (South Central) represents the most well-studied region with numerous geographically suitable habitats including lagoons, bays, islands, islets, atolls, and reefs providing diverse seagrass habitats. The total area of 3,109 hectares supports the highest species diversity with 15 species recorded, including the full complement of tropical Indo-Pacific seagrass flora.

Region 4 (Southern Vietnam) harbors the largest seagrass extent at 7,609 hectares across 9 provinces, dominated by the extensive Phu Quoc Island meadows. Recent surveys documented 7,579 hectares at Phu Quoc Island alone, representing the largest seagrass bed in Vietnam. An additional 30-hectare bed was recently documented at the Hai Tac archipelago. This region supports 13 species including the dominant canopy-forming species Enhalus acoroides, which occurs from 16°N southward, benefiting from the consistently warm sea water temperatures of 21.6-31.0°C throughout the year.

4.2.2.3 Species Diversity and Taxonomic Considerations

The Vietnamese seagrass flora comprises 15 documented species including putative hybrids, representing exceptional diversity within the broader Indo-Pacific seagrass bioregion. Species composition exhibits pronounced latitudinal zonation reflecting sea water temperature gradients. In Regions 1 and 2, sea water temperatures range from 15.7°C to 30.7°C (averaging 24.1°C in winter and 28.5°C in summer), while Regions 3 and 4 experience consistently warmer conditions of 21.6°C to 31.0°C (averaging 27.5°C in winter and 28.9°C in summer).

The genus Halophila presents particular taxonomic challenges due to overlapping leaf morphological traits among species. Recent molecular analyses have clarified several taxonomic issues: (1) specimens previously identified as Halophila johnsonii are now recognized as narrow-leaf morphotypes of H. ovalis; (2) Halophila major was confirmed as a distinct species in Vietnamese waters based on leaf morphology and ITS genetic analysis; (3) putative hybridization between H. ovalis and H. major has been documented at Nha Trang Bay, similar to reports from Sri Lankan waters. The occurrence of H. minor in Vietnamese waters remains questionable, with specimens previously labeled as this species requiring reclassification as H. ovalis based on morphological and genetic analysis.

Environmental partitioning between morphologically similar Halophila species is observed: H. ovalis typically grows in lagoons experiencing large salinity fluctuations, low water velocity, and weak wave action, whereas H. major occurs predominantly at offshore islands with more stable marine conditions. Halophila beccarii, listed as Vulnerable on the IUCN Red List, has been locally extirpated from the Philippines but persists in brackish lagoon habitats in Vietnam. Halophila decipiens occupies deeper subtidal zones at 5-15 meters depth around offshore islands.

4.2.3.4 Documented Decline and Change Detection

Detailed change detection analyses at specific sites reveal alarming rates of seagrass loss. At Van Phong Bay, satellite Landsat TM/OLI image analysis documented loss of 186.2 hectares representing 35.8% of the original seagrass beds over three decades. Typhoons were identified as the main driver for seagrass loss at open-sea sites, while human-induced stressors including aquaculture activities, excavation, and terrigenous obliteration drove losses in protected sites.

In Cam Ranh Bay, analysis of Landsat TM/ETM+/OLI imagery from 1996 to 2015 revealed that the total seagrass area declined by approximately 25% (66 hectares), primarily due to coastal development and infrastructure construction. For the broader Khanh Hoa coastal area, analysis using Sentinel-2, Landsat-8, and VNREDSat-1 data showed that submerged aquatic vegetation including seagrass was reduced by 74.2%, with gains in new areas compensating for less than half of these losses.

The Tam Giang-Cau Hai lagoon system exemplifies the severity of seagrass decline. Historical surveys in 1999 recorded approximately 2,450 hectares of seagrass meadows. Contemporary assessments indicate current extent of approximately 1,000-2,037 hectares, representing a loss of up to 60% over two decades. Salinity fluctuations and sediment composition (silt versus sand) were identified as the two main factors governing seagrass distribution and abundance in the lagoon, with increased sedimentation and eutrophication from watershed land-use changes driving the decline.

4.2.2.5 Biodiversity Associated with Seagrass Beds

Seagrass beds in Vietnam support substantially higher biodiversity than adjacent unvegetated sediments, functioning as critical nursery habitat for commercially important species and supporting complex food webs. The density of fish larvae and juveniles within seagrass beds at Cat Ba Island (Region 1) was 180 times higher than in bare sediment (327 versus 1.79 individuals per m^2), though species diversity was limited to six taxa. For crustaceans, common groups include juveniles of Penaeidae, Alpheidae, Palaemonidae, Aryidae, Squillidae, Sergestidae, and Pandalidae families.

Table 5: Marine Fauna Diversity in Seagrass Beds by Habitat Type

Parameter	Tam Giang-Cau Hai (lagoon)	Lap An (lagoon)	Cua Dai (estuary)	Phu Quy (island)	Phu Quoc (island)
Fish larvae/juveniles - Families	47	15	12	19	20
Fish larvae/juveniles - Species	87	15	15	24	30
Crustacean larvae - Families	6	8	2	3	8

Crustacean larvae - Species	20	12	8	12	20
Adult fish - Families	n.a.	50	32	14	34
Adult fish - Species	n.a.	151	55	25	86

Source: Nguyen (2013); Nguyen et al. (2022), Frontiers in Plant Science

The Tam Giang-Cau Hai lagoon supports the highest larval fish diversity with 87 taxa representing 47 families, including high-value commercial species such as Epinephelus sexfasciatus, Lutjanus russelii, Lethrinus spp., and Siganus sp. A positive correlation exists between above-ground seagrass biomass and diversity of fish larvae and juveniles. Adult fish diversity is highest at Lap An lagoon with 151 species in 50 families.

At Thuy Trieu lagoon (Region 3), the density of Penaeidae larvae and juveniles in seagrass beds (78 individuals per m^3) was eight times higher than in bare sediment (17.12 individuals per m^3). Fish composition within seagrass beds included 87 species belonging to 12 orders and 47 families, with order Perciformes showing the highest family representation (30 families). In Phu Quoc Island seagrass beds, 33 species of larvae and juvenile fish were recorded, with crustacean larvae density reaching 350 individuals per m^2 and adult fish comprising 86 species with family Apogonidae showing highest diversity (18 species).

Table 6: Zoobenthos Diversity in Seagrass Beds by Region

Taxonomic Group	Northern Regions (1 & 2)	Southern Regions (3 & 4)
Annelida - Families/Species	18 / 40	13 / 21
Gastropoda - Families/Species	15 / 31	24 / 105
Bivalvia - Families/Species	15 / 38	24 / 114
Asteroidea - Families/Species	n.d.	4 / 8
Echinoidea - Families/Species	n.d.	5 / 10
Holothuroidea - Families/Species	1 / 1	3 / 12
Arthropoda - Families/Species	13 / 22	10 / 20
Total Species/Families	63 / 134	85 / 292

Source: Nguyen (2013); Nguyen et al. (2022), Frontiers in Plant Science. n.d. = not determined

Zoobenthos diversity in seagrass beds exhibits a pronounced north-south gradient, with southern regions (3 and 4) supporting 292 species across 85 families compared to 134 species in 63 families in northern regions (1 and 2). Gastropoda and Bivalvia show substantially higher diversity in the south (105 and 114 species respectively versus 31 and 38 species in the north), while Annelida and Arthropoda show relatively similar or higher diversity in northern regions. This pattern reflects the warmer temperatures and higher habitat complexity of southern seagrass ecosystems.

4.2.2.6 Blue Carbon Storage Capacity

Seagrass beds function as efficient natural carbon sinks, capturing carbon dioxide through photosynthesis and storing organic carbon in biomass and sediments over long timescales. The total organic carbon content (in both sediment and living biomass) in Vietnamese seagrass beds was estimated at 133.16 ± 36.97 Mg C per hectare. This value is higher than recorded in Malaysia and Myanmar but lower than in the Philippines and Indonesia.

The average total blue carbon stock in Vietnamese seagrass ecosystems was estimated at 2.06-2.95 million tons, with annual accumulation rates of 25.18-29.28 thousand tons organic carbon per year. Compared to neighboring countries, the total organic carbon stock from Vietnamese seagrass beds is substantially lower than in the Philippines (259.17-425.21 million tons) and Indonesia (62.08-107.50 million tons) but higher than Malaysia (0.005-0.25 million tons) and Myanmar (0.02-0.04 million tons). This difference reflects the smaller total seagrass area in Vietnam compared to the Philippines (44 times larger) and Indonesia (139 times larger) rather than lower per-hectare carbon density.

Local and regional organic carbon variation among seagrass beds is controlled by multiple factors including seagrass community complexity, fine sediment fraction, seawater depth, sediment run-off, and primary production rates. In the Thi Nai lagoon, the total organic carbon and carbon dioxide fixed by seagrass beds was estimated at 136.7 and 501 tonnes per hectare respectively. The Tam Giang-Cau Hai lagoon ecosystem was estimated to produce 25.71 tonnes C per day during the rainy season and 28.93 tonnes C per day in the dry season, though this estimate was based on Halodule pinifolia which is not a dominant species in the lagoon.

3.2.2.7 Threats and Degradation Processes

Vietnamese seagrass ecosystems face a constellation of interacting anthropogenic and natural stressors that have driven the documented 46.5% decline since 1990. Primary threats include:

- Aquaculture expansion: Conversion of coastal habitats for shrimp and fish farming, with associated water quality degradation from effluent discharge and nutrient loading
- Coastal development: Infrastructure construction, port development, and urban expansion causing direct habitat destruction and increased sedimentation
- Sedimentation: Increased suspended sediment loads from watershed deforestation, agricultural intensification, and dredging operations reducing light penetration essential for photosynthesis
- Eutrophication: Agricultural fertilizer runoff and inadequately treated domestic effluent promoting epiphytic algae growth and macroalgal blooms

- Destructive fishing: Push nets, beam trawls, and bottom dredging physically uprooting seagrass and destroying sediment structure essential for rhizome development
- Typhoon impacts: Extreme weather events causing physical destruction of seagrass beds, particularly at exposed open-sea sites (e.g., the local extirpation of Thalassodendron ciliatum from Con Dao following the 1997 typhoon)
- Heavy metal contamination: Accumulation of Cu, Pb, Zn, and Cd in seagrass tissues, particularly near shipyards where Cu concentrations in Enhalus acoroides rhizomes reached 140 µg/mg DW compared to <20 µg/mg DW at other locations

Climate change impacts including ocean warming and acidification pose emerging long-term threats. The difference in sea water temperatures between northern and southern Vietnam may shift species distributions as warming progresses, with tropical-affinity species potentially expanding northward while temperate species like Zostera japonica face thermal stress. Studies on heavy metal accumulation reveal that seagrasses can play roles in phytoremediation processes in polluted areas, but high concentrations of heavy metals cause growth inhibition and mortality, contributing to overall decline in contaminated localities.

4.2.3 Coral Reef Systems

4.2.3.1 Geographic Distribution and Species Diversity

Vietnamese coral reef systems span a latitudinal gradient of approximately 15 degrees from the Gulf of Tonkin in the north to the Gulf of Thailand and offshore Spratly Islands in the south. The national coral fauna exhibits exceptional diversity, with more than 340 Scleractinia (hard coral) species documented representing approximately 80% of the Indo-Pacific species pool. This high diversity reflects Vietnam's position within the Coral Triangle, the global epicenter of marine biodiversity.

Coral reefs are distributed across three principal biogeographic regions: the Gulf of Tonkin including Ha Long Bay, Cat Ba, Co To, and Bach Long Vi islands; the Central and South-Central coast including Cu Lao Cham, Nha Trang Bay, Van Phong Bay, and Hon Mun; and the southern islands including Phu Quoc, Con Dao, and the Spratly archipelago. Each region exhibits distinctive reef morphologies, species assemblages, and exposure to environmental stressors. The geographic extent of these coral reef systems, spanning from the Gulf of Tonkin to the southern offshore archipelagos, is depicted in Figure 3.

FIGURE 3 GEOGRAPHIC DISTRIBUTION OF CORAL REEF SYSTEMS IN VIETNAM.

The locations of the coral reefs (in purple) are shown stretching along the continental shelf and around several islands.

4.2.3.2 Reef Condition Assessment

Comprehensive condition assessments reveal substantial degradation of Vietnamese coral reef systems. Analysis of 142 transect surveys conducted across seven priority sites prior to the 1998 mass bleaching event indicates that only 1.4% of reefs exhibited excellent condition (greater than 75% live coral cover), while 37.3% were classified in good condition (51-75% cover), 43.0% in fair condition (26-50% cover), and 28.2% in poor condition (less than 25% cover). These baseline conditions have subsequently declined further following repeated thermal stress events and continued anthropogenic pressures.

Table 5: Coral Reef Condition by Site (Pre-1998 Baseline)

Site	Transects	Excellent	Good	Fair	Poor
Con Dao	23	0	17	5	1
Ha Long Bay	24	0	3	9	11
Cu Lao Cham	20	0	5	10	5
Cat Ba	14	0	2	6	6
Nha Trang	13	0	0	9	4
Hon Me	7	0	0	0	7

Source: Vo Si Tuan (1998), Institute of Oceanography. Cover categories: Excellent >75%, Good 51-75%, Fair 26-50%, Poor <25%

Con Dao Islands exhibited the highest proportion of reefs in good condition, with 17 of 23 transects recording 51-75% coral cover and only one transect in poor condition. This relatively favorable status reflects Con Dao's isolation from mainland sediment and pollution sources, limited coastal development, and the protective influence of the Con Dao National Park. Ha Long Bay, conversely, showed pronounced degradation with 11 of 24 transects in poor condition, attributable to high turbidity from sediment resuspension, pollution from intensive tourism vessel traffic, and coastal urban development.

Regional Coral Reef Characteristics

The Gulf of Tonkin coral communities represent the northernmost reef development in Vietnamese waters, characterized by reduced species diversity and coral cover relative to southern regions. Water temperatures drop below 20°C during winter months, approaching the lower thermal tolerance limits for many coral species. Turbidity is elevated due to river discharge from the Red River system and resuspension of fine sediments. Despite these constraints, approximately 107 scleractinian species have been documented in the Ha Long Bay-Cat Ba area, with Porites and Goniopora genera dominating the coral assemblages due to their tolerance of turbid, variable temperature conditions.

The Central Coast region, extending from Da Nang to Binh Thuan Province, supports more diverse reef communities with over 200 coral species documented at sites including Cu Lao Cham, Hon Mun, and the Nha Trang Bay complex. Reef development is constrained by narrow continental shelf widths and episodic high-energy wave exposure during typhoon events. The Cu Lao Cham Marine Protected Area, designated as a UNESCO Biosphere Reserve, supports 188 reef fish species and provides important biodiversity conservation functions despite ongoing fishing pressure.

Southern reef systems at Con Dao, Phu Quoc, and the offshore Spratly archipelago exhibit the highest species diversity, benefiting from stable warm temperatures, clear oceanic water, and reduced terrestrial influence. Con Dao supports approximately 342 Scleractinia species representing near-complete Indo-Pacific reef fauna. The Spratly Islands, while politically contested, harbor globally significant coral reef ecosystems that remain inadequately documented due to access constraints.

4.2.3.3 Reef Fish Communities

Coral reef fish assemblages exhibit strong spatial gradients in density and diversity reflecting underlying reef condition and environmental parameters. Quantitative surveys document substantial variation across sites.

Table 6: Reef Fish Community Parameters by Site

Site	Density (ind./500m²)	Range	Species Richness
Con Dao	2,017	71-5,143	202
Phu Quoc	748	438-1,412	135
Van Phong	676	223-1,814	100
Cu Lao Cham	540	148-1,446	188
Nha Trang	226	109-486	256
Co To (Gulf of Tonkin)	45	-	30-60

Source: Vo Si Tuan (1998), Institute of Oceanography

Con Dao Islands support the highest reef fish densities with mean values of 2,017 individuals per 500 square meters and exceptional range from 71 to 5,143 individuals, alongside 202 documented species. This abundance reflects healthy coral habitat structure, effective protection within the National Park, and relatively limited fishing pressure. Nha Trang Bay paradoxically exhibits the highest species richness at 256 species despite substantially lower densities of 226 individuals per 500 square meters, reflecting both high habitat heterogeneity and severe depletion of fish stocks from intensive fishing pressure.

The Gulf of Tonkin sites exhibit markedly reduced fish assemblage parameters, with Co To Islands recording merely 45 individuals per 500 square meters and 30-60 species. This impoverishment reflects the marginal coral reef development in the cooler, more turbid waters of the northern Gulf, combined with intensive fishing exploitation.

4.2.3.4 Case Study: Nha Trang Bay Degradation Gradient

Nha Trang Bay, despite formal Marine Protected Area designation since 2002 under the Hon Mun MPA, exemplifies the extreme spatial heterogeneity of reef conditions in Vietnamese waters. Detailed surveys conducted between 2013 and 2014 documented a pronounced onshore-offshore gradient in reef condition driven by differential exposure to terrestrial stressors.

Remote offshore reef sites in Nha Trang Bay maintain relatively healthy conditions with approximately 75% live coral cover, supporting 63 documented species and Shannon diversity indices of 3.0. These sites harbor mature

Acropora colonies exceeding 350 centimeters in diameter, estimated at more than 30 years of age, indicating sustained coral growth under favorable conditions. The offshore location provides natural protection from river-borne sediment and pollutant inputs, maintaining water clarity essential for coral photosynthesis.

Nearshore sites adjacent to the Cai River mouth and areas impacted by dredging operations present catastrophic degradation. Surveys recorded coral cover as low as 0.6% with merely 6 species present and Shannon diversity indices of 0.5. The substrate at these degraded sites was dominated by macroalgae at 56% cover and unconsolidated rubble at 20.3%, indicating complete functional loss of reef ecosystem structure.

Crown-of-thorns starfish (Acanthaster planci) populations have increased dramatically from zero recorded individuals per 100 square meters in 1998 to 1.7 individuals per 100 square meters by 2014, exceeding the active outbreak threshold. This corallivore outbreak compounds thermal and sedimentation stresses, accelerating coral decline particularly for preferred prey species including tabular and branching Acropora.

Notably, the Hon Mun site benefits from seasonal upwelling that reduces sea surface temperatures by 3-5 degrees Celsius during the May-August southwest monsoon period. This thermal refuge has prevented bleaching threshold exceedance since the 1997 event, suggesting potential climate resilience for sites with similar oceanographic characteristics.

4.2.3.5 Threats to Coral Reef Systems

Vietnamese coral reefs face a constellation of interacting threats including destructive fishing practices, sedimentation, eutrophication, thermal stress, and crown-of-thorns starfish outbreaks. Destructive fishing documented in 21 of 29 coastal provinces includes dynamite fishing, cyanide application for live fish capture, and bottom trawling in reef habitats. Illegal cyanide fishing for the live grouper trade is particularly prevalent in northern and central waters, with no systematic catch statistics available to assess stock impacts.

Sedimentation from watershed land-use change, coastal construction, and dredging operations represents a chronic stressor, reducing light penetration, smothering coral tissue, and impairing recruitment success. The Nha Trang Bay gradient demonstrates how even relatively short distances from sediment sources can determine reef viability.

Climate change impacts including ocean warming and acidification pose existential long-term threats. The 1998 mass bleaching event caused substantial mortality throughout Vietnamese waters, with recovery trajectories highly variable depending on local conditions and continued anthropogenic pressures. Projected increases in bleaching frequency under climate change scenarios may exceed coral recovery capacity, driving phase shifts to algal-dominated states.

4.3. Biodiversity Hotspots and Sensitive Areas

4.3.1 Priority Conservation Sites

Analysis of ecological significance indicators including species diversity, endemism, habitat condition, and ecosystem connectivity identifies several priority sites requiring enhanced conservation attention.

4.3.1.1 Con Dao Islands

The Con Dao archipelago, located approximately 185 kilometers offshore from the Mekong Delta, represents arguably the most ecologically significant marine site in Vietnamese waters. The islands support 200 hectares of seagrass meadows with 8 species, coral reefs exhibiting the highest proportion of sites in good condition nationally, and reef fish densities of 2,017 individuals per 500 square meters exceeding all other surveyed localities. The archipelago provides critical nesting habitat for endangered green turtles (Chelonia mydas) and hawksbill turtles (Eretmochelys imbricata), with beaches supporting the largest remaining nesting populations in Vietnam. Con Dao National Park provides formal protection, yet enforcement challenges persist.

4.3.1.2 Phu Quoc Island

Phu Quoc Island in Kien Giang Province harbors the largest seagrass formation in Vietnamese waters at 10,063 hectares, providing critical foraging habitat for endangered dugong (Dugong dugon). The island's sheltered eastern coast maintains multi-species seagrass meadows dominated by Enhalus acoroides and Thalassia hemprichii extending to depths of 10 meters. Adjacent coral reef systems support 135 fish species with densities of 748 individuals per 500 square meters. Phu Quoc Marine Protected Area was established to protect these ecosystems, yet rapid tourism and infrastructure development pose escalating threats.

4.3.1.3 Can Gio Mangrove Biosphere Reserve

The Can Gio Mangrove Biosphere Reserve, designated by UNESCO in 2000, represents the largest contiguous mangrove formation proximate to a major urban center in Southeast Asia. Located in Ho Chi Minh City, the reserve encompasses approximately 75,740 hectares including a core mangrove zone of approximately 32,404 hectares. The reserve provides essential nursery habitat for commercially important fish and shrimp species, coastal protection for Ho Chi Minh City's southern districts, and substantial carbon storage. The site demonstrates successful mangrove rehabilitation following extensive defoliation during the Vietnam War, with most current forest originating from replanting efforts in the 1980s.

4.3.1.4 Ca Mau Cape

Ca Mau Province at the southern tip of the Mekong Delta harbors approximately 55,743 hectares of mangrove forest, representing the largest provincial mangrove estate in Vietnam. The Ca Mau Cape area exhibits active deltaic progradation with new mangrove colonization on accreting mudflats, presenting opportunities for natural expansion of the forest estate. Ngoc Hien District alone contains approximately 34,093 hectares, with recent gains of 6.4% attributable to successful restoration initiatives. The area provides critical nursery functions for the shrimp fishery that constitutes the primary livelihood for coastal communities.

4.3.2 Ecological Continuum: Mangrove-Seagrass-Coral Connectivity

Vietnamese coastal ecosystems exhibit functional connectivity reflecting the ecological continuum concept wherein mangroves, seagrass meadows, and coral reefs form an integrated seascape. This connectivity manifests through several mechanisms including ontogenetic habitat shifts, nutrient cycling, sediment dynamics, and larval dispersal.

Many commercially and ecologically important fish species utilize multiple habitat types during their life cycles. Juvenile fish often recruit to mangrove prop root systems where complex structure provides refuge from predators, subsequently migrating to seagrass meadows and finally to coral reefs as adults. Studies in similar Indo-Pacific systems demonstrate that coral reef fish assemblages adjacent to mangroves and seagrass exhibit substantially higher biomass and diversity than isolated reefs.

Mangrove systems trap sediments and filter nutrients, reducing loads that would otherwise degrade adjacent seagrass and coral habitats. Conversely, seagrass meadows attenuate wave energy and stabilize sediments, reducing turbidity stress on coral communities. Disruption of any component of this seascape continuum propagates impacts across the connected system.

Con Dao and Phu Quoc islands exemplify sites where all three ecosystem types co-occur, enabling assessment of connectivity functions. Conservation planning for these sites should explicitly incorporate seascape connectivity, protecting not only individual habitat patches but the corridors and hydrological connections that link them.

4.3.3 Functional Connectivity Mechanisms

Ontogenetic habitat shifts represent a primary connectivity mechanism, wherein fish species utilize different habitats during successive life stages. Juvenile snappers (Lutjanidae), grunts (Haemulidae), and parrotfish (Scaridae) commonly recruit to mangrove prop root habitats where structural complexity provides refuge from predators. As individuals grow, they migrate first to seagrass meadows for intermediate growth phases, then to coral reefs as adults where they contribute to reef fish biomass and ecological functions including herbivory and predation.

Nutrient and carbon fluxes connect mangrove, seagrass, and coral reef ecosystems through both dissolved and particulate organic matter transport. Mangrove leaf litter decomposition releases nutrients that enhance productivity in adjacent seagrass meadows. Seagrass detritus in turn provides carbon subsidies to coral reef food webs. Stable isotope analyses in similar Indo-Pacific systems demonstrate that 30-50% of carbon in coral reef fish tissues originates from mangrove and seagrass sources, underscoring the nutritional importance of these connections.

Sediment dynamics represent another critical connectivity pathway. Mangrove forests trap suspended sediments, reducing turbidity and sedimentation stress on downstream seagrass and coral communities. Where mangroves have been removed, increased sediment loads reach adjacent habitats, smothering seagrass blades and coral polyps while reducing light penetration essential for photosynthesis. The Nha Trang Bay degradation gradient illustrates how proximity to sediment sources determines reef viability even within relatively short distances.

Larval dispersal connects geographically separated populations through oceanographic transport. Coral, fish, and invertebrate larvae may disperse for days to weeks in the plankton before settling on suitable substrate. Marine Protected Area networks should be designed with connectivity in mind, ensuring that protected source populations can supply larvae to downstream sink populations and that stepping-stone habitats enable dispersal across longer distances.

4.4 Threatened and Endemic Species

4.4.1 Marine Megafauna

Vietnamese coastal and marine ecosystems support populations of several threatened marine megafauna species requiring targeted conservation attention.

4.4.1.1 Dugong (Dugong dugon) - IUCN Vulnerable

The dugong, listed as Vulnerable on the IUCN Red List, represents one of the most endangered marine mammals in Vietnamese waters. Historical populations have contracted dramatically due to habitat loss, entanglement in fishing gear, and direct hunting. Current populations persist primarily in association with the extensive seagrass meadows of Phu Quoc Island and Con Dao, where Enhalus acoroides and Thalassia hemprichii provide primary forage resources. No systematic population assessment has been conducted, precluding quantitative trend analysis. Protection of remaining seagrass habitats is essential for dugong persistence in Vietnamese waters.

4.4.1.2 Marine Turtles

Green turtles (Chelonia mydas) and hawksbill turtles (Eretmochelys imbricata) are both listed as Endangered and Critically Endangered respectively on the IUCN Red List. Both species face intensive exploitation pressure in Vietnamese waters, with trade centers documented in Nha Trang, Vung Tau, and Ha Tien where turtle products are processed for souvenirs and traditional medicine. Con Dao Islands support the most significant remaining nesting populations in Vietnam, with protection efforts focused on beach monitoring and nest relocation. However, at-sea mortality from fishing gear entanglement and intentional capture remains inadequately addressed.

4.4.2 Commercially Exploited Species Under Pressure

Several commercially targeted species exhibit stock depletion requiring management intervention. The absence of systematic stock assessments for most species precludes quantitative evaluation of exploitation status, yet multiple indicators suggest overfishing across diverse taxa.

4.4.2.1 Live Reef Fish

The live reef fish trade, particularly for groupers (Epinephelus spp., Plectropomus spp.) and Napoleon wrasse (Cheilinus undulatus) destined for Hong Kong and Chinese restaurant markets, drives intensive fishing pressure on coral reef systems. Illegal cyanide fishing to capture fish alive is practiced throughout northern and central Vietnamese waters. The cyanide solution stuns fish, facilitating capture, but causes delayed mortality and damages coral tissue, creating compounding ecosystem impacts.

No systematic catch statistics are compiled for the live reef fish trade, precluding stock assessment. Anecdotal reports from fishers indicate declining catch rates requiring longer fishing trips and exploitation of increasingly remote reef areas. Napoleon wrasse, listed as Endangered on the IUCN Red List, has become extremely rare in Vietnamese waters due to targeted fishing pressure. Large grouper species similarly show evidence of stock depletion, with average sizes declining over time as larger individuals are progressively removed.

4.4.2.2 Sea Cucumbers

Sea cucumber harvesting supports an export industry of 150,000 to 180,000 tonnes per year, primarily destined for China, Hong Kong, Singapore, Taiwan, and Japan. This extraction level likely exceeds sustainable yields given the low reproductive rates and sedentary nature of holothurian species, yet no stock assessments or management measures are implemented. Sea cucumbers provide essential bioturbation services, and their depletion may compromise nutrient cycling and sediment health in coastal ecosystems.

4.4.2.3 Corals

Direct coral harvesting for the ornamental trade and construction materials poses localized threats, particularly for branching Acropora species prized in aquariums. Official records indicate that Binh Thuan Province permitted extraction of 15,000 kilograms of coral skeleton in 2000 alone. Staghorn Acropora species have become increasingly rare in accessible nearshore areas, indicating overharvesting relative to recovery capacity.

4.4.3 Endemic and Range-Restricted Species

Vietnamese coastal ecosystems support several species with restricted geographic ranges requiring conservation attention.

Seven mangrove species are restricted to the southern Mekong Delta region, reflecting the thermal preferences of tropical mangrove flora. These species, including Avicennia alba, Avicennia officinalis, Rhizophora mucronata, Bruguiera cylindrica, and Bruguiera parviflora, reach their northern distributional limits in central Vietnam. Conversely, Myoporum bontioides and Scaevola hainanensis are restricted to northern Vietnam, adapted to the subtropical climate of the Gulf of Tonkin.

The seagrass species Thalassodendron ciliatum was documented at Con Dao prior to the 1997 typhoon but has not been subsequently recorded, representing an apparent local extirpation. This species reaches its northern distributional limit in southern Vietnam, and its loss from Con Dao may indicate vulnerability to extreme weather events that may intensify under climate change.

4.5. Governance, Management, and Economic Analysis

4.5.1 Institutional Framework

Management authority for Vietnamese coastal and marine ecosystems is distributed across multiple agencies with overlapping and sometimes conflicting mandates.

The Ministry of Agriculture and Rural Development (MARD), through its Vietnam Administration of Forestry (VNFOREST), holds primary responsibility for mangrove forests classified as protection or special-use forests under the 2017 Forestry Law. MARD also manages fisheries resources through the Directorate of Fisheries, though coordination between forestry and fisheries divisions is often limited.

The Ministry of Natural Resources and Environment (MONRE) holds responsibility for marine environmental protection, biodiversity conservation outside forest areas, and coastal zone management. The Vietnam Administration of Seas and Islands (VASI) under MONRE coordinates marine spatial planning and Marine Protected Area designation.

Provincial People's Committees exercise substantial authority over land-use planning, aquaculture licensing, and enforcement within their jurisdictions. This decentralized structure creates coordination challenges, as provincial economic priorities often conflict with national conservation objectives. District-level capacity for enforcement is frequently inadequate, contributing to widespread non-compliance with fisheries and forest protection regulations.

4.5.2 Policy Framework

Several policy instruments govern coastal ecosystem management, though implementation effectiveness varies substantially.

Decision 120/QD-TTg of 2015 established ambitious targets to protect 310,695 hectares, rehabilitate 9,602 hectares, and plant 46,058 hectares of mangroves by 2020. Subsequent Decision 770/QD-TTg of 2019 adjusted targets to 21,600 hectares of new plantation for the 2021-2025 period, acknowledging implementation constraints encountered during the first phase.

The 2017 Forestry Law provides the legal framework for forest classification into special-use, protection, and production categories, with corresponding management requirements. Mangroves may be classified under any category depending on ecological significance and land-use history. Decision 419/QD-

TTg establishes the framework for REDD+ implementation, recognizing the carbon values of mangrove ecosystems within international climate finance mechanisms.

Vietnam's Nationally Determined Contribution under the Paris Agreement commits to 30,000 hectares of mangrove restoration, with estimated mitigation potential of 4.41 million tonnes CO2 equivalent for 2021-2030. Achieving this commitment requires sustained investment in restoration, monitoring, and enforcement substantially exceeding current allocations.

4.5.3 Marine Protected Area System

Vietnam's Marine Protected Area system currently encompasses twenty designated sites with proposals to expand to thirty, increasing coral reef protection from 1,528 hectares to 3,118 hectares under the proposed network. However, MPA effectiveness is severely constrained by implementation challenges.

The Hon Mun MPA in Nha Trang Bay, established in 2002 as a flagship site with international support, exemplifies these challenges. Despite formal protection status, fishing, shipping, and aquaculture activities continue within MPA boundaries. International funding for enforcement and community outreach ended in 2005, after which illegal activities resurged.

Con Dao National Park demonstrates more effective implementation, benefiting from geographic isolation that naturally limits access and a sustained commitment to enforcement. Yet even here, illegal fishing incursions occur, and surrounding waters lack formal protection despite ecological connectivity with park habitats.

4.5.4 Economic Valuation of Ecosystem Services

Comprehensive economic valuation of Vietnamese coastal ecosystem services remains limited, yet available estimates indicate substantial values.

The average value per hectare of the ecosystems is presented in Table , expressed in billion VND at 2010 prices. These values can be applied to recent years because the underlying studies were conducted over multiple years. The values were then applied to the total area (ha) of these ecosystem complexes in 2021 (see Table 8) to calculate the total value. Of the total value, almost all (94%) is attributable to mangrove ecosystems, while coral reefs account for 2%, coastal ecosystems about 1%, and ocean ecosystems nearly 3%. Overall, ecosystem services contribute on average about 0.60% of the total GVA of the entire economy over the period from 2010 to 2020.

TABLE 8. VALUE OF VIETNAM COASTAL ECOSYSTEM, MANGROVE AND CORAL (SOURCE: PROMOTING SUSTAINABLE DEVELOPMENT OF VIETNAM'S MARINE ECONOMY - RESEARCH ON PUBLIC INVESTMENT AND EXPENDITURE, WB 2025)

Marine ecosystem	Area (ha)	Average value (international $/ha/year)	Average value (thousand VND, 2010 prices)	Total value (billion VND, 2010 prices)	% of GVA
Coastal ecosystem (excluding mangroves)	471,122	21.5	399.5	188.2	0.01%
Mangroves	302,359	2,432.2	45,270.8	13,688.0	0.56%
Coral reefs	11,475	1,322.5	24,615.8	282.5	0.01%
Open sea ecosystem	169,617	1,950.3	36,300.0	416.5	0.02%
Total	784,956			14,575.2	0.60%

Marine ecosystems are being exploited and managed unsustainably. In the World Bank's Country Environmental Analysis (WB, 2022a), a substantial portion of protective mangrove forests was destroyed between 1950 and 1990, shrinking from more than 250,000 ha to 71,000 ha—an astonishing loss of 72%. This decline was driven mainly by the use of toxic chemicals in earlier years and, more recently, by shrimp farming activities, as well as the reduction of special-use forests and coastal protection forests due to climate change impacts, landslides, and riverbank and coastal erosion.

Although losses have slowed over the past two decades thanks to replanting measures implemented from 1999 to 2015, the net loss still amounts to 13,500 ha of protective mangroves. The World Bank's Country Environmental Analysis (WB, 2022)[2] estimates that the annual damage from the loss of mangrove ecosystem service values in the Mekong Delta region over the 20-year period 1997–2017 was USD 20.3 million per year, equivalent to 0.01% of GDP (Table 9), with the largest losses occurring in ecosystem services related to soil and coastal protection, aquaculture, and carbon sequestration.

Mangrove ecosystem services including fisheries support, coastal protection, carbon sequestration, and tourism values are estimated at a mean of USD 4,185 per hectare per year, though methodological variation produces wide confidence intervals with a median estimate of USD 239 per hectare per year. Applying even conservative valuations to the national mangrove estate of 168,538 hectares yields annual ecosystem service values in the tens of millions of dollars.

Fisheries production dependent on mangrove and seagrass nursery habitats supports approximately 23% of coastal households, with total coastal fisheries production contributing substantially to national food security and export

[2] World Bank. 2022. Accelerating Clean, Green, and Climate-Resilient Growth in Viet Nam: A Country Environmental Analysis. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/37704

revenues. The shrimp aquaculture industry, valued at hundreds of millions of dollars annually, depends on water quality and juvenile shrimp production mediated by coastal wetland ecosystems.

Carbon values under international climate finance mechanisms provide emerging revenue opportunities. At carbon prices of USD 5-10 per tonne CO2 equivalent, the national mitigation potential of 4.41 million tonnes CO2 equivalent for 2021-2030 represents potential revenues of USD 22-44 million over the decade, providing an economic justification for restoration investment.

Tourism and Recreation Values

Coastal and marine tourism represents a rapidly growing sector of the Vietnamese economy, with reef diving, island visits, and coastal recreation generating substantial revenues. Nha Trang Bay alone receives over 2 million tourists annually, with dive operators and boat tours generating tens of millions of dollars in direct revenue. However, unmanaged tourism growth poses threats to the ecosystems that underpin the industry, creating potential for resource degradation that undermines long-term tourism sustainability.

Mangrove ecotourism has emerged as a niche sector, particularly in Can Gio Biosphere Reserve where boat tours and forest walks attract domestic and international visitors seeking nature-based experiences proximate to Ho Chi Minh City. Expansion of ecotourism offers potential to generate conservation revenues while providing economic alternatives to extractive resource use.

Coastal Protection Values

The coastal protection services provided by mangrove ecosystems deliver substantial economic value that is often underappreciated in development planning. Analysis of Typhoon Damrey impacts in 2005 demonstrated that the Da Loc commune in Thanh Hoa Province, protected by 1.6 kilometers of mangrove forest buffer, experienced markedly lower damage than adjacent unprotected areas. Property losses in protected areas were reduced by an estimated 70-90% relative to exposed coastlines.

The cost-effectiveness of mangrove-based coastal protection relative to engineered seawalls makes nature-based solutions increasingly attractive for climate adaptation investment. Mangrove planting costs approximately USD 200-500 per hectare while providing self-maintaining protection that improves over time as forests mature. Concrete seawalls, by contrast, cost USD 1,000-10,000 per linear meter with ongoing maintenance requirements and no co-benefits for fisheries, carbon, or biodiversity.

4.5.5 Management Gaps and Challenges

Despite progress in policy development, substantial gaps persist between policy intent and implementation outcomes.

Enforcement deficits represent the most critical constraint, with destructive fishing practices documented in 21 of 29 coastal provinces despite legal prohibitions. Provincial enforcement agencies lack vessels, personnel, and political support to effectively patrol vast coastal areas. Corruption and political interference further compromise enforcement effectiveness.

Fragmented institutional mandates create coordination failures, with MARD, MONRE, and provincial authorities often pursuing conflicting objectives without effective mechanisms for harmonization. The absence of integrated coastal zone management frameworks at operational scales perpetuates these coordination failures.

Monitoring systems remain inadequate for adaptive management. No systematic tracking of mangrove restoration survival rates is conducted, precluding evaluation of program effectiveness. Carbon monitoring and verification systems required for international climate finance participation are in early developmental stages. Coral reef monitoring relies on periodic research surveys rather than sustained observation networks.

Economic conflicts between conservation and development remain unresolved. Aquaculture, while providing livelihoods for millions, continues to drive mangrove conversion despite policy restrictions. The opportunity cost of mangrove protection relative to aquaculture income creates powerful incentives for illegal conversion that enforcement alone cannot address.

4.6. Priority Actions and Regional Cooperation

4.6.1 Priority Actions

4.6.1.1 Nature-Based Solutions

Nature-based solutions offer cost-effective approaches to address multiple environmental challenges while delivering biodiversity and livelihood co-benefits.

4.6.1.2 Mangrove Restoration and Rehabilitation

Priority restoration should focus on degraded sites with favorable hydrological conditions for natural regeneration, reducing reliance on costly planting programs with variable survival rates. The Ecological Mangrove Rehabilitation approach emphasizes restoration of hydrological connectivity to enable natural colonization, achieving higher survival and better ecological outcomes than plantation forestry approaches.

Silvo-fishery systems integrating mangrove rehabilitation with extensive aquaculture offer potential to reconcile conservation and livelihood objectives. Under appropriate designs, these systems maintain mangrove cover while generating aquaculture income, addressing the economic opportunity cost that drives illegal conversion.

4.6.1.3 Coral Reef Restoration

Reef restoration efforts should prioritize protection of surviving healthy reef areas, particularly those benefiting from thermal refugia such as upwelling zones. Active restoration techniques including coral gardening and substrate stabilization may accelerate recovery at degraded sites, but cannot substitute for addressing underlying stressors including sedimentation, pollution, and destructive fishing.

Marine spatial planning should identify and protect reef areas with natural resilience characteristics, establishing connectivity corridors that enable larval dispersal and population recovery. Integration of reef protection with watershed management is essential to reduce sediment and nutrient loads reaching reef systems.

4.6.1.4 Seagrass Conservation

Seagrass conservation priorities should focus on reducing sedimentation and eutrophication from watershed sources, combined with elimination of destructive fishing practices within seagrass meadows. The dramatic declines observed in Tam Giang-Cau Hai Lagoon demonstrate that protection of seagrass beds alone is insufficient without watershed-scale intervention.

Designation of seagrass areas as critical habitat for endangered dugong provides a flagship species approach to mobilize conservation attention and resources. Integration of seagrass protection with Marine Protected Area planning should ensure that connectivity with adjacent mangrove and coral habitats is maintained.

4.6.1.5 Strategic Policy Recommendations

Effective coastal ecosystem conservation requires policy reforms addressing underlying governance and economic constraints.

1. Strengthen enforcement capacity: Increase budget allocations for patrol vessels, personnel, and prosecution of violations. Establish inter-agency enforcement task forces combining MARD, MONRE, and provincial resources.
2. Integrate coastal zone management: Develop operational integrated coastal zone management frameworks at provincial and district scales, harmonizing sectoral plans for fisheries, aquaculture, tourism, and infrastructure within ecological carrying capacity constraints.
3. Develop payment for ecosystem services: Implement carbon payment mechanisms for verified mangrove restoration, providing economic incentives that align private interests with conservation objectives. Pilot coastal protection payment schemes where mangroves reduce infrastructure and life safety risks.
4. Expand Marine Protected Area network: Advance proposals to expand from 20 to 30 MPAs, prioritizing sites with high ecological connectivity and demonstrated management capacity. Allocate sustained funding for enforcement rather than time-limited project support.
5. Establish monitoring systems: Develop national coastal ecosystem monitoring networks integrating remote sensing, in-situ surveys, and community-based observation. Track restoration survival rates, carbon

accumulation, and biodiversity indicators to enable adaptive management.

4.6.2 Regional Cooperation Requirements

Vietnamese coastal ecosystems share connectivity with neighboring countries through larval dispersal, migratory species movements, and transboundary pollution transport, requiring regional cooperation for effective management.

4.6.2.1 Mekong Basin Coordination

Mangrove and coastal ecosystem health in the Mekong Delta depends critically on upstream water and sediment inputs. Dam construction throughout the Mekong basin has altered sediment transport, contributing to coastal erosion and saline intrusion that stress mangrove systems. Participation in Mekong River Commission processes is essential to advocate for environmental flows and sediment management that maintain deltaic ecosystem functions.

4.6.2.2 South China Sea Cooperation

The UNEP/GEF South China Sea Project established regional frameworks for coordination on seagrass and coral reef conservation that should be sustained and expanded. Shared monitoring protocols, data exchange mechanisms, and coordinated management of migratory species require continued regional investment.

Transboundary Marine Protected Area networks linking Vietnamese, Chinese, and Philippine sites would enhance connectivity and resilience of marine ecosystems throughout the South China Sea, though geopolitical tensions complicate such cooperation.

4.6.2.3 Regional Knowledge Networks

Establishment of regional data hubs compiling standardized monitoring data for mangroves, seagrass, and coral reefs would enable comparative analysis of ecosystem trajectories and management effectiveness. The Coral Triangle Initiative provides models for regional coordination that could be adapted for the South China Sea context.

Capacity building for coastal ecosystem management should be coordinated regionally, sharing expertise in restoration techniques, monitoring technologies, and enforcement approaches. South-South learning exchanges between Vietnamese managers and counterparts in Thailand, Indonesia, and the Philippines would accelerate adoption of proven practices.

4.6.2.4 Climate Change Adaptation Coordination

Climate change impacts on coastal ecosystems transcend national boundaries, requiring coordinated regional adaptation responses. Sea level rise projections for the South China Sea indicate 20-40 centimeters of rise by 2050 under moderate emissions scenarios, with implications for mangrove zonation, seagrass depth limits, and coral bleaching thresholds throughout the region.

Regional climate vulnerability assessments should identify ecosystem refugia where natural resilience characteristics may enable persistence under changing conditions. Upwelling zones, deep-water thermal refugia, and areas with naturally variable conditions that pre-adapt species to climate variability represent priority sites for enhanced protection. Coordinated identification of climate resilient reefs across the South China Sea would enable strategic allocation of limited conservation resources.

Assisted migration and translocation of climate-adapted genotypes represents an emerging adaptation strategy that may require regional coordination. Moving heat-tolerant coral genotypes to recipient reefs, or establishing mangrove species at higher latitudes as temperature envelopes shift, could enhance regional ecosystem resilience but requires scientific protocols and regulatory frameworks that transcend national boundaries.

4.6.2.5 Financing Mechanisms for Regional Conservation

Sustainable financing for coastal ecosystem conservation requires diversification beyond traditional government budget allocations and time-limited project support. Regional approaches to conservation finance offer potential scale and efficiency benefits.

Blue carbon credit markets provide opportunities for Vietnam and neighboring countries to monetize mangrove and seagrass carbon sequestration services. Coordinated regional standards for carbon measurement, reporting, and verification would reduce transaction costs and enhance market credibility. The ASEAN Center for Biodiversity could coordinate development of regional blue carbon protocols building upon existing national REDD+ frameworks.

Payment for ecosystem services schemes could be structured at regional scales to capture transboundary benefits. Fisheries in downstream countries benefit from nursery habitat provision in upstream mangroves and seagrass meadows. Regional mechanisms to compensate countries providing these services would align economic incentives with conservation outcomes while addressing equity concerns regarding the distribution of conservation costs and benefits.

4.7 Conclusion

Vietnam's coastal and marine ecosystems represent nationally significant natural assets providing essential ecological services for millions of people while contributing to global biodiversity and climate objectives. The mangrove, seagrass, and coral reef systems documented in this assessment face severe pressures from coastal development, destructive fishing, pollution, and climate change, yet retain substantial resilience and recovery potential when appropriate management interventions are implemented.

Realizing conservation and sustainable development objectives requires sustained political commitment, adequate resource allocation, effective enforcement, and integration across sectoral and jurisdictional boundaries. The economic case for ecosystem conservation is compelling, with ecosystem service values substantially exceeding the costs of protection and restoration. International climate finance mechanisms offer emerging opportunities to mobilize resources for blue carbon ecosystem conservation.

Regional cooperation is essential given the transboundary connectivity of marine ecosystems and shared management challenges throughout the South China Sea. Vietnam can leverage its relatively strong institutional capacity and growing economy to demonstrate leadership in regional coastal ecosystem conservation, generating benefits for both national development and global environmental sustainability. Priority actions include strengthening enforcement capacity, developing integrated coastal zone management frameworks, implementing payment for ecosystem services mechanisms, expanding the Marine Protected Area network, and establishing comprehensive monitoring systems to enable adaptive management.

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CHAPTER 5. FISHERIES (TO BE UPDATED)

CHAPTER 6. GOVERNANCE

Executive summary

Viet Nam has a 3,260 km coastline and an exclusive economic zone (EEZ) of roughly one million square kilometers. These assets underpin a rapidly growing "blue economy" that is estimated to account for 47–60 percent of national GDP when ocean-related activities are included. Fisheries and aquaculture contribute around 4–5 percent of GDP, employ millions across value chains, and provide essential food for domestic consumers, particularly in coastal and rural areas. At the same time, key coastal and marine ecosystems—coral reefs, mangroves, and seagrass beds—are being degraded by overfishing, coastal development, pollution, and climate change. Saline intrusion, sea-level rise, and more frequent extreme weather events are also increasing risks in vulnerable regions.

Against this backdrop, Viet Nam has adopted ambitious marine-related targets, including expanding marine protected areas to around 6 percent of national sea area by 2030, advancing a sustainable marine economy strategy, and contributing to SDG 14 (Life Below Water) and the Kunming–Montreal Global Biodiversity Framework. This report assesses whether current governance arrangements—including laws, institutions, coordination mechanisms, stakeholder roles, and financing—are adequate to deliver these outcomes in a transboundary context, where dynamics in the South China Sea (SCS) and the Gulf of Thailand (GoT) significantly shape national risks and opportunities.

Using the TWAP Level 1 governance architecture methodology, this report assesses Viet Nam's coastal and marine governance across three core dimensions—completeness, integration, and engagement.

- Completeness (50–60 percent; medium–low): Viet Nam has a relatively strong legal and policy base, including UNCLOS ratification, the Fisheries Law (2017), ICZM-related policies, and advancing climate and biodiversity strategies. Implementation is supported by monitoring tools such as vessel monitoring systems (VMS) and electronic catch documentation. However, enforcement capacity, feedback loops from monitoring to adaptive management, and consistent implementation across provinces remain constrained. Several instruments—such as fully operational marine spatial planning and comprehensive climate legislation—are still in development.
- Integration (0.25–0.35 on a 0–1 scale; weak): Fragmentation across fisheries, conservation, ports, energy, aquaculture, and tourism—combined with uneven provincial capacity and incomplete land–sea and transboundary linkages—represents the most significant governance constraint. Existing bilateral and ASEAN mechanisms address elements of shared stocks, pollution, and marine debris, but there is no coherent LME-scale governance framework for the South China Sea. Arrangements remain partial in the Gulf of Tonkin and the Gulf of Thailand.

- Engagement (55–65 percent; medium): Community-based fisheries and mangrove co-management models, including examples such as the Tam Giang Lagoon, indicate that locally grounded governance can improve ecological and livelihood outcomes. Civil society and private-sector actors in seafood value chains provide relevant expertise and operational platforms. However, participation is often project-dependent; formal consultation mechanisms are inconsistently applied; and small-scale fishers, women, and youth remain under-represented in decision-making and benefit-sharing.

Overall, Viet Nam's coastal and marine governance faces moderate-to-high residual risk. Foundational laws and institutions are in place, pilot models demonstrate feasibility, and political commitment to a sustainable blue economy is evident. Nevertheless, persistent implementation and coordination gaps could undermine progress toward fisheries sustainability, biodiversity targets, SDG 14, and climate-resilience objectives by 2030.

6.1 Key findings

6.1.1 Legally comprehensive, institutionally fragmented governance, with persistent implementation gaps

Viet Nam's coastal and marine governance rests on a comparatively strong legal and strategic framework aligned with international commitments and domestic priorities. However, institutional fragmentation continues to weaken implementation: enforcement capacity, routine feedback from monitoring to management, and consistent application across provinces remain uneven. Fragmentation across fisheries, conservation, ports/shipping, energy, aquaculture, and tourism—together with large disparities in provincial capacity and financing—is the single most critical constraint to effective ecosystem-based and transboundary governance. This is reflected in TWAP-related scores: medium–low completeness, weak integration, and limited but gradually strengthening engagement, particularly through community and civil society participation.

6.1.2 MSP is a central integration instrument, but institutionalisation is incomplete.

National MSP is increasingly used to reconcile competing uses (ports/shipping, fisheries, conservation, tourism, energy) through spatial rules. Scenario-based planning suggests potential economic and social gains under "blue" pathways, but benefits depend on legal embedding, enforceable cross-sector procedures, and stronger provincial capacity for implementation, permitting, and compliance.

6.1.3 MPAs face structural financing and enforcement constraints, with coverage and effectiveness shortfalls

MPA coverage remains below stated ambitions, including the 2030 target. Many sites have constrained operating budgets, uneven enforcement presence, and gaps in management planning and monitoring. Overlapping pressures from fishing, tourism development, and land-based pollution can reduce ecological effectiveness even where MPAs are formally designated.

6.1.4 IUU fishing remains a persistent governance stressor despite compliance gains

Viet Nam has strengthened administrative sanctions and reduced some vessel-monitoring violations, including under EU "yellow card" scrutiny, but IUU risks remain material. Drivers include limited patrol and inspection coverage, procedural and evidentiary challenges in case handling, livelihood-related incentives among parts of the small-scale fleet, and operational complexity in disputed or sensitive South China Sea waters.

6.1.5 Conservation responsibilities are centralized, but the strongest pressures are controlled by provinces—especially after deeper decentralization following sector mergers

In Viet Nam, assessing ecosystem status and initiating conservation responses sits mainly with the natural resources and environment sector, while the main drivers of marine ecosystems decline come from development sectors (transport, construction, industry and trade, tourism, and fisheries) that provinces steer through planning, licensing, and field management. Weak provincial cross-sector coordination—together with overlapping mandates and inconsistent legal objectives—reduces effectiveness and often makes policy responses slower than rising pressures. This challenge is sharper under strengthened decentralization after sector consolidation, making provincial leadership more visible and decisive. In this context, the Chair of the Provincial People's Committee is a key institutional "decision point", shaping whether conservation is prioritized or traded off in coastal growth. Without clear accountability and performance assessment, short-term growth incentives can continue to dominate long-term ecosystem protection.

6.1.6 Transboundary cooperation exists, but operational coverage and utilization remain limited

Bilateral and regional frameworks (China–Viet Nam fisheries arrangement in the Gulf of Tonkin; ASEAN initiatives on marine debris and SDG 14; East Asian Seas platforms) provide partial scaffolding. Gaps persist in science-based shared-stock management, routine information exchange and joint enforcement, and coordinated pollution control and climate-risk governance across shared systems.

6.1.7 Co-management models show promise but need durable institutional anchoring

Experience in Tam Giang Lagoon, Ham Thuan Nam, and other pilots indicates co-management and ecosystem-based approaches can improve ecological outcomes and livelihood compatibility when backed by clear rights, monitoring, and credible enforcement linkages. However, many models remain project-dependent and can weaken when external funding or facilitation ends, underscoring the need for integration into provincial planning, budgets, and accountability systems.

6.1.8 Blue economy strategy and SDG 14 commitments create a reform window—conditional on tools and finance

Strategies, SDG 14 monitoring, and blue economy scenario analysis point to economic and social gains from more integrated, climate-smart, and equitable governance. Achieving these gains requires implementation-ready instruments (operational rules, data systems, enforcement pathways) and scalable financing (e.g., conservation trust funds, blue bonds, PES), supported by credible monitoring and benefit-sharing arrangements.

Strategic implications

The assessment concludes that Vietnam's marine governance challenge is not a lack of policies or institutions, but rather a need to:

- Strengthen implementation and enforcement, particularly on IUU fishing and MPA regulations.
- Institutionalize integration through binding MSP, inter-ministerial coordination, and robust provincial ICZM mechanisms.
- Scale and sustain participatory models, making co-management and community-based conservation a routine part of state governance rather than a project exception.
- Secure sustainable financing, shifting from short-term donor projects to domestic and blended instruments that can reliably fund enforcement, conservation, and adaptation.
- Deepen transboundary cooperation in the South China Sea and Gulf of Thailand through science-based shared-stock management, joint monitoring, and pollution and climate-risk coordination.

Taken together, these reforms can convert Vietnam's strong legal and strategic commitments into tangible improvements in fisheries sustainability, ecosystem health, climate resilience, and social equity by 2030, and position the country as a regional leader in blue economy governance in Southeast Asia.

6.2. Economic arrangements

6.2.1 Political and economic drivers

Over the past decade, Viet Nam has demonstrated significant economic convergence within the ASEAN-6 group of major marine economies (Indonesia, Thailand, Malaysia, Viet Nam, Philippines, Cambodia). World Bank data reveals a trajectory of rapid structural transformation: Viet Nam has surpassed Malaysia and the Philippines in total economic size (Nominal GDP) and is effectively narrowing the gap with Thailand.

While Viet Nam remains a lower-middle-income economy in terms of GDP per capita, its external position is exceptionally strong. The economy is characterized by substantial current account surpluses driven by a manufacturing export boom, a pattern that contrasts with the deficits often observed in peer economies like the Philippines and Indonesia. At current growth rates, Viet Nam is on a trajectory to challenge Thailand for the second-largest economic position in ASEAN (behind Indonesia) within the next decade.

For a Transboundary Diagnostic Analysis (TDA), this macroeconomic performance is a direct driver of marine pressure: the export-led growth model relies heavily on maritime transport, coastal logistics, and industrial inputs, thereby linking national economic success directly to the intensity of coastal land use and shipping traffic in the South China Sea.

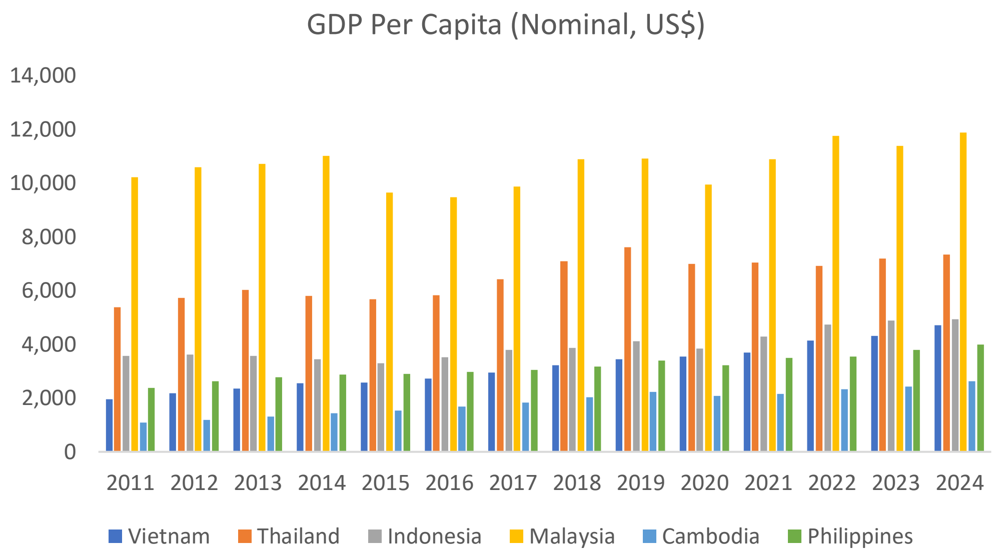

Figure 1. GDP per Capita (Current US$): Vietnam and Selected Southeast Asian Economies, 2011–2024 (World Bank, 2025)

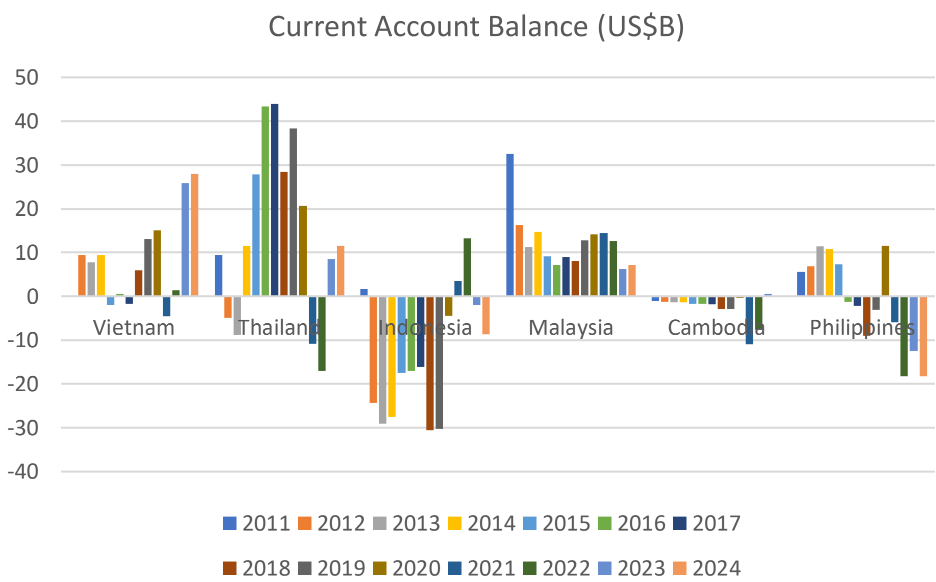

Figure 2. Current Account Balance (US$ billions): Vietnam and Selected Southeast Asian Economies, 2011–2024 (World Bank, 2025)

Vietnam is a fast-growing economy progressing toward middle-income status, supported by stronger inflation control. After 2020, growth became more volatile, but the economy showed strong recovery capacity. Inflation rose slightly in 2024 but stayed moderate, which underscores the importance of improving productivity and managing macro-financial risks while sustaining high growth.

From 2011 to 2024, Vietnam's economy expanded substantially. Nominal GDP (current US$) increased from US$173 billion (2011) to US$476 billion (2024), reflecting a large rise in economic scale. Before COVID-19, real GDP growth was high and relatively stable, mostly 5.3–7.5% during 2011–2019 (about 6.6% on average). The pandemic led to a sharp slowdown, with growth falling to 2.87% (2020) and 2.55% (2021). Despite this, nominal GDP continued to increase, from US$347 billion (2020) to US$366 billion (2021). Growth then rebounded to 8.54% (2022), moderated to 5.07% (2023), and strengthened again to 7.09% (2024). Overall, the long-term pattern is rapid growth, with short-term changes mainly linked to external shocks (Figure 1.1.3).

GDP per capita (current US$) also rose steadily, from US$1,951 (2011) to US$4,717 (2024), more than double. The pace after 2021 was particularly clear: per-capita GDP increased from US$3,704 (2021) to US$4,148 (2022) and continued rising through 2024. Inflation outcomes improved markedly. Inflation was very high in 2011 (18.7%), declined to single digits by 2012–2014, and reached a low of 0.6% (2015). From 2016 onward, inflation remained mostly within a ~2–4% range, including 3.2% (2022), 3.3% (2023), and 3.6% (2024). This indicates a transition from earlier instability toward a more stable macroeconomic environment, with strong growth occurring alongside moderate inflation (Figure 4).

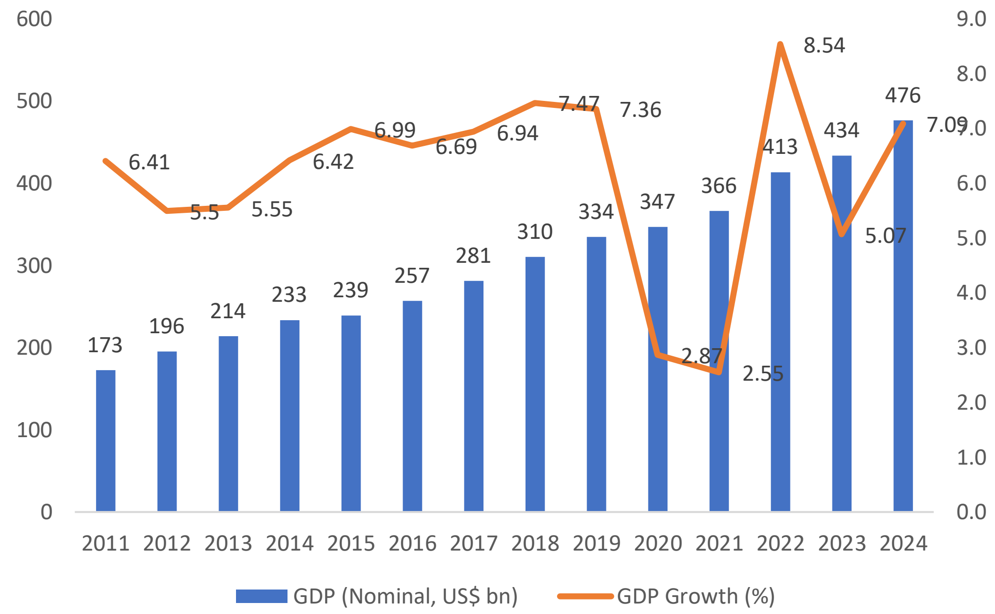

Figure 3 Vietnam: Nominal GDP and Real GDP Growth, 2011–2024 (World Bank, 2025)

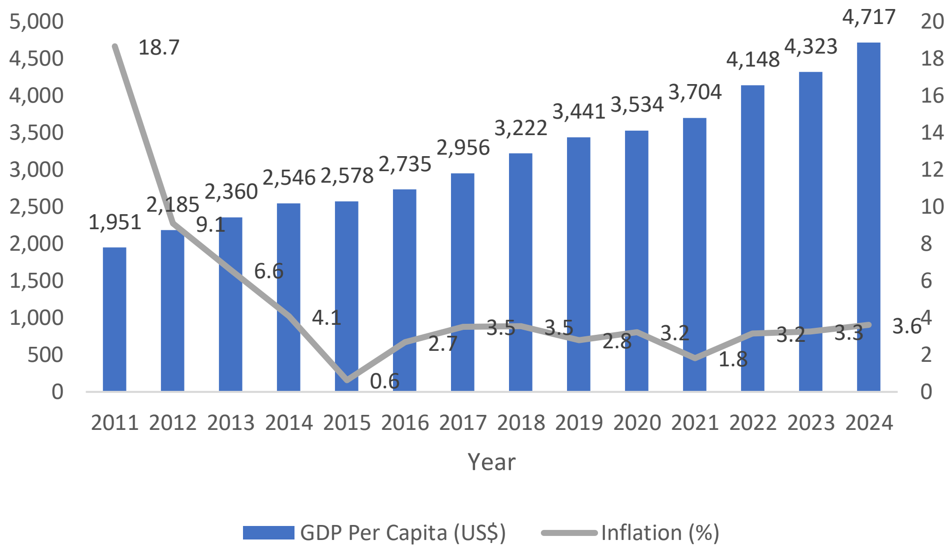

Figure 4. Vietnam: GDP per Capita and Inflation, 2011–2024 (World Bank, 2025)

Macroeconomic conditions directly influence the state's ability to fund environmental and marine priorities. Recent public sources indicate that the current account surplus reached 6.6% of GDP in 2024 (IMF Article IV), reflecting strong external earnings but also exposure to trade shocks. The National Assembly-approved state budget deficit estimate for 2024 was 3.6% of GDP, while Ministry of Finance public reporting indicates an estimated 2024 deficit around 3.1% of realized GDP (MOF budget transparency portal). This public debt as below the National Assembly ceiling, and this fiscal space is relevant to infrastructure-led growth strategies.

The Blue Economy Strategy National political direction explicitly prioritizes sea-based economic development while increasingly recognizing environmental risks. Resolution No. 36-NQ/TW regarding the *Strategy for Sustainable Development of Viet Nam's Sea-Based Economy* (to 2030, vision to 2045) frames the marine economy as a primary national development driver. Crucially, the Resolution acknowledges that marine pollution (including plastic waste), ecosystem degradation, and weak cross-sector linkages act as binding constraints on long-term growth. This strategic framing creates a "design signal" prioritizing large-scale coastal investments (ports, industry, energy). However, it simultaneously creates an urgent requirement for integrated coastal management (ICM) and enforcement capacity to mitigate the environmental externalities of such rapid development.

The growth model of Viet Nam concentrates economic activity and infrastructure in coastal zones. Key drivers include:

- **Export-Oriented Manufacturing:** Coastal industrialization is clustered near deep-water ports and logistics corridors. This drives demand for coastal land conversion, dredging, and industrial zone expansion, increasing risks associated with wastewater discharge and hazardous waste management.

- **Maritime Transport:** The expansion of port capacity increases operational and accidental pollution risks (oil spills, ship-generated waste, invasive species via ballast water etc.). These risks are inherently transboundary, as shipping lanes connect Viet Nam's waters to regional seas and neighboring states.
- **Fisheries and Aquaculture:** The sheer economic weight of this sector creates powerful incentives for fleet expansion and aquaculture intensification, which can lead to stock depletion and habitat conversion unless constrained by effective management.
- **Coastal Tourism and Urbanization:** Rapid urban growth, particularly in provinces with major beach destinations, increases seasonal loads of municipal wastewater and solid waste, while raising demand for shoreline protection against erosion.
- **Energy and Infrastructure:** The expansion of nearshore and offshore energy development introduces cumulative impacts, including marine space competition and potential habitat disturbance.

However, the economic drivers vary by marine/coastal subregion, with governance implications for spatially uneven implementation.

- **South China Sea – Gulf of Tonkin:** Strong concentration of port–industrial activity and FDI-attractive localities (Hai Phong and Quang Ninh), increasing risks from industrial effluents, port development, and land-based marine pollution.
- **South China Sea – Central Coast and South-Central Coast:** Mixed tourism–port–fisheries economies. Where rapid urban tourism growth outpaces sanitation investment, coastal water quality risks rise.
- **South China Sea – Southeast Coast:** Major port and industrial cluster dynamics (including large logistics nodes in Ho Chi Minh), with high exposure to shipping-related pollution and coastal industrial discharges.
- **Gulf of Thailand (Southwest Coast):** Strong dependence on fisheries, aquaculture, and mangrove-linked livelihoods, with governance sensitivity to small-scale fisheries access, aquaculture effluent control, and shoreline ecosystem condition.

To link drivers to governance needs, Table 1 summarizes typical pathways.

Table 1. Economic drivers and governance-relevant pressure pathways

Economic driver	**Typical concentration (by coastal subregion)**	**Main pressure pathways relevant to NTDA**	**Governance/ financing implications**
Port/logistics expansion	Gulf of Tonkin; Southeast Coast	Dredging impacts; accidental spills; ship	Higher needs for port reception

		waste; coastal habitat conversion	facilities, spill preparedness, and compliance monitoring (often multi-agency; costly)
Coastal industrial zones	Gulf of Tonkin; Southeast Coast; selected Central/South-Central nodes	Wastewater/nutrients; hazardous waste; thermal pollution; shoreline modification	Requires sustained budgets for inspections, monitoring, and treatment infrastructure; enforcement resourcing becomes critical
Fisheries and aquaculture	All subregions; aquaculture particularly strong in Mekong Delta coasts (SCS and GoT)	Stock depletion; bycatch; habitat conversion; nutrient/chemical loads from ponds	Requires financing for management measures (data, monitoring, compliance) and pollution control in production landscapes
Tourism/urban growth	Central Coast; South-Central Coast; selected islands/coastal cities	Municipal wastewater; solid waste; coastal erosion from shoreline hardening	Strong demand for sanitation investment, solid waste systems, and coastal risk reduction finance

While Resolution 36-NQ/TW establishes the high-level intent to balance growth with protection, the effectiveness of this strategy depends on whether public investment, regulation, and enforcement budgets can keep pace with the localized pressures generated by these powerful economic drivers.

6.2.2. National budgetary allocations

6.2.2.1. Budgetary structure

Viet Nam uses fiscal policy instruments to generate revenue and influence environmental behavior, but the link between revenue and coastal outcomes depends on budget allocation decisions. The Environmental Protection Tax as a fiscal instrument intended to help address environmental issues, including by generating revenues associated with environmentally harmful products

(ESCAP, 2017). The legal basis is the Law on Environmental Protection Tax No. 57/2010/QH12). In governance terms, the tax is a design feature; whether it improves marine outcomes depends on how revenues contribute to waste management, wastewater treatment, and enforcement capacity.

The budget system follows the Law on the State Budget. Spending is planned and reported across central and local budgets and across major categories (development investment, recurrent spending, contingencies, etc.). Most coastal and marine management is delivered at the local level. This includes inspection, waste services, small ports and fisheries landing sites, coastal pollution control, fisheries enforcement, and protected area operations. In contrast, the central budget mainly funds national standards, national programmes, and specialised forces.

In practice, spending that affects coastal and marine outcomes is spread across many sector budget lines (environment and climate, construction and urban infrastructure, agriculture and fisheries, transport and ports, disaster risk management) and across both central and provincial budgets. This makes it difficult to track and coordinate funding for specific coastal outcomes.

Budget constraints are stronger in provinces that depend on transfers. Only 9 of 28 coastal provinces are fiscally self-balancing, while 19 rely on central budget transfers (World Bank, 2025). Provincial budgets must also prioritise “non-deferrable” recurrent costs (salaries and social security), which can reduce flexible funding for marine management.

6.2.2.2. Public spending on environment and climate

UNICEF (2021) estimates that in 2020, public spending on environment and climate action was 1.5% of total general government spending (about VND 25.6 trillion). Most of this spending focused on:

- Solid waste management, averaging about VND 10 trillion per year (2018–2020).
- Wastewater management, whose share increased from 21.9% (2018) to 27.5% (2020) of environmental spending.

These areas are relevant for reducing land-based pollution. However, broad budget categories (including “other environmental protection”) limit assessment of how much spending directly benefits coastal waters versus inland priorities.

6.2.2.3. Public investment priorities in the marine economy

Analysis of public investment classified under “marine economy” groups suggests a strong focus on infrastructure rather than ecosystem management.

Infrastructure dominates: Coastal infrastructure and construction represented 74% of marine economy public investment in 2016–2019, rising to 87% in 2020–2022 (World Bank, 2025). This spending is mainly for “hard” assets such as expressways, coastal arterial roads, irrigation works, and sea dikes.

Fisheries investment declined: The share for fisheries and aquaculture fell from 8% (2016–2019) to 3% (2020–2022).

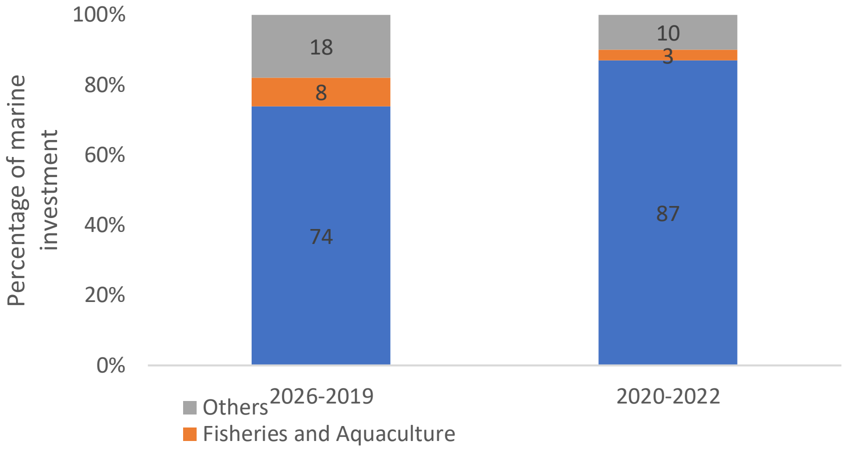

Figure 5. Comparative bar chart showing the divergence between Infrastructure and Fisheries investment shares over time (sources: World Bank, 2025)

The funding structure for the marine economy is overwhelmingly public. Between 2016 and 2022, 97.53% of investment was financed by the state budget (90.57% domestic public capital; 6.96% ODA). Official Development Assistance (ODA), while secondary, has been preferentially used for capital-intensive projects such as dyke systems (World Bank, 2025).

Allocations for Biodiversity and Marine Protected Areas (MPAs) Public budgets are the dominant source for biodiversity conservation, accounting for 77% of total expenditures in the 2011–2015 period (Tran, 2023; UNDP, 2018). However, operating budgets for Marine Protected Areas (MPAs) remain limited:

- Marine/Coastal PA Management Boards: 0.7–2.0 billion VND/year.
- National Park Management Boards: 10–30 billion VND/year.

The Financial Needs Assessment (FNA) estimates that maintaining the existing marine and coastal protected area system requires 242.7 billion VND in 2024, rising to 307.4 billion VND by 2030 (Tran, 2023). However, meeting the new area targets for MPAs will require a substantial increase in capital and recurrent financing. Total annual needs are estimated to rise sharply to 2,906.1 billion VND by 2026 and 6,347.5 billion VND by 2030, driven by establishment and infrastructure costs.

This allocation pattern supports economic connectivity and physical coastal resilience but may not automatically secure funding for the "soft" infrastructure of governance, such as monitoring, enforcement, and ecosystem-based management (World Bank, 2025).

Table 2 compiles core macro indicators commonly used in national governance TDAs. IMF values for 2024–2025 should be treated as estimates/projections as of July 2024 (IMF, 2024), while the GSO value is an official statistic for 2024 (GSO, 2025).

Table 2. Core macro-fiscal indicators relevant to governance diagnostics

Indicator Category	Indicator Name	Value / Status	Source / Year
Macro-Fiscal	Real GDP Growth Projection	7.09% (2024) 8.02% (2025)	General Statistics Office of Viet Nam, 2025.
	Public Debt (% of GDP)	33.8% (2024)	IMF, 2024
	State Budget Net Borrowing (% of GDP)	-2.6% (2024)	IMF, 2024
	Unemployment rate	2.24% (working-age unemployment rate, Q4 2024)	General Statistics Office of Viet Nam, 2025
Public Spending	Environment Spending (% of Gen. Govt. Exp.)	1.5% (approx. 25.6T VND)	UNICEF, 2021
	Wastewater Share of Env. Spending	27.5%	UNICEF, 2021
Marine Investment	Infrastructure Share (M8) of Marine Investment	87%	World Bank, 2025
	Fisheries Share (M4) of Marine Investment	3%	World Bank, 2025
Biodiversity Finance	MPA Maintenance Need (2024)	242.7 Billion VND	UNDP/Tran, 2023
	MPA Expansion Target Need (2030)	6,347.5 Billion VND	UNDP/Tran, 2023

6.2.3 Investments (national and international) (DDI/FDI/ODA by relevant coastal sectors)

6.2.3.1 Scale and Composition of Investment in Coastal Zones

Investment flows are a major driver of environmental change in Viet Nam's land–sea system. They influence where economic activity expands, what types of infrastructure are built, and how much financing is available for environmental management. Between 2011 and 2022, total realised social investment in Viet

Nam’s 28 coastal provinces and cities reached VND 14,158.9 trillion, equal to 51.2% of the national total (GSO, 2023).

The investment structure in coastal provinces has shifted toward domestic private capital. The state-sector share fell from 27.18% (2016) to 22.61% (2022). Over the same period, the non-state (domestic private) share increased from 56.58% to 63.81%, while the FDI share declined slightly from 16.24% to 13.59% (World Bank, 2025). This pattern suggests that transboundary environmental management cannot rely only on public budgets. It also increases the importance of regulatory tools that shape private investment decisions, such as enforceable environmental compliance requirements in supply chains and extended producer responsibility (EPR).

6.2.3.2. Foreign Direct Investment (FDI)

Although its share declined slightly, FDI remains an important channel for industrial development, with clear concentration in major logistics and industrial hubs. In 2024, FDI inflows were strongly clustered in provinces and cities, Hai Phong—a major port city in the Gulf of Tonkin—was among the top destinations with about USD 4.94 billion in registered capital. Quang Ninh (Gulf of Tonkin) and Ho Chi Minh City (Southeast Coast) were also reported among leading destinations (Ministry of Planning and Investment, 2025).

Evidence also indicates a gap between investment in industrial platforms and investment in environmental infrastructure. In several coastal provinces, including Quang Binh and Thai Binh, the number of compliant wastewater treatment plants remains lower than the number of industrial parks and export-processing zones (World Bank, 2025). This creates a direct risk of land-based pollution reaching shared marine waters.

6.2.3.3. Public Investment

Public investment in the “ocean/marine economy” increased from VND 10,144.5 billion (2016) to VND 32,729.2 billion (2022) (World Bank, 2025). Financing for this portfolio is mainly domestic-public: 97.53% comes from the state budget, while 6.96% is reported as Official Development Assistance (ODA). Although ODA is small in aggregate terms, it can be strategically important in selected “new ocean economy” sectors and ecosystem restoration.

- Renewable energy: For the renewable energy sector, ODA accounted for 57.22% of identified financing, compared with 37.10% from domestic state budgets (World Bank, 2025).
- Ecosystem restoration: ODA has been important for mangrove planting and restoration. Examples from 2016–2019 include projects in Kien Giang (VND 306 billion), Ca Mau (VND 179 billion), Thai Binh (VND 159 billion), Bac Lieu (VND 90 billion) (World Bank, 2025). These locations align with key transboundary links. Thai Binh connects the Red River Delta to the Gulf of Tonkin, while Kien Giang, Bac Lieu and Ca Mau connect the Mekong Delta to the Southwest Coast. The condition of

mangrove systems in these areas influences sediment movement, nursery habitats, and plastic retention in shared marine waters.

ODA and development finance remain significant for sanitation and environmental infrastructure in coastal cities. The World Bank's Viet Nam Coastal Cities Sustainable Environment Project (P156143) is a concrete example. The project objective was to increase access to sanitation services and improve the operational performance of sanitation utilities, implemented through provincial project management units in Quang Binh, Binh Dinh, Ninh Thuan, and Khanh Hoa (World Bank, 2024a). These provinces/cities align with South China Sea coastal subregions (Central Coast and South-Central Coast).

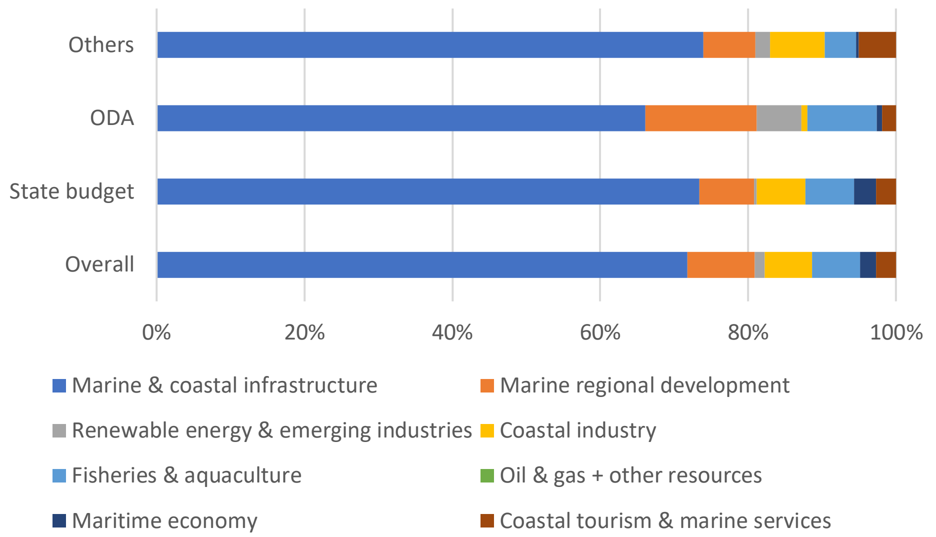

Figure 6. Investment structure (by investment decision), total 2016–2022 (source: World Bank, 2025)

6.2.3.4 Emerging Sustainable Finance Instruments

Investments in sustainable finance instruments are emerging but remain unevenly linked to coastal outcomes. For instance, BIDV developed a Green Bond Framework (2023) and a Sustainability Bond Framework (2024) with World Bank technical assistance (World Bank, 2024b). While these instruments have the potential to support wastewater and climate adaptation investments, their impact on coastal integrity depends on rigorous project selection, verification, and transparency regarding the use of proceeds.

6.2.4 Provincial Investment Profile and Socio-Economic Drivers

Coastal provinces play a structural role in Viet Nam's economy. Overall, they tend to show higher socio-economic development than inland provinces, reflected in a larger economic scale, higher growth, and higher urbanisation. Figure 1.4.1 indicates that in several years, GDP growth in coastal provinces exceeded the national average. In 2018 and 2019, for example, coastal provinces grew about 1 percentage point faster than provinces without a coastline. During the post–COVID-19 recovery, coastal provinces also recorded stronger growth than non-coastal provinces. Urbanisation is also higher in coastal areas: in 2016, the average urbanisation rate across the 28 coastal provinces was 37.6%, compared with 30.11% in non-coastal provinces. The gap has narrowed to around 6.1 percentage points, as inland provinces have urbanised rapidly.

From 2018 to 2022, the combined Gross Regional Domestic Product (GRDP) of the 28 coastal provinces remained close to half of national GDP, ranging from 49.8% to 50.9%. In 2022, coastal GRDP was estimated at VND 4,786 trillion, equal to 49.8% of national GDP (MONRE, 2024). Coastal growth is also a major driver of national performance: during 2011–2022, coastal provinces contributed about 47.6% of national GDP growth (GSO, 2023).

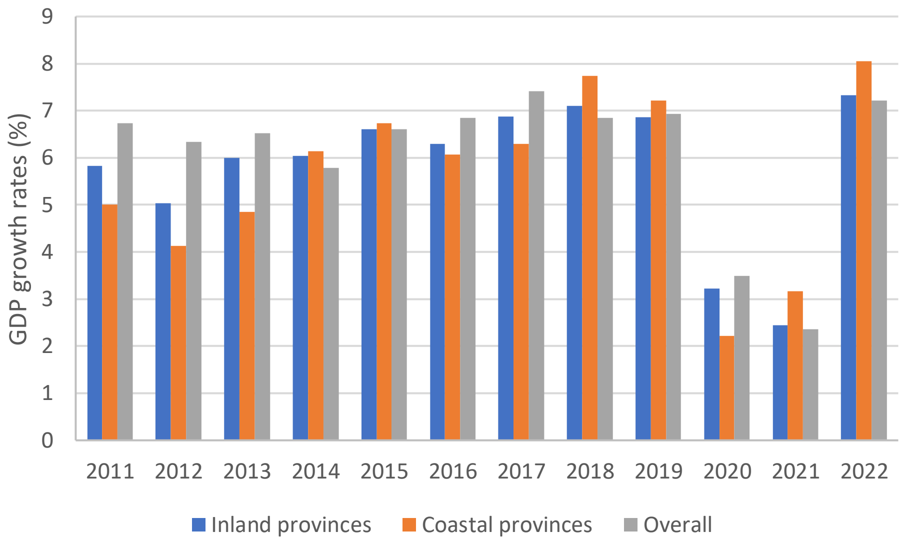

Figure 7. GDP growth rates (%) of the coastal provinces, non-coastal provinces, and national average

The marine economy is closely linked to livelihoods and urbanisation. In 2022, coastal provinces had 48.6 million people (48.9% of the national population) and a labour force of 25.2 million (48.7% of the national total). Higher urbanisation in coastal provinces supports structural change toward industry, port logistics, and services (World Bank, 2024).

The economic weight of the coastal zone is supported by large capital formation. Total realised social investment in coastal provinces during 2011–2022 reached VND 14,158.9 trillion, equal to 51.2% of total investment across all 63 provinces (GSO, 2023). However, investment is uneven and concentrated in a small number of “growth poles” that function as port–industrial hubs. Major concentrations include Ho Chi Minh City (VND 3,801.2 trillion), Thanh Hoa (VND 1,185.6 trillion), Hai Phong (VND 1,054.2 trillion), and Quang Ninh (VND 739.4 trillion). In provinces such as Hai Phong and Quang Ninh—key nodes in the Gulf of Tonkin—investment-to-GDP ratios have exceeded 50% in recent years (World Bank, 2024).

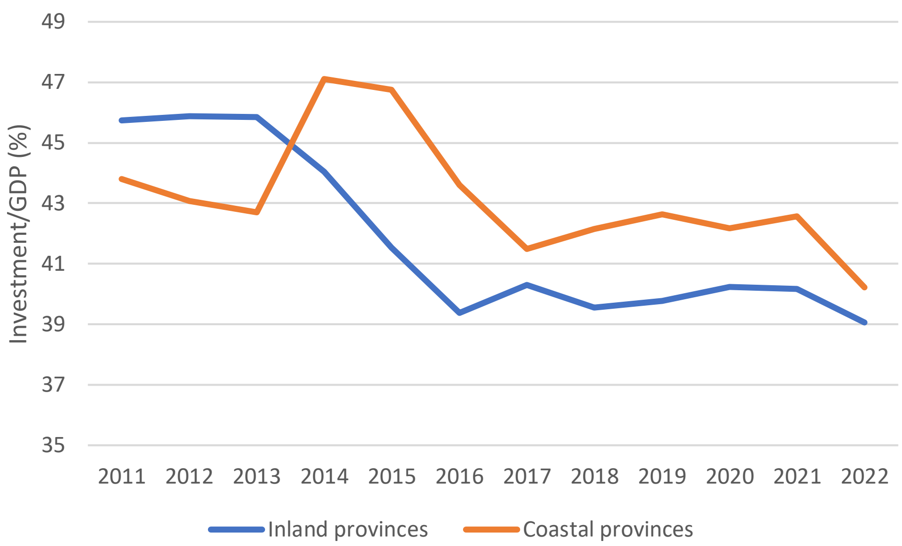

Figure 8. Comparative Investment Intensity (Investment/GDP) in Coastal and Inland Provinces (2011–2022)

This pattern reinforces the "gateway" role of coastal provinces. Seaports and related infrastructure support trade connectivity and participation in global value chains. At the same time, the World Bank (2024) notes that logistics competitiveness still requires continued infrastructure upgrades and governance reforms.

Table 3. Indicative coastal province typology for governance diagnostics

Typology (investment/sector profile)	**Typical subregion examples**	**Likely dominant marine pressures**	**Implications for governance capacity needs**
Port–industrial / high FDI coastal nodes	Gulf of Tonkin (Hai Phong); Southeast Coast (Ho Chi Minh City)	Industrial effluents; port pollution; spill risks; dredging impacts	Higher monitoring frequency, enforcement staffing, port waste systems, spill readiness; stronger inter-agency coordination
Mixed tourism–urban growth nodes	Central Coast; South-Central Coast	Municipal wastewater; solid waste leakage; shoreline modification	Strong sanitation capex/opex needs; service performance monitoring; tourism-sector compliance systems

Aquaculture–fisheries livelihood provinces	Gulf of Thailand; parts of Mekong Delta coasts	Nutrient loading; habitat conversion; fishing effort and gear conflict	High need for local compliance systems, community engagement costs, and pollution controls integrated with livelihoods
Lower-investment / capacity-constrained coastal provinces	Present across all subregions	Often cumulative small sources; weaker waste systems; informal coastal uses	Risk of implementation gaps despite national policies; needs targeted transfers, technical assistance, shared services/data systems

Investment concentration creates both opportunities and risks for governance. Provinces with high investment levels may have higher own-source revenues and stronger administrative capacity. This can help them co-finance environmental infrastructure and strengthen monitoring systems. However, high investment also increases the scale and complexity of environmental pressures. In many cases, development can move faster than wastewater treatment, solid waste services, and enforcement, especially where several sectors expand at the same time (industry, ports, and tourism).

Provinces with major ports and industrial zones are connected to transboundary risks through shipping corridors, including accidental spills and ship-generated waste. These areas can also contribute to marine litter that can be transported across shared waters. Provinces with high fishing effort are linked to shared and migratory fish stocks. This increases the need for coordination beyond provincial borders and, in some cases, across national boundaries.

6.2.5 Sustainable financing initiatives and mechanisms

Sustainable financing initiatives provide the necessary mechanisms for predictable, long-term funding beyond short-term projects or annual budget cycles. For the National Transboundary Diagnostic Analysis (TDA), this is critical because priority actions—such as mangrove restoration, fisheries enforcement, and pollution monitoring—require recurrent finance. However, a structural gap remains. The national biodiversity finance assessment estimates that meeting a subset of national biodiversity targets requires 114,718.3 billion VND for the 2024–2030 period. Conversely, mobilized and expected resources are insufficient, resulting in a projected shortfall of approximately 27,984.4 billion VND (UNDP Viet Nam, 2024). This gap stems from limited public budgets and transaction costs in fund mobilization, creating a strong policy rationale for expanding the toolkit of sustainable financing instruments.

Viet Nam utilizes fiscal instruments to simultaneously generate revenue and influence environmental performance.

- **Environmental Protection Tax:** The *Law on Environmental Protection Tax No. 57/2010/QH12* provides the legal basis for taxing goods with negative environmental impacts (Government of Viet Nam, 2010). While this instrument generates stable revenue streams, its effectiveness for the marine sector is constrained by the lack of direct earmarking; revenues are not automatically allocated to coastal waste systems or enforcement (ESCAP, 2017).
- **Extended Producer Responsibility (EPR):** The *Law on Environmental Protection (2020)* and *Decree No. 08/2022/ND-CP* establish EPR mechanisms for packaging and products. By shifting waste management costs from local budgets to producers, EPR has the potential to strengthen recycling systems. However, in coastal tourism hubs where leakage risks are high, success depends on rigorous verification and the integrity of local collection chains.

A potential domestic revenue source is the capture of resource rents from the use of marine space (sea-area allocation fees and related payments). By 2024, 24 of 28 coastal provinces had issued decisions to allocate sea areas to organisations for exploitation and use (Viet Nam Administration of Seas and Islands, 2024).

Examples show the scale of this revenue stream:

- Tra Vinh Province: As of 30 August 2024, sea-area use revenues included more than VND 500 billion paid to the central budget and VND 214.4 billion to the local budget. Cumulative revenues linked to allocation decisions since 2016 were nearly VND 1,500 billion.
- Ca Mau Province: Reported sea-area use revenues above VND 100 billion, largely linked to sea-area allocations for offshore wind power.

National authorities are also considering auctions of sea-area use rights to increase state revenues. If these mechanisms include strong environmental safeguards, the revenues could support cumulative impact management and environmental monitoring in high-pressure regions such as the Gulf of Tonkin and the Southeast Coast.

PPPs and green bonds provide a legal pathway to mobilize private capital for infrastructure relevant to marine outcomes (wastewater, solid waste, climate resilience). Private capital is increasingly used to finance infrastructure that affects marine outcomes, including wastewater treatment and climate resilience.

- **Public–Private Partnerships (PPPs):** The Law on PPP Investment No. 64/2020/QH14 provides a legal framework for large investments in sanitation and waste management. A key constraint is financial viability. PPP projects need stable and predictable revenue, which is often difficult in municipal waste services without tariff reforms.

- **Green and sustainability bonds:** These instruments are emerging to complement public finance. For example, BIDV developed green and sustainability bond frameworks with technical support from the World Bank (World Bank, 2024b). Their effectiveness depends on (i) a clear pipeline of "bankable" coastal projects (climate adaptation infrastructure) and (ii) transparent monitoring and reporting.

Ecosystem markets and community finance

- **Payments for ecosystem services (PES):** PES has been effective in the forestry sector, but applying it to coastal and marine ecosystems remains difficult. The Sustainable Ocean Economy analysis highlights challenges in identifying payers and beneficiaries for "direct payment" schemes linked to coastal aquaculture and tourism (World Bank, 2025).
- **Community-based finance:** In nearshore fisheries, **78%** of co-management models report having a community fund. However, contributions are often small (**VND 5,000 per household per year**). These funds can support local participation, but they are not large enough for wider ecosystem management without state co-financing (World Bank, 2025).

6.3. Institutional Setting And Governance Architecture

Viet Nam's coastal and marine governance is implemented through a multi-level, multi-sector administrative system. Structurally, it combines (i) central policy and regulatory functions, (ii) decentralized implementation by coastal provincial governments, and (iii) specialized maritime enforcement forces operating in offshore zones.

Significantly, the governance landscape has undergone a fundamental restructuring following the issuance of Decree No. 35/2025/ND-CP (Government of Viet Nam, 2025). Effective March 2025, the former Ministry of Agriculture and Rural Development (MARD) and the former Ministry of Natural Resources and Environment (MONRE) were merged to form the Ministry of Agriculture and Environment (MAE). This consolidation aims to streamline the state apparatus and integrate the management of land, water, and biological resources.

For this NTDA governance profile, the institutional setting is assessed as governance design (formal mandates, roles, organisational arrangements) and governance effectiveness (coordination, implementation capacity, monitoring and enforcement performance, and evidence of results where available). The transboundary relevance of institutions is highlighted where mandates relate to cross-border environmental pollution, shared fisheries risks (including IUU fishing), shipping corridors, and incident response.

6.3.1 Institutions, regulatory agencies, and administrative arrangements

6.3.1.1 Institutional architecture and mandates

Viet Nam's institutional system for coastal and marine governance is based on national laws and national plans, but implementation relies strongly on provincial authorities. Core functions include marine spatial planning and coastal resource planning; environmental management and pollution control; fisheries management and compliance; maritime transport and port administration; and maritime law enforcement and security.

The creation of the Ministry of Agriculture and Environment (MAE) represents an important institutional change. By merging the functions of the former Ministry of Agriculture and Rural Development (MARD) and the former Ministry of Natural Resources and Environment (MONRE), the 2025 reorganisation is designed to bring most land–sea interface functions under one lead ministry. In principle, this consolidation covers:

- **Integrated marine management:** marine spatial planning and coastal zone management (previously under MONRE).
- **Sectoral resource management:** fisheries, aquaculture, and conservation (previously under MARD).
- **Pollution control:** regulation of waste and wastewater (previously under MONRE).

However, several critical functions remain outside MAE and are managed by other ministries. These include national defense, maritime security, transport and logistics, foreign affairs and diplomacy.

Key National and Sub-national Institutions Table 4 summarizes the primary institutions whose mandates shape marine governance outcomes in the South China Sea and Gulf of Thailand.

Table 4. Core institutions and mandates relevant to coastal and marine governance

Institution / level	Core mandate relevant to governance	Illustrative legal/mandate basis	Main operational interface
(1) National Assembly & Government	Approves national plans and adopts/implements legal frameworks for marine space, environment, fisheries, and enforcement.	*National Marine Spatial Planning Resolution No. 139/2024/QH15*	National planning decisions; Treaty ratification.
(2) Ministry of Agriculture	State management across agriculture,	*Decree No. 35/2025/ND-CP*	National programs;

and Environment (MAE)	fisheries, and environment; hosts agencies responsible for sea–island governance and fisheries management after 2025 reorganisation.		Technical standards; Data systems; Sector oversight.
(3) Viet Nam Sea and Islands Administration/Department (VASI) under MAE	Dedicated body for sea and islands administration; supports integrated management of marine resources and environment. Responsible for marine spatial planning, coastal corridor management, and marine plastics policy.	*Law on Marine and Island Resources and Environment No. 82/2015/QH13*	ICZM; Coastal planning; Marine monitoring data; Cross-sector coordination.
(4) Fisheries Directorate & Surveillance *(under MAE)*	Manages fisheries allocation, aquaculture standards, and combats IUU fishing. Operates the Vessel Monitoring System (VMS).	*Fisheries Law No. 18/2017/QH14*;	Port state measures; Traceability; VMS operations; At-sea inspection.
(5) Nature and Biodiversity Conservation Agency (*under MAE*)	Leads nature conservation and biodiversity management; policy/technical oversight for protected areas and biodiversity conservation instruments (including marine/coastal ecosystems as relevant).	*Law on Biological Diversity (2008 and 2018)*	Protected area policy and guidance; biodiversity data/monitoring linkages; coordination with provinces and site-level management boards.
(6) Department of Climate	Leads national climate change governance relevant to	*Law on Environmental Protection No.*	National adaptation planning

Change (DCC) (*under MAE*)	coastal/marine planning (adaptation, climate-risk management/sea-level rise considerations), and mitigation instruments (GHG management and carbon market) that affect marine/coastal sectors.	*72/2020/QH14; Decree No. 06/2022/NĐ-CP (GHG mitigation & ozone layer)*	guidance and M&E; national GHG inventory and MRV implementation; allocation/management of emissions quotas; domestic carbon market policy and operation; ozone-layer protection measures; coordination for international reporting/implementation under relevant treaties (Paris Agreement UNFCCC and Montreal Protocol-related obligations).
(7) Provincial People's Committees (coastal provinces)	Decentralised implementation of marine-related responsibilities; coastal planning implementation; local environmental monitoring programmes; local reporting to central level.	*Law on Local Government Organization No. 77/2015/QH13*; *Law on Environmental Protection* No. 72/2020/QH14 *Law on Marine and Island Resources and Environment 82/2015/QH13*	Licensing/permits as decentralised; monitoring; inspections; local enforcement coordination; coastal protection corridors and marine environmental incidents
(8) Viet Nam Coast Guard (Ministry of	Patrol, inspection, control and law enforcement in	*Viet Nam Coast Guard Law No. 33/2018/QH14*	Maritime zones; incident response

National Defence - MoD)	maritime zones; may conduct international cooperation relevant to maritime law enforcement.		coordination; cross-border engagement.
(9) Border Guard (Ministry of National Defence - MoD)	Coastal/border law enforcement; defined sanctioning powers for fisheries administrative violations.	*Viet Nam Border Defence Law No. 66/2020/QH14. Decree 38/2024/ND-CP on administrative penalties in the fisheries sector.*	Ports, coastal waters, border areas.
(10) Environmental Police (Ministry of Public Security - MPS)	Enforcement functions including sanctioning powers for fisheries violations (administrative) and broader environmental compliance roles through national enforcement system.	*Environmental Police Ordinance No. 10/2014/UBTVQH13*	Environmental crime/violations; coordination with provinces.
(11) Ministry of Construction (MoC) – Vietnam Maritime and Waterway Administration and port authorities	Port and maritime administration roles; responsibilities connected to flag/port-state functions and port governance.	*Viet Nam Maritime Code No. 95/2015/QH13;* *Circular 18/2025/TT-BXD on organisation/operation of maritime and inland waterway port authorities.*	Major ports and shipping corridors affecting pollution risk and compliance.
(12) Ministry of Foreign Affairs (MOFA)	Coordinates international cooperation for transnational marine pollution response with MAE (formerly MONRE).	*Law on Marine and Island Resources and Environment No. 82/2015/QH13*	Regional and bilateral cooperation; incident response diplomacy.

(13) Ministry of Finance (MoF)	Manages public finance levers that enable coastal/marine governance: state budget allocation, fiscal instruments (fees/charges), and oversight of public spending supporting marine protection, monitoring, and enforcement;	*Law on Environmental Protection No. 72/2020/QH14 (cross-sector compliance interface);* *Decree 14/2023/ND-CP on MoF functions, tasks, powers, and organisational structure*	Budgeting and finance for programmes/projects; environmental finance tools;
(14) Ministry of Science and Technology (MOST)	Leads national science & technology policy, research programmes, standards and quality infrastructure that support marine governance.	*Law on Science and Technology 29/2013/QH13;*	Marine R&D programmes; standards/technical regulation support; technology transfer; innovation for monitoring and environmental solutions.
(15) Ministry of Industry and Trade (MOIT)	Sector governance for energy, industry and trade (offshore energy supply chains, coastal industrial zones, petroleum/energy-related risks), supporting cross-sector coordination with environment and maritime regulators.	*Law on Environmental Protection No. 72/2020/QH14 (cross-sector compliance interface).*	Industrial & energy policy; coordination on coastal/offshore projects; compliance interfaces with environment/ports
(16) Ministry of Culture, Sports and Tourism (MCST)	State management of tourism and cultural heritage; in UNESCO-linked contexts (World Heritage/heritage sites and associated destinations;	*Decree No. 43/2025/ND-CP on functions, tasks, powers, and organisational structure of*	PPCs and provincial DoCST; destination/site management boards; tourism licensing/standa

	Biosphere Reserves where tourism pressure/financing is material), provides the sector basis for visitor-use management and tourism business regulation—requiring alignment with conservation and PPC decisions.	*MCST. Law on Tourism No. 09/2017/QH14. Law on Cultural Heritage No. 28/2001/QH10 (and amendments).*	rds; coordination with MAE (ecosystem protection) and MOFA/UNESCO processes where relevant.

In addition to formal mandates, Viet Nam uses multi-agency steering arrangements for priority issues that require rapid inter-ministerial coordination. A prominent example is national-level steering for IUU fishing compliance, involves leadership from the Central Government, Ministry of Agriculture and Environment, Ministry of National Defense, and Coastal Provinces. It bypasses standard bureaucratic hierarchies to ensure rapid response to the European Commission's "Yellow Card" requirements.

While the central level is integrated, the system remains heavily reliant on Provincial People's Committees for execution. This creates a "double accountability" challenge where local departments must answer to both the Ministry (for policy) and the Provincial Chairman (for budget).

6.3.1.2 Vertical coordination and decentralised implementation

Viet Nam's marine governance operates on a "Unitary but Decentralized" model, characterized by a clear division of labor between normative oversight and executive implementation.

- Central Level (MAE and other Ministries): Responsible for "State Management". This entails setting legal standards, formulating national master plans, issuing technical guidance, and organizing national-scale monitoring and database systems.
- Provincial Level (People's Committees and Departments**):** Responsible for "Implementation". Coastal provinces execute local monitoring programs, supervise compliance, license investment projects, and report on environmental quality.
- Specialized Forces**:** In maritime zones beyond provincial jurisdiction, specialized forces (Fisheries Surveillance, Coast Guard, Border Guard) enforce specific legal regimes and provide support to provinces where local enforcement capacity is insufficient.

This pattern is explicitly reflected in the Law on Marine and Island Resources and Environment (2015), which assigns the MAE (formerly MONRE) roles to organise and examine implementation of coastal resource master planning, to develop marine databases, and to receive annual reports from ministries and coastal provinces.

In addition, the Law on Marine and Island Resources and Environment requires annual reporting by: (i) MAE (formerly MONRE) to the Government, and (ii) ministries and coastal provincial People's Committees to MAE on baseline surveys, exploitation and use of marine resources, and marine environmental protection within their management scope.

Similarly, the *Law on Environmental Protection* (2020) establishes a multi-level monitoring network. MAE directs national monitoring programs (including cross-border sea areas), while provincial PPCs organize local monitoring networks and report results upward. This design relies heavily on the technical interoperability of provincial data with central systems.

Since mid-2025, the governance landscape has shifted toward greater devolution. Decree No. 136/2025/ND-CP regarding decentralization in agriculture and environment fields introduces provisions that delegate authority for allocating, recognizing, and withdrawing sea area use rights to the provincial level.

In practice, vertical effectiveness differs across coastal subregions because policy problems and administrative burdens differ:

- Gulf of Tonkin and Southeast Coast (SCS): higher density of ports/industrial activities increases demand for monitoring, permitting, and enforcement coordination with transport and port authorities.
- South-Central Coast and Central Coast (SCS): strong exposure to tourism/coastal development pressures raises demands on coastal corridor implementation and local spatial planning compliance.
- Gulf of Thailand (Southwest Coast): higher salience of cross-border fishing and IUU risks increases coordination needs among fisheries agencies, border forces, and ports.

These are institutional workload differences; publicly comparable province-by-province capacity metrics (staffing, patrol days, inspection frequency) are not consistently available in one national dataset and are therefore treated as a data gap for effectiveness assessment.

Table 5. Vertical coordination demands by marine region

Marine Region	Primary Economic Driver	Primary Vertical Coordination Challenge	Key Agencies Involved
Gulf of Tonkin	Port–Industrial Complexes (Hai Phong, Quang Ninh)	Industrial Permitting: Coordinating central transport/environment mandates with local zoning.	MAE, Ministry of Transport (VINAMARINE), Provincial DORE

Central Coast	Urban Tourism & Coastal Infrastructure	Spatial Zoning: Enforcing coastal setbacks against tourism development pressure.	MAE (Sea & Islands), Provincial Construction Dept, Provincial PPC
Southwest Coast	Fisheries & Mangrove Ecosystems	Cross-Border Enforcement: Coordinating IUU patrols and VMS response in border waters.	MAE (Fisheries Surveillance), Border Guard, Coast Guard, Provincial PPC

6.3.1.3 Horizontal coordination

Effective marine governance in Viet Nam requires robust horizontal coordination because the primary drivers of degradation operate across sectoral boundaries. Land-based pollution impacts marine water quality; port expansion alters coastal hydrology; and conservation measures directly affect fisheries livelihoods and tourism development. Consequently, governance cannot be siloed: it requires structural alignment between the Ministry of Agriculture and Environment (MAE) and external partners, particularly the transport authorities, security forces, and provincial administrations.

The *Law on Marine and Island Resources and Environment* (2015) establishes the formal basis for horizontal coordination, mandating specific inter-agency processes:

- Joint Planning Oversight: MAE (formerly MONRE) is responsible for coordinating with line ministries and coastal provincial authorities to organize and inspect the implementation of coastal resource master planning.
- Consultation Requirements: The law mandates the public posting of coastal master planning documents and defines consultation periods to ensure sectoral inputs are captured.
- Data Integration: It establishes a duty for ministries and provinces to integrate sectoral data into a centralized National Marine and Island Database, led by MAE.

National Marine Spatial Planning (MSP) serves as the primary institutional framework for horizontal alignment. The National Assembly's recent resolution approving the national MSP defines a comprehensive scope covering coastal land, islands, and marine waters across 28 coastal provinces (Resolution No. 139/2024/QH15). Following the Government's implementation plan (Resolution No. 37/NQ-CP/2025), the MSP framework acts as a binding mechanism that forces inter-sectoral alignment. It requires that marine economic sectors (energy, transport, fisheries) align their spatial footprints with environmental protection objectives, theoretically resolving conflicts before they manifest as operational disputes.

While MSP addresses planning, the control of Illegal, Unreported, and Unregulated (IUU) fishing illustrates horizontal coordination in enforcement. Official reporting describes a sophisticated national coordination mechanism linking central and local levels and multiple agencies, including engagement of defence-related forces and digital service providers for monitoring. This is relevant for transboundary fisheries governance because preventing illegal fishing in foreign waters and ensuring traceability require coordination among fisheries management, enforcement forces, ports, and legal oversight bodies.

The MAE merger may reduce internal fragmentation between environment and fisheries functions. However, horizontal coordination remains necessary with: (i) the Ministry of National Defence (coast guard/border guard), (ii) the Ministry of Transport (ports/shipping), and (iii) the Ministry of Foreign Affairs (transboundary incidents and cooperation). MAE has described the merger's policy intent as an opportunity to restructure and increase efficiency, but operational effectiveness will depend on implementing rules, shared data systems, and incentives that sustain collaboration across agencies.

6.3.2 Monitoring, compliance, and enforcement arrangements

a. Environmental Monitoring:

The Law on Environmental Protection (2020) establishes the legal basis for a comprehensive monitoring system comprising both national and provincial components. Crucially for the TDA, the law explicitly lists seawater as an environmental component subject to monitoring and assigns the Ministry of Agriculture and Environment (MAE, formerly MONRE) the responsibility to organize national programs, including those serving inter-regional and cross-border areas. Provincial People's Committees are concurrently required to organize local monitoring and report results upward to the central ministry.

In practice, an official reporting process is operational. The National State of Sea and Islands Environment Report (2016–2020) serves as the first consolidated output following the Law on Marine and Island Natural Resources and Environment. It utilizes data from national monitoring programs and dedicated analysis stations, with coverage extending across a subset of coastal provinces. However, official assessments highlight significant constraints in evidence generation. Comprehensive assessments of pollution loadings discharged directly into the marine environment remain limited. Available studies often focus on specific sectors or isolated activities due to persistent data limitations (MONRE, 2021).

b. Fisheries monitoring, control and surveillance (MCS) and IUU compliance:

For capture fisheries, monitoring and compliance rely on a combination of specialised enforcement forces and digital monitoring tools.

Fishery control force mandate: *Decree No. 102/2012/ND-CP* defines the Fishery Control Force as a specialized state force under the fisheries administration. Its functions include patrol, inspection, detection, and the handling of fisheries violations within Viet Nam's sea areas

Vessel Monitoring System (VMS) operational monitoring: The Directorate of Fisheries operates a 24/7 VMS monitoring system at the central level. This system is designed to detect and follow up on high-risk behaviors, such as VMS disconnections or boundary crossings. Implementation involves ongoing coordination and training on electronic traceability software across localities, the Border Guard, fishing port management boards, and seafood businesses.

Reported compliance trends: Official communications from the Directorate of Fisheries report a positive trend, noting that the number of vessels violating IUU-related requirements—such as encroaching on foreign waters or losing VMS connectivity—has decreased compared to the same period in 2024. While this serves as a positive directional indicator, it does not replace the need for consistent, public statistical reporting of violation counts, sanction outcomes, and deterrence measures by province.

c. Administrative enforcement powers and sanctioning jurisdiction

Enforcement at sea involves several forces with defined sanctioning powers.

- Fisheries sanctions: Decree No. 38/2024/ND-CP, effective from May 20, 2024, establishes strict administrative sanctions for violations in the fisheries sector, replacing Decree No. 42/2019/ND-CP to combat Illegal, Unreported, and Unregulated (IUU) fishing. It clearly defines the sanctioning jurisdiction for a wide range of authorities, including Chairpersons of People’s Committees, Police, Border Guard, Fisheries Inspection Forces & Inspectors, Forestry Rangers and Coast Guard, aiming to enhance the effectiveness of law enforcement, particularly regarding vessel monitoring and compliance with maritime regulations.
- Coast guard operational powers and cooperation: The Law on Viet Nam Coast Guard (No 33/2018/QH14) provides broad powers to patrol, inspect, and control activities within Viet Nam’s maritime zones. It also includes specific provisions enabling international cooperation in accordance with treaties, which is vital for transboundary incident response.
- Environmental sanctions: Decree No. 45/2022/ND-CP applies administrative penalties for environmental violations occurring within Viet Nam’s contiguous zone, territorial sea, exclusive economic zone (EEZ), and continental shelf. It also applies to Vietnamese-flagged seagoing ships globally, unless otherwise provided by international treaty

d. Overlap and coordination implications

The existence of multiple authorities (Coast Guard, Border Guard, Police, Fisheries Surveillance, Local Governments) with overlapping sanctioning jurisdiction creates a critical requirement. Effective governance requires clear operational protocols for: (i) Ensuring seamless transfer of violations detected by one force to the agency with the appropriate sanctioning power, (ii) Maintaining chain-of-custody for evidence used in administrative or criminal proceedings, (iii) Ensuring that sanctions applied by different agencies are consolidated into national databases. Without such protocols, overlaps can weaken deterrence and reduce transparency about enforcement outcomes, particularly for transboundary-relevant issues (IUU fishing in foreign waters; pollution incidents affecting neighbouring states). This is an institutional effectiveness risk rather than a design gap.

6.3.3 Institutional capacity and resourcing

Viet Nam's marine governance framework has undergone significant structural reform to address fragmentation and improve resource efficiency. However, the system faces persistent challenges regarding human resource quantity and quality, financial dependence on state budgets, and limitations in technical infrastructure.

A major administrative restructuring occurred in 2025 with the merger of the Ministry of Agriculture and Rural Development (MARD) and the Ministry of Natural Resources and Environment (MONRE) to form the Ministry of Agriculture and Environment (MAE), This consolidation aims to resolve long-standing "sectoral silos" and overlapping mandates between resource exploitation and conservation agencies.

Within the MAE, key specialized units include:

- Viet Nam Administration of Seas and Islands (VASI): Tasked with integrated marine management, marine spatial planning, and international cooperation.
- Directorate of Fisheries and Fisheries Surveillance: Responsible for fisheries management, combating illegal fishing (IUU), and managing marine protected areas (MPAs).
- Department of Nature Conservation and Biodiversity: Oversees the implementation of the National Biodiversity Strategy.

The MAE merger may create opportunities to align environment–fisheries planning and monitoring functions within one ministry. However, it can also create short-term transition burdens: reassigning responsibilities, integrating data systems, harmonising internal procedures, and clarifying provincial reporting lines. An MAE communication frames the merger as an administrative reform step aiming for a streamlined and effective apparatus. Whether these intended benefits translate into coastal/marine outcomes depends on implementation details and resourcing decisions at both central and provincial levels.

Marine governance at the local level is decentralized to the 28 coastal provinces (reorganized into 21 provinces following administrative mergers). The Provincial People's Committee (PPC) serves as the primary decision-making body for marine spatial planning and resource allocation within 6 nautical miles of the coast. Specialized advice is provided by the Department of Agriculture and Environment, formed by merging local agricultural and environmental agencies.

Human resource shortages are acute at the local level:

Staffing Density: Many provincial agencies allocate only 3 to 5 staff members to manage fisheries protection and development, which is insufficient for the scope of duties. At the district and commune levels, staff often work on a part-time or concurrent basis (kiêm nhiệm) without specialized training in marine governance.

Quality and Expertise: There is a shortage of personnel with deep expertise in marine biology, oceanography, and international law. Recruitment is difficult as universities struggle to attract students to fisheries and marine mechanics majors.

Aging Workforce: A significant portion of the current workforce is approaching retirement age, creating a potential leadership vacuum in the period leading up to 2030.

Effective coastal and marine outcomes in Viet Nam depend on how well the institutional design translates into implementation. Where vertical reporting, monitoring networks, and enforcement powers operate coherently, the system can reduce pollution pressures (through monitoring, permitting, and sanctions), improve fisheries sustainability (through VMS, port controls, and deterrence of IUU behaviors), and strengthen resilience to marine incidents (through incident response coordination and cross-agency mobilisation). However, where provincial capacity is limited, where inter-agency data exchange is slow, or where overlapping mandates are not operationally coordinated, enforcement consistency and monitoring coverage can weaken. This can allow continued land-based and marine-source pressures to accumulate, with transboundary implications including shared stock impacts, cross-border IUU risks, and marine pollution transport across the SCS and GoT systems.

6.4 Legal and Policy Setting

6.4.1 International legal/policy frameworks

6.4.1.1 United Nations Convention on the Law of the Sea (UNCLOS)

Viet Nam ratified UNCLOS on 25 July 1994, establishing the fundamental legal framework for its maritime zones and activities. UNCLOS serves as the basis for national legislation, including the 2012 Law of the Sea of Viet Nam. Viet Nam is also a party to the two implementing agreements under UNCLOS:

- Agreement relating to the implementation of Part XI of the United Nations Convention on the law of the sea (Part XI Agreement)**:** Viet Nam acceded to the Agreement relating to the implementation of Part XI of UNCLOS (regarding deep seabed mining) on 27 April 2006.
- UN Fish Stocks Agreement (UNFSA): Viet Nam acceded to the United Nations Fish Stocks Agreement (UNFSA) on 18 December 2018, committing to the long-term conservation and sustainable use of straddling and highly migratory fish stocks.
- BBNJ Agreement (Biodiversity Beyond National Jurisdiction): Viet Nam was among the first countries to sign the Agreement under UNCLOS on

the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (BBNJ) in 2023, aimed at protecting biodiversity in the high seas.

- UN Fish Stocks Agreement (UNFSA): Viet Nam acceded on 18 December 2018 (Entry into force: 17 January 2019). This instrument provides the legal basis for cooperation on straddling and highly migratory fish stocks, directly relevant to the South China Sea fisheries.
- FAO Port State Measures Agreement (PSMA): As a Party, Viet Nam is obligated to implement port-based compliance measures, denying entry or services to foreign vessels engaged in IUU fishing. This links Viet Nam's major ports to the global fight against illegal fishing.
- WTO Agreement on Fisheries Subsidies: On 15 September 2025, Viet Nam deposited its instrument of acceptance. This binding agreement disciplines harmful subsidies that contribute to IUU fishing and the fishing of overfished stocks, necessitating reforms in domestic subsidy programs.

6.4.1.2 Maritime Safety and Security (IMO Conventions)

As a member of the International Maritime Organization (IMO) since 1984, Viet Nam is a party to major safety and security conventions:

- COLREG 72: International Regulations for Preventing Collisions at Sea (joined 1990).
- SOLAS 74: International Convention for the Safety of Life at Sea (joined 1990).
- STCW 78: International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (joined 1990).
- SAR 79: International Convention on Maritime Search and Rescue (joined 2007).
- SUA 88: Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (joined 2002).

6.4.1.3 Pollution control and waste management

Pollution governance is shaped by a suite of treaties addressing chemicals, waste, and ship-source pollution.

- Basel Convention: Regulates the transboundary movement of hazardous wastes, critical for managing imported plastic waste streams that pose leakage risks in coastal zones.
- Stockholm Convention (POPs): Addresses Persistent Organic Pollutants, which accumulate in marine sediments and food webs through long-range transport and riverine discharge.

- Minamata Convention: Viet Nam's participation (Entry into force: 2017) addresses mercury risks, relevant to seafood safety and industrial pollution control.
- Ballast Water Management (BWM) Convention: In June 2024, the Prime Minister approved the National Implementation Plan (Decision No. 515/QD-TTg) for the BWM Convention. This is a key preventive measure against invasive alien species introduced via international shipping traffic in major ports like Hai Phong and Ho Chi Minh City.

6.4.1.4 Biodiversity and climate frameworks

- Convention on Biological Diversity (CBD): Participation in the CBD underpins Viet Nam's national biodiversity strategies, requiring the protection of marine habitats and reporting on conservation targets. It establishes expectations for cooperation on migratory species.
- Climate Change Integration: While governed by separate climate treaties (UNFCCC/Paris Agreement), climate resilience is explicitly integrated into marine policy via Resolution No. 36-NQ/TW (2018). This resolution frames sea-level rise and coastal erosion as critical governance challenges, particularly for the low-lying deltas (Mekong and Red River) that interface with the sea.

6.4.2 Regional legal/policy frameworks and forums

Viet Nam actively participates in a tiered system of regional governance, ranging from broad multilateral cooperation platforms to specific bilateral legal instruments.

6.4.2.1 Regional Cooperation Platforms (Multilateral)

These frameworks provide the mechanisms for policy coordination, technical standardization, and joint actions on marine environmental issues across the East Asian Seas.

- Coordinating Body on the Seas of East Asia (COBSEA): COBSEA is one of the United Nations Environment Programme (UNEP) Regional Seas Programmes. Established in 1981, it oversees the implementation of the Action Plan for the Protection and Sustainable Development of the Seas of East Asia. Viet Nam joined COBSEA in 1993. This body coordinates activities related to marine ecosystem assessment, coral reef protection, and marine pollution prevention. Current cooperation includes projects to reverse environmental degradation trends in the South China Sea and the Gulf of Thailand.
- Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) PEMSEA acts as an intergovernmental organization fostering healthy and resilient coasts and oceans through Integrated Coastal Management (ICM). Viet Nam has been a member since 2003. PEMSEA supports the scaling up of ICM in coastal provinces and facilitates partnerships for the sustainable development of the blue economy.

- ASEAN Cooperation on Coastal and Marine Environment (AWGCME): Cooperation is operationalized through mechanisms such as the ASEAN Working Group on Coastal and Marine Environment. ASEAN platforms facilitate high-level dialogue and shared problem framing (regarding marine debris and biodiversity conservation). They enable coordination on regional work programs that align national policies with regional priorities.
- Western and Central Pacific Fisheries Commission (WCPFC): Established to manage highly migratory fish stocks (primarily tuna) in the Western and Central Pacific Ocean, the WCPFC implements conservation measures consistent with the United Nations Convention on the Law of the Sea (UNCLOS). Viet Nam holds the status of a Cooperating Non-Member, allowing it to participate in fisheries management dialogues and technical compliance mechanisms.
- Southeast Asian Fisheries Development Center (SEAFDEC): SEAFDEC is an autonomous intergovernmental body that promotes sustainable fisheries development. It collaborates with ASEAN to establish regional plans of action, particularly concerning the prevention of Illegal, Unreported, and Unregulated (IUU) fishing.
- Regional Cooperation Agreement on Combating Piracy and Armed Robbery against Ships in Asia (ReCAAP) Viet Nam joined ReCAAP in 2006. This is the first regional government-to-government agreement to promote and enhance cooperation against piracy and armed robbery against ships in Asia. The agreement mandates information sharing, capacity building, and cooperative arrangements for law enforcement. An Information Sharing Centre (ISC) facilitates these activities.
- Regional Plan of Action to Promote Responsible Fishing Practices (RPOA-IUU): Viet Nam participates in this voluntary instrument, established in 2007, to manage fishing capacity and combat IUU fishing in the South China Sea, Sulu-Sulawesi Seas, and Arafura-Timor Seas.
- Strategic Action Programmes: Through mechanisms like the GEF/UNDP projects, Viet Nam engages in the implementation of Strategic Action Programmes for the South China Sea and the Gulf of Thailand to address transboundary environmental challenges.
- Marine Pollution and Plastic Waste: Viet Nam cooperates internationally on marine plastic debris through ASEAN and global mechanisms. The country is active in negotiations for a global treaty on plastic pollution and implements regional action plans to reduce marine debris.
- Disaster Risk and Search and Rescue: Viet Nam is a party to the ASEAN Agreement on Disaster Management and Emergency Response (AADMER) and participates in regional search and rescue (SAR) coordination. The legal framework includes specific regulations for

coordinating SAR activities at sea, facilitating cooperation with neighboring states during maritime incidents.

6.4.2.2. Sub-regional and bilateral legal arrangements

Viet Nam has established a legal framework for maritime governance through specific boundary agreements with neighboring countries, which facilitate joint management and resource exploitation:

- Gulf of Tonkin: Agreement on the Delimitation of the Territorial Seas, Exclusive Economic Zones, and Continental Shelves with China (2000).
- Gulf of Thailand: Agreement on the Delimitation of the Maritime Boundary with Thailand (1997) and Agreement on Historic Waters with Cambodia (1982).
- Continental Shelf: Agreement concerning the Delimitation of the Continental Shelf Boundary with Indonesia (2003).
- Joint Development: Memorandum of Understanding on Defining Areas of Joint Oil and Gas Exploration and Exploitation with Malaysia (1992).

6.4.3 National legislation and policies

Viet Nam's governance framework for marine and coastal areas is established through a hierarchy of legal instruments, ranging from strategic Party resolutions to specific technical circulars. Recent administrative reforms, particularly those noted in 2024 and 2025 sources, indicate a shift toward integrated management and decentralization.

6.4.3.1 Strategic Policy Framework

The overarching orientation for marine governance is defined by the Communist Party and concretized by the Government.

- Resolution No. 36-NQ/TW (2018): This resolution on the "Strategy for Sustainable Development of Viet Nam's Marine Economy to 2030, with a Vision to 2045" serves as the primary strategic guideline. It shifts focus from resource extraction to a "Blue Economy" model, targeting sustainable development across six priority marine economic sectors.
- Resolution No. 26/NQ-CP (2020): This government resolution establishes the master plan and five-year action plan to implement Resolution No. 36, identifying specific programs and projects for marine infrastructure, tourism, and renewable energy.
- Strategy for Sustainable Exploitation (2023): Approved by Resolution No. 48/NQ-CP, this strategy outlines the sustainable use of marine resources and environmental protection through 2030, serving as a critical tool for state management.

6.4.3.2 Key national legislation

The legislative framework is anchored by several fundamental laws that regulate sovereignty, resource use, and environmental protection.

- Law of the Sea of Viet Nam (2012): This law asserts Viet Nam's sovereignty, sovereign rights, and jurisdiction over maritime zones (internal waters, territorial sea, contiguous zone, EEZ, and continental shelf) in accordance with UNCLOS 1982. It provides the legal basis for maritime economic development and defense.
- Law on Marine Resources and Environment of Seas and Islands (2015): This is the central legal instrument for "integrated coastal zone management" (ICZM). It mandates: (1) Integrated Management: Managing marine resources based on an ecosystem approach rather than sectoral administrative boundaries; (2) Coastal Protection Corridors: Establishing setbacks along the coast to protect ecosystems and ensure public access to the sea; (3) Pollution Control: Regulating Ocean dumping, oil spill responses, and pollution from land-based sources.
- Law on Fisheries (2017): This law provides the national legal basis for fisheries activities and state management. It regulates aquaculture and capture fisheries with a focus on sustainability and combating Illegal, Unreported, and Unregulated (IUU) fishing. Key provisions include: (1) Co-management: Legalizing the sharing of management rights and responsibilities between the State and community organizations for fishery resource protection; (2) Marine Protected Areas (MPAs): Establishing the legal basis for MPAs to protect spawning grounds and aquatic habitats.
- Law on Marine and Island Resources and Environment (2015): This law establishes an integrated management orientation for marine and island resources and protection of the marine and island environment. Its design relevance is cross-sectoral because it frames marine resources/environment governance beyond single sectors.
- Law on Environmental Protection (2020): This law provides a comprehensive framework for environmental protection activities and responsibilities, including planning and assessment tools, such as: Environmental Impact Assessment (EIA), Payments for Ecosystem Services (PES), Marine Plastic Debris. For coastal and marine outcomes, it is relevant to land-based sources of marine pollution (waste, wastewater, industrial discharge) and the environmental assessment requirements shaping coastal development.
- Law on Planning (2017): This law reorganized the national planning system, mandating the creation of the National Marine Spatial Plan (MSP) to resolve conflicts between economic sectors.

6.4.3.3. Sub-law instruments and regulations

Decrees and circulars provide detailed guidance for implementing the primary laws.

- Marine Spatial Planning (MSP): The National Assembly Resolution No. 139/2024/QH15 approves National marine spatial planning for 2021–

2030, vision to 2050, and defines scope including coastal land, islands/archipelagos, and waters. This is a cornerstone planning instrument intended to guide sectoral allocation and reduce conflicts among uses (shipping/ports, fisheries, conservation, tourism, energy, and other marine uses).

- Pollution Control and Permits: Decree No. 08/2022/NĐ-CP also regulates the management of waste and plastic debris, centralize control through Environmental Permits. This permit-based approach applies to land-based discharges reaching the sea, including sediments, nutrients, and chemicals.
- Circular No. 02/2022/TT-BTNMT provides detailed regulations on environmental protection measures, including waste management from marine economic activities.
- Sea area allocation: Decree No. 11/2021/NĐ-CP regulates the assignment of sea areas to organizations and individuals for exploitation. It decentralizes authority, empowering Provincial People's Committees (PPCs) to allocate areas within 6 nautical miles of the coast, while the Ministry of Natural Resources and Environment (or the merged Ministry of Agriculture and Environment) manages areas beyond this limit.
- Marine resource exploitation: Decree No. 65/2025/ND-CP of March 12, 2025, amending and supplementing a number of articles of the Government's Decree No. 40/2016/ND-CP of May 15, 2016, detailing a number of articles of the Law on Marine and Island Resources and Environment, and the Government's Decree No. 11/2021/ND-CP of February 10, 2021, providing the assignment of certain sea areas to organizations and individuals for marine resource exploitation and utilization.
- Marine Protected Areas Management Regulations: Decree No. 309/2025/ND-CP dated November 29, 2025 of the Government amending and supplementing a number of articles of the Government's Decree No. 26/2019/ND-CP of March 08, 2019, detailing a number of articles of, and measures to implement, the Law on Fisheries, amended and supplemented under the Government's Decree No. 37/2024/ND-CP of April 04, 2024.
- Wetland Conservation: Decree No. 66/2019/NĐ-CP on the conservation and sustainable use of wetlands. Circular No. 07/2020/TT-BTNMT provides detailed guidance on implementing this decree.
- Sanctions and enforcement: Decree 38/2024/ND-CP and Decree 301/2025/ND-CP (amending and supplementing several articles of Decree 38/2024/ND-CP), sets penalties for fisheries violations, including heavy fines for IUU fishing. Decree No. 37/2022/NĐ-CP stipulates penalties for violations in integrated marine management, such as illegal dumping or encroachment on coastal corridors.

- Decentralization: Decree No. 136/2025/NĐ-CP outlines the decentralization of state management in agriculture and environment, granting specific powers to local authorities for establishing MPAs and managing biodiversity. Circular No. 11/2025/TT-BNNMT regulates the decentralization of state management in nature conservation and biodiversity. Circular No. 10/2025/TT-BNNMT defines the decentralized authorities for fisheries and fisheries surveillance, clarifying which agency manages specific marine resources. Circular No. 19/2025/TT-BNNMT guides the functions and powers of local specialized agencies (Departments of Agriculture and Environment) in managing MPAs and marine ecosystems.

6.4.3.4. Subnational Implementation (Provincial Level)

The 28 coastal provinces (consolidated to 21 in late 2025) are the primary units for on-the-ground implementation.

- Provincial Mandates: Provincial People's Committees (PPCs) are responsible for managing coastal waters up to 6 nautical miles from the shoreline. This includes allocating sea areas for aquaculture, issuing local environmental permits, and managing nearshore fisheries.
- Coastal Protection Corridors: By mid-2024, 27 out of 28 coastal provinces had approved the list of areas requiring coastal protection corridors to prevent erosion and maintain ecosystem services.
- Local Regulations: Provinces issue local decisions to manage specific resources. For example, Ca Mau and Kien Giang have specific regulations for mangrove forests and wetland conservation.

6.4.4 Current development plans and policies

Viet Nam's marine governance is guided by a complex architecture of national strategies and spatial plans. Structurally, this operates as a four-tier planning system: (i) the National Master Plan and National Marine Spatial Plan; (ii) National Sectoral Plans; (iii) Regional Plans; and (iv) Provincial Plans. Lower-level plans are legally required to conform to higher-level plans, creating a "consistency mandate" for the 28 coastal provinces bordering the South China Sea and Gulf of Thailand.

6.4.4.1 The Cross-Cutting National Plans

Three national-level instruments form the core spatial framework for managing cumulative pressures from fisheries, shipping, and coastal development.

- National Marine Spatial Plan (MSP) (2021–2030, vision 2050): Adopted by the National Assembly (*Resolution No. 139/2024/QH15*), this is the cornerstone instrument. It divides marine space into functional zones for protection, conservation, and economic development. In governance terms, the MSP is the primary mechanism for resolving conflicts between shipping corridors, offshore energy, and fisheries in the South China Sea.

- Master plan for the sustainable exploitation and use of coastal resources for 2021-2023, with a vision toward 2050 (Decree 1117/QĐ-TTg 2024): Focusing on the coastal zones, this plan explicitly links land-use planning to ecosystem protection and incident response. It is critical for managing the land-sea interface where industrial discharges and pressure of urbanization are most acute.
- Resolution No. 36-NQ/TW (2018) on the "Strategy for Sustainable Development of Viet Nam's Marine Economy to 2030, with a Vision to 2045". This resolution sets the goal for Viet Nam to become a "strong maritime nation," aiming for the marine economy to contribute approximately 10% to the national GDP. It prioritizes green growth and the conservation of marine ecosystems. Serving as the overarching political directive, this resolution sets the strategic trajectory for the "Blue Economy." It mandates a shift from purely exploitation-based growth to sustainable development, though it acknowledges that policy coherence remains a constraint. This strategy is operationalized by Resolution No. 26/NQ-CP (2020), which establishes a master plan and five-year action plan, identifying specific marine economic sectors for development, such as tourism, maritime transport, and renewable energy

6.4.4.2 Sectoral Strategies and Action Plans

Beyond spatial zoning, specific national strategies drive investment and compliance behavior in key sectors.

- Fisheries Development: *Decision No. 339/QĐ-TTg (2021)* approves the Strategy for Development of Viet Nam’s Fisheries. It frames the transition toward responsible fisheries and aquaculture modernization. The Directorate of Fisheries also issued an action plan for implementation of Decision 339/QD-TTg, indicating the intended translation of strategy into operational tasks.
- Marine Plastic Debris: *Decision No. 1746/QD-TTg (2019)* promulgates the National Action Plan on Marine Plastic Debris Management through 2030. This is a targeted instrument relevant to transboundary litter transport across the South China Sea and Gulf of Thailand circulation systems and to domestic coastal tourism and fisheries interactions with debris. It requires provinces to implement waste collection systems and port reception facilities, directly addressing the "leakage" problem.
- Environmental Protection: *Decision No. 450/QD-TTg (2022)* provides the National Environmental Protection Strategy. It reinforces the mandate for pollution prevention in coastal industrial zones and establishes the framework for waste management investment.
- Ballast Water Management: *Decision No. 515/QD-TTg (2024)* approves the implementation plan for the BWM Convention, addressing biosecurity risks from international shipping.

- Environmental Protection Strategy: *Decision No. 450/QD-TTg (2022)* approves the National Environmental Protection Strategy until 2030, vision to 2050. This strategy provides an overarching framework that should influence marine pollution control through stronger prevention, control, and planning measures, including for coastal industrial development and waste management.

6.5 Civil society, stakeholders, and participation

Civil society and stakeholder participation determine how coastal and marine regulations are interpreted, accepted, and enforced on the ground. In Viet Nam, this participation is structured by a unique combination of state-led governance structures, legal requirements for environmental consultation, and emerging mechanisms for community-based co-management.

6.5.1 Key NGOs and special interest groups

6.5.1.1 Civil Society and Community Organizations

The legal framework for stakeholder engagement is anchored in the *Law on Environmental Protection (2020) and* Law on Fisheries (2017). The laws explicitly assigns roles to:

- Mass Organizations: Organizations such as the Viet Nam Fatherland Front, the Women's Union, and the Youth Union participate in raising awareness, social supervision, and community-based environmental protection initiatives, oversight and social criticism regarding environmental policies.
- Socio-Political and Professional Organizations: Granting them rights to access environmental information, consult on projects, and propose remedies for violations.
- Co-management Organizations: Community organizations are granted legal rights to co-manage aquatic resources. These groups participate in protecting coral reefs and fishery resources, often supported by international projects.

This design creates a formal channel for "organized" civil society to interact with the state, primarily focused on compliance monitoring and policy feedback.

6.5.1.2 Scientific and Technical Organizations

- Viet Nam Academy of Science and Technology (VAST): Conducts marine scientific research and baseline surveys. The Institute of Oceanography under VAST plays a key role in marine biodiversity assessment.
- Research Institutes: Various institutes support the government with data for planning, such as the Research Institute for Marine Fisheries (RIMF) and the Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE).

6.5.1.3 Private Sector and Industry Associations

- Viet Nam Association of Seafood Exporters and Producers (VASEP): A key stakeholder in the fisheries sector, VASEP coordinates with government agencies to ensure compliance with international standards, such as IUU fishing regulations, and promotes sustainable trade.
- Tourism and Energy Enterprises: Private enterprises are increasingly involved in marine economic development, particularly in high-end tourism and offshore renewable energy. However, coordination between these sectors and conservation goals remains a challenge.

6.5.1.4 Non-Governmental Organizations (NGOs) and International Organizations (IOs):

WWF, IUCN, SNV, GIZ, TRAFFIC, HSI, MCD, ENV etc. provide technical assistance, capacity building, and financial support for marine conservation, plastic waste reduction, and livelihood development projects.

6.5.1.5 International Partners

Viet Nam cooperates with numerous international organizations to enhance ocean governance capacity. Key partners include:

- UN Agencies: UNDP, UNEP, GEF-SGP, and FAO support projects on blue economy, biodiversity conservation, and sustainable fisheries.
- Regional Bodies: PEMSEA (Partnerships in Environmental Management for the Seas of East Asia) and COBSEA (Coordinating Body on the Seas of East Asia) support integrated coastal management and marine pollution control.
- Financial Institutions: The World Bank and Asian Development Bank (ADB) provide funding and technical advice for marine infrastructure and sustainable development strategies.

6.5.2 Trade associations and business groups

Trade and professional associations are not created by the environmental consultation rules alone. However, the environmental law explicitly recognizes roles for socio-professional organizations to (i) access or request environmental information, (ii) provide advice on relevant investment projects, (iii) conduct "consultancy and criticism," and (iv) propose competent agencies to handle violations, with an obligation on state environmental authorities to create conditions for these organizations to exercise their rights.

Several business and professional group functions are directly relevant to marine governance effectiveness, especially for fisheries sustainability, IUU compliance, and pollution control at ports/landing sites.

- The Viet Nam Association of Seafood Exporters and Producers (VASEP) publicly position itself as providing advocacy and training, and maintains dedicated content and structures linked to combatting IUU fishing (including a visible "IUU Steering Committee" section and related materials on its portal). These functions matter for governance because export-oriented supply chains often transmit compliance requirements (traceability, legal sourcing) back to vessels, ports, and processors.

- Viet Nam Fisheries Society (VINAFIS) operates an information portal and indicates membership structures that can include corporate, provincial, and institute/university members.
- Vietnam Seaculture Association (VSA) is a voluntary, non-governmental organization of enterprises and R-D institutions, as well as organizations and individuals engaged in operations of the mariculture value chains (seed production, farming, preserving, processing and transporting marine species, such as marine fishes, seaweeds, molluscs, crustaceans, ornamental creatures and other marine species) and associated productions, business and services activities with development of seaculture industry of Vietnam.
- Commodity- or fishery-specific associations and industry platforms: such as Viet Nam Tuna Association (VinaTuna), Vietnam Shrimp Association etc.
- Provincial Fisheries Associations: Located throughout the 28 coastal provinces, play a key role in connecting government policies with local fishing communities, promoting sustainable practices, and supporting the "yellow card" combat against IUU fishing.

6.5.3 Co-management, traditional systems, and customary rights

Viet Nam's legal framework defines a specific formal mechanism for community participation in resource protection. Article 10 of the Law on Fisheries (2017) establishes the legal basis for co-management, effectively creating an institutional bridge between state enforcement and local social control.

Key design features include:

- Recognition and Rights Allocation: A community organization can be granted management rights if it comprises local households benefiting from the resource, registers a defined spatial area, and adopts a protection plan.
- Delegated Authority: Competent authorities (District or Provincial People's Committees) have the power to recognize these organizations and grant rights. Notably, the law creates a mechanism for negotiation when a co-management area spans administrative boundaries.
- Operational Powers: Once recognized, communities are empowered to:
    1. Patrol and inspect activities within their granted area.
    2. Propose that competent agencies handle violations.
    3. Establish a community fund for sustainable financing.

- State Oversight: The delegation is conditional; state agencies retain the authority to inspect community organizations and revoke decisions if management fails.

It is important to note that Viet Nam’s legal framework does not recognize "customary marine tenure" in the sense of unconditional indigenous property rights. However, the co-management mechanism serves as the statutory vehicle to operationalize locally rooted practices. By granting legal recognition to community organizations and their internal regulations (*Quy ước*), the state validates traditional norms regarding access and resource protection, aligning statutory law with the cultural practices of fishing communities (UNDP, 2023).

Evidence from international agencies and NGOs indicates that co-management is transitioning from isolated pilots to a recognized policy approach, though implementation remains spatially uneven.

(a) South-Central and Southeast Coast: This sub-region serves as the primary laboratory for co-management models.

- Binh Thuan Province: The Ham Thuan Nam model is cited as an example of effective post-2017 implementation, attributed to its combination of formal recognition, clear exploitation strategies, and the establishment of revolving livelihood funds (UNDP, 2023).
- Binh Dinh Province: FAO (2020) highlights the integration of ecosystem-based approaches in small-scale fisheries, linking governance directly to local livelihood realities.
- Khanh Hoa Province (Nha Trang Bay): Documented dialogues focus on scaling models from resource protection to broader governance issues, such as the management of fish landing sites (UNDP, 2023).

(b) Gulf of Thailand

- Ca Mau Province: Recent technical support reports indicate the development of provincial co-management plans through 2030 (MCD, 2025). This suggests that the model is expanding to the complex mangrove-fishery systems of the Mekong Delta, utilizing defined coordination mechanisms approved by provincial authorities.

6.5.4 Decentralised and coastal governance mechanisms

Viet Nam’s governance framework provides specific, legally defined entry points for consultation, oversight, and grievance redress. These mechanisms are anchored primarily in the *Law on Environmental Protection (2020)*.

(a) Consultation in Environmental Impact Assessment (EIA) The law mandates consultation as a prerequisite for project approval, establishing a formal dialogue between investors and affected parties.

- Who: Consultation must include resident communities and individuals directly impacted by the project, as well as relevant agencies and organizations.

- Scope: Consultation covers the project location, environmental impacts, mitigation measures, and incident response plans.
- Accountability: Opinions must be reflected "fully and honestly." If the project owner rejects recommendations, the EIA report must provide a specific written explanation.
- Transparency: To enable informed participation, the law requires the public disclosure of EIA reports and approval decisions on government portals (Government of Viet Nam, 2020, Article 33).

(b) The Role of Mass and Socio-Political Organizations The governance design assigns a unique oversight role to the Viet Nam Fatherland Front and associated socio-political organizations.

- Political Oversight: The Fatherland Front is empowered to conduct "social criticism" and oversee the implementation of environmental policies (Article 157).
- Technical Advisory: Socio-professional organizations have the right to provide independent advice on investment projects and propose enforcement actions against violations (Article 158).

(c) Resident Community Rights and Grievance Channels The 2020 Law significantly strengthens the rights of local communities. Representatives are empowered to:

1. Request information from project owners regarding actual environmental protection activities.
2. Participate in assessing environmental outcomes.
3. Access online systems to submit reports and recommendations (Article 159). Furthermore, formal Grievance and Denunciation channels allow individuals to file environmental complaints or denounce violations to competent agencies (Article 163).

Governance Effectiveness: Evidence from Practice While the legal channels are robust, operational effectiveness varies based on the mechanism and sector.

(a) Structured Multi-Stakeholder Convening Effectiveness is highest where the state actively convenes stakeholders for sector-wide review. UNDP (2025a) reports that the 2025 National Conference on Fisheries Environmental Protection included provincial departments, port authorities, MPA boards, enterprises, and NGOs (WWF, IUCN, MCD). This indicates that participation is evolving beyond reactive EIA consultation into proactive policy learning.

(b) Capacity Development for Decentralization To operationalize decentralized governance, technical capacity is being strengthened. UNDP (2025b) highlights the development of training materials for Marine Spatial Planning (MSP) and Integrated Coastal Zone Management (ICZM) in collaboration with the Viet Nam

Administration of Seas and Islands (VASI). This confirms recognition that effective local participation requires technical literacy, not just legal rights.

(c) Implementation Constraints and Financing Gaps Despite policy signals promoting Public-Private Partnerships (PPP) and co-management, significant implementation gaps persist.

- Port Management: UNDP (2023) identifies the absence of effective PPP mechanisms in fishing port management. Without financial incentives to involve wholesalers and private enterprises, pollution control at landing sites remains weak.
- ICZM Sustainability: Peer-reviewed synthesis (Cong et al., 2020) notes that while the legal basis for ICZM exists, implementation is not yet self-reliant and frequently struggles with sustainable financial resources.

Implications for Coastal and Marine Outcomes

- Governance Design: Viet Nam possesses a comprehensive design with multiple feedback loops: EIA consultation, Fatherland Front oversight, and direct community monitoring rights.
- Governance Effectiveness: Participation is most effective where structured incentives exist—specifically in fisheries co-management (South-Central Coast) and export traceability (VASEP).
- The Outcome Gap: However, uneven implementation in "brown" sectors (port waste management, wastewater) creates governance risks. Where stakeholder roles are not financed (through PPPs), compliance at the local level weakens, directly contributing to marine litter leakage and near-shore pollution hotspots.
- Transboundary Relevance: Effective participation mechanisms are essential for meeting international expectations regarding IUU fishing (traceability) and Marine Litter (gear loss prevention), connecting local governance actions to regional South China Sea obligations.

Viet Nam’s governance design provides multiple entry points for participation: (i) legally required EIA consultation and disclosure, (ii) defined oversight roles for mass/socio-professional organizations, (iii) resident community rights to information and feedback, and (iv) formal fisheries co-management with delegated local monitoring and protection functions. Governance effectiveness is demonstrated most clearly where participation is linked to structured mechanisms and incentives—especially fisheries co-management (documented examples in South-Central and Southeast Coast settings) and export-facing fishery improvement/traceability initiatives. However, available public sources also suggest that participation can remain uneven and constrained by financing and operational arrangements (port/landing site management and waste control), which matters directly for marine plastic leakage, nearshore pollution hotspots, and compliance with fisheries controls. Finally, transboundary relevance is direct for (i) shared and migratory fish stocks (tuna governance linkages and regional dialogues referenced in the tuna

FIP context), and (ii) marine litter and gear loss where sector initiatives and national discussions connect to wider regional/global processes.

6.6. TWAP GOVERNANCE ARCHITECTURE RISK ASSESSMENT

6.6.1 Assessment method and scoring

The TWAP methodology evaluates the structure of formal transboundary governance arrangements addressing key LME issue groups—notably fisheries, pollution, and biodiversity—using a policy-cycle logic. This approach allows for comparative assessment across different Large Marine Ecosystems globally (UNEP, 2011; Fanning et al., 2015).

Table 6. The assessment utilizes three core indicators, defined and applied

Dimension	Definition	Assessment Focus
Completeness	Extent to which governance structures, laws, and policy cycles cover all identified transboundary issues	Presence of legal frameworks; institutional mandates; policy instruments (marine protected areas, fisheries regulations); completeness of policy cycle (planning → implementation → enforcement → monitoring → adaptive review)
Integration	Degree of coordination and linkage among arrangements across levels (national-provincial-local), sectors (fisheries, conservation, tourism), and organizations	Cross-sectoral coordination; vertical governance integration; alignment among institutions; land-sea linkages; transboundary cooperation; data and decision integration
Engagement	Level of stakeholder participation, accountability, and equity in governance processes	Participation of communities, civil society, and private sector; transparency and accountability; equity in benefit-sharing; evidence of behavioral change and compliance

These three dimensions are evaluated against five outcome categories: (1) stakeholder engagement and compliance, (2) reduced stresses on ecosystems, (3) improved ecosystem condition, (4) socially just solutions, and (5) improved human well-being.

6.6.2. Vietnam's Governance Completeness Assessment

Completeness Score: 50–60% (Medium-Low)

Vietnam demonstrates a comprehensive foundation of coastal and marine governance instruments but faces persistent implementation gaps and incomplete policy cycles across governance levels.

Strengths in Governance Completeness

Legal and Policy Framework

Vietnam has established an extensive legal basis for marine governance, including international commitments (UNCLOS 1994; Fish Stocks Agreement 2018; BBNJ ratification 2024), foundational sectoral laws (Fisheries Law 2017; Environmental Protection Law), and emerging policy frameworks. National strategies such as the Nationally Determined Contributions (NDCs 1.0–3.0) and the fisheries sector strategy align with international sustainability commitments. Marine protected area designations have been established, with a national network of MPAs and fishery resource conservation zones, and the government has set a target to increase marine protected area coverage from 0.24 percent to 6 percent of sea area by 2030, aligned with the CBD 30×30 target.

Institutional Mandates

Institutional structures for coastal governance exist at multiple levels. National agencies (now organized under the Ministry of Agriculture and Environment, MAE; formerly DARD and MONRE), provincial Departments of Fisheries and Environment, and local administrative bodies carry explicit mandates for marine resource management, environmental protection, and fisheries regulation. Integrated Coastal Zone Management (ICZM) committees have been established in several provinces, providing platforms for inter-agency coordination.

Monitoring and Data Systems

Vietnam has invested in multiple monitoring systems to support evidence-based governance. Electronic Catch Documentation (eCDT) systems are being implemented to track seafood origin and legality, supporting port state control measures. Vessel Monitoring Systems (VMS) are mandated on commercial fishing vessels, providing real-time location data for fisheries surveillance. Smart patrols in protected areas generate consistent enforcement records. The Directorate of Fisheries collaborates with FAO on catch statistics and stock assessments. These systems provide the technical foundation for adaptive management, though linkage to policy decisions remains inconsistent.

Gaps Limiting Completeness

Incomplete Policy Cycles

While planning and implementation mechanisms exist, the feedback loop from monitoring to adaptive policy revision remains weak. Protected area monitoring occurs through METT (Management Effectiveness Tracking Tool) assessments in some sites, but results are not systematically used to modify management rules, zoning, or enforcement strategies. Fisheries monitoring generates data on catch, effort, and species composition, but adaptive harvest controls and stock rebuilding measures are limited.

Enforcement and Compliance Constraints

Laws establishing fishing restrictions, pollution limits, and protected area boundaries exist, but compliance monitoring and sanction mechanisms are underdeveloped. IUU (Illegal, Unreported, Unregulated) fishing persists despite legal prohibitions, reflecting limited patrol capacity, incomplete vessel monitoring, and weak prosecution capacity. Pollution from land-based sources (industrial discharge, agricultural runoff, urban wastewater) exceeds legal standards in many coastal zones, indicating weak enforcement of environmental protection laws.

Uneven Provincial Implementation

Decentralization of governance to provincial and district levels has created variation in implementation effectiveness. Provinces with stronger fiscal capacity (high-GDP coastal provinces like Ho Chi Minh City, Da Nang, Hai Phong, Quang Ninh) implement laws more comprehensively, while low-capacity provinces (inland-dependent or remote coastal areas) lack resources for effective enforcement and monitoring. This capacity heterogeneity undermines national policy coherence.

Pending Core Instruments

Several foundational governance instruments remain incomplete. Marine Spatial Planning (MSP), while emerging as a national framework priority, is not yet operational at scale to guide development, conservation, and resource-use decisions across the marine space. The Climate Change Act, expected to strengthen institutional coordination on climate adaptation for coastal zones, remains pending parliamentary enactment. These instruments, once finalized, will enhance completeness but their absence currently limits comprehensive policy cycles.

6.6.3. Vietnam's Governance Integration Assessment

Integration Score: 0.25–0.35 (Weak)

Vietnam's governance system comprises many individual components, but coordination among them—across sectors, government levels, and with transboundary partners—remains fragmented.

Cross-Sectoral Coordination Weaknesses

Sectoral Mandates Without Coherence

Fisheries (now under MAE), marine conservation (coordinated through MONRE/MAE), coastal development (Ministry of Construction, provincial authorities), aquaculture (MAE), and tourism (Ministry of Culture, Sports and Tourism) operate under separate legislative frameworks and institutional structures. National committees (Fisheries Committee, Environmental Board) provide some coordination, but inter-agency cooperation at provincial and local levels remains weak. Development pressures from aquaculture expansion, coastal industrialization, and port development often proceed without adequate integration with conservation objectives, resulting in habitat loss and ecological degradation despite parallel conservation targets.

Provincial Implementation Fragmentation

ICZM committees exist in only five provinces; many coastal provinces lack formal inter-agency coordination mechanisms. Even where committees exist, they meet irregularly and lack dedicated secretariat support or enforcement authority. As a result, coordination on conflicts between fishing zones and marine protected areas, or between tourism and conservation, depends on ad-hoc negotiations rather than systematic procedures.

Data Integration Gaps

Multiple agencies collect marine data (fisheries, environmental, coastal development), but these datasets are not standardized or integrated into unified decision-support systems. Fisheries catch data, environmental monitoring, habitat assessments, and socioeconomic information remain in separate databases, limiting holistic understanding of cumulative pressures on marine systems. Data from community-based management (SMART patrols, community catch monitoring) are inconsistently ingested into official statistics and policy reviews.

Transboundary Coordination Limitations

Regional Cooperation Mechanisms

Vietnam participates in ASEAN fisheries cooperation, bilateral agreements with Cambodia and Thailand on shared fish stocks, and global organizations (WCPFC for tuna, COBSEA for pollution, PEMSEA for integrated coastal management). However, transboundary coordination remains limited by competing national interests, incomplete data sharing, and weak enforcement of regional agreements. Shared fish stocks (in the Gulf of Tonkin and Gulf of Thailand) lack consistent regional management arrangements with neighboring countries.

Incomplete Transboundary Risk Governance

Transboundary risks such as shared pollution (nutrient loading from the Mekong River affecting Vietnamese coastal zones), climate impacts (sea-level rise affecting all Mekong Delta nations), and migratory species (sea turtles nesting in Vietnamese coastal habitats but foraging in waters of multiple countries) require coordinated, multi-country governance but often operate through separate national frameworks. Regional platforms exist (Mekong River Commission for inland waters; ASEAN for maritime issues), but integration with coastal/marine governance in Vietnam remains limited.

Vertical Integration Constraints

National-Provincial-Local Alignment

National policies and mandates are not consistently implemented at provincial and local levels, both because provincial capacity varies and because local governance operates with considerable discretion. Provincial People's Committees may prioritize economic development (port expansion, aquaculture) over conservation targets if national enforcement and oversight are weak. Fisheries regulations set nationally may be interpreted or enforced differently across provinces depending on local enforcement capacity and political priorities.

Decentralization Without Adequate Support

Governance decentralization grants provinces and districts management authority, but insufficient technical support and financing limit their capacity. Low-capacity provinces lack expertise in marine spatial planning, habitat monitoring, or modern fisheries management techniques. Central government incentives for provincial compliance with national targets (marine protected area coverage expansion) are weak, relying on normative appeals rather than financial or institutional support.

6.6.4 Vietnam's Governance Engagement Assessment

Engagement Score: 55–65% (Medium)

Vietnam demonstrates a growing foundation of stakeholder participation mechanisms, with emerging community-based management and civil society presence, but participation remains uneven, project-dependent, and limited by institutional barriers.

Strengths in Stakeholder Engagement

Community-Based Management Expansion

Co-management arrangements have been established in seven provinces (Ha Tinh, Quang Nam, Binh Dinh, Phu Yen, Khanh Hoa, Binh Thuan, Tuyen Quang), with 19 recognized community-based organizations. The Tam Giang Lagoon model (Thua Thien-Hue Province) represents Vietnam's most successful systematic co-management structure, with 22 Fisheries Sub-associations implementing participatory rules on fishing access, gear restrictions, no-take zones, and benefit-sharing. Evidence from these sites shows that community-based governance improves patrol consistency, reduces destructive practices (poison, explosives), and generates community commitment to resource protection.

Civil Society Engagement

International (IUCN, WWF, CARE) and national NGOs (MCD, ENV, Vietnam Fisheries Society) contribute technical expertise, community facilitation capacity, and advocacy voice that government alone cannot provide. NGO facilitation of co-management has been essential to success in sites like Tam Giang Lagoon and mangrove management areas.

Formal Consultation Structures

Provincial people's committees, provincial environmental and fisheries departments, and Vietnam Fatherland Front provide formal channels for civil society and community input, though consultation mechanisms are not always binding or effective in practice.

Engagement Limitations

Small-Scale Fisher Marginalization

While fishing associations and cooperatives provide formal structures for fisher participation, these organizations are often dominated by larger-scale operators or government representatives. Small-scale and artisanal fishers—who depend most directly on coastal resources—have limited voice in policy-making on fisheries licensing, aquaculture zoning, marine protected area designation, and market access. Informal dispute resolution (van chai systems, community mediation) exists but is not formally recognized in policy, limiting its institutional durability.

Gender and Social Equity Gaps

Women are substantially engaged in coastal livelihoods (fish processing, trading, crew support) but under-represented in formal governance structures such as fishing associations, co-management committees, and provincial coordination bodies. Youth engagement is mostly limited to awareness-raising campaigns rather than sustained participation in decision-making. Vulnerable groups (poorest fishers, ethnic minorities in coastal areas) often lack mechanisms to ensure their voices are heard in governance processes.

Project-Dependent Participation

Community-based management models and participatory mechanisms are largely project-dependent, supported by donor funding and NGO facilitation. When external support withdraws, participation often declines and community institutions lose effectiveness. The sustainability of participatory governance beyond project cycles remains uncertain, reflecting weak institutionalization at provincial and national levels.

Weak Consultation on Major Decisions

Statutory mechanisms for participatory consultation in fisheries licensing decisions, aquaculture zoning approvals, marine protected area designation, and major development projects remain limited. While consultation occurs in some cases (particularly where NGOs facilitate), it is not uniformly required by law and often occurs late in decision processes, limiting communities' ability to influence outcomes.

Transparency and Accountability Constraints

Public access to information on fisheries policy decisions, environmental impact assessments, and resource allocations is limited. Grievance mechanisms for resource conflicts are weak; informal processes depend on traditional leaders or government officials rather than institutionalized procedures. This reduces accountability and may deter communities from voicing concerns about governance fairness.

6.6.5 Synthesis: Vietnam's Governance Architecture Risk Profile

Table 7. The TWAP assessment synthesizes across all three dimensions to characterize overall governance effectiveness and risk level

Dimension	Score	Characterization	Key Implications
Completeness	50–60% (Medium-Low)	Comprehensive laws and institutions exist but enforcement gaps, incomplete policy cycles, variable provincial implementation, and pending instruments (MSP, Climate Act) limit effectiveness	Foundation is present; significant effort required to strengthen implementation and close policy cycles
Integration	0.25–0.35 (Weak)	Weak cross-sectoral coordination; provincial fragmentation; limited transboundary cooperation; incomplete land-sea linkages; economic-environmental misalignment	Persistent risk that sectoral interests and development pressures override conservation/sustainability goals; transboundary issues inadequately addressed
Engagement	55–65% (Medium)	Growing community-based management (7 provinces); established NGO presence; but limited national-scale institutionalization	Participatory foundation exists but fragile; scaling and institutionalization needed for sustained equity and compliance

		; small-scale fishers, women, youth under-represented; project-dependent participation	
Overall Risk Assessment	**MODERATE TO HIGH**	Foundational structures present but significant implementation gaps; transboundary risks inadequately managed; persistent capacity heterogeneity across provinces; climate adaptation integration weak	Requires sustained capacity-building, inter-sectoral coordination, transboundary cooperation, and institutional strengthening to move from policy frameworks to effective, equitable governance

6.6.6 Comparative Context: Vietnam in the South China Sea and Gulf of Thailand LMEs

Regional Governance Landscape

Vietnam's governance challenges are shared across the South China Sea (LME #36) and Gulf of Thailand (LME #35) regions. Comparative assessments of Thailand (2025) and Cambodia (2025) show similar patterns:

- Thailand: Completeness 50%, Integration 0.1-0.2 (very weak), Engagement 70% (high). Thailand's strength in participation mechanisms contrasts with very weak cross-sectoral integration and economic disparities limiting provincial coordination.
- Cambodia: Completeness 55-60%, Integration 0.35-0.45 (high-medium risk), Engagement 45-55% (medium). Cambodia's weaker engagement reflects project dependence, while integration challenges include fragmented mandates pending NCCMD marine sub-decree.
- Vietnam: Completeness 50-60%, Integration 0.25-0.35 (weak), Engagement 55-65% (medium). Vietnam's weakest dimension is integration, reflecting sectoral fragmentation, provincial variation, and limited transboundary coordination.

Transboundary Governance Implications

The South China Sea LME and Gulf of Thailand are managed through overlapping regional frameworks (ASEAN, COBSEA, PEMSEA, bilateral agreements) and national systems. Integrating governance across countries remains incomplete. Shared fish stocks lack coordinated management at the LME scale. Transboundary pollution (Mekong River nutrient loading, shipping emissions), climate risks, and sea turtle migration require closer coordination than currently exists. Vietnam's weak integration dimension contributes to and is compounded by limited regional coordination, increasing risk of unmanaged cumulative impacts.

6.6.7 Residual Governance Risks and Priorities

Key Residual Risks

1. Fisheries sustainability: Incomplete integration of stock assessments across provincial and transboundary scales; weak enforcement of conservation measures; economic incentives for overfishing exceed conservation incentives.
2. Coastal habitat loss: Marine protected area expansion slow (0.24% → 6% target by 2030); effectiveness limited by incomplete enforcement and insufficient financing; integration of conservation with development planning weak.
3. Pollution and water quality: Land-based pollution (industrial discharge, agricultural runoff, urban wastewater) inadequately controlled; integration of upstream (Mekong) and coastal/marine governance incomplete; climate-driven saline intrusion exacerbating coastal water quality.
4. Transboundary risks: Shared fish stocks, migratory species (sea turtles, seabirds), and transboundary pollution inadequately managed through regional coordination; weak integration of Vietnam's national governance with LME-scale arrangements.
5. Climate adaptation: Integration of climate governance (NDCs) with coastal/marine management incomplete; provincial capacity for climate-resilient planning uneven; critical adaptation investments (mangrove restoration, seagrass bed recovery, coastal protection) under-financed.

Priority Governance Enhancements

To improve governance effectiveness and reduce residual risks, Vietnam should prioritize:

1. Strengthen cross-sectoral integration: Establish binding inter-ministerial coordination procedures; empower provincial ICZM committees with authority and dedicated budgets; integrate development planning (ports, aquaculture, tourism) with conservation objectives through mandatory environmental impact assessment and strategic environmental assessment with genuine stakeholder consultation.

2. Enhance vertical integration: Increase technical and financial support to low-capacity provinces; standardize monitoring and reporting systems; link provincial compliance with national targets to incentive mechanisms (fiscal transfers, capacity support, recognition).
3. Deepen transboundary cooperation: Formalize shared stock management arrangements with neighboring countries; establish joint monitoring systems; coordinate pollution and climate adaptation responses across Mekong Basin.
4. Institutionalize participation mechanisms: Move from project-dependent to government-anchored community-based management; guarantee participation rights in licensing, zoning, and protected area designation decisions; establish independent grievance mechanisms; ensure equitable gender and intergenerational participation.
5. Complete core policy instruments: Enact and operationalize Marine Spatial Planning framework; finalize Climate Change Act; establish comprehensive monitoring-to-adaptation feedback loops; develop sustainable financing mechanisms (blue bonds, environmental trust funds) for long-term conservation and enforcement.

6.7 Qualitative Synthesis

6.7.1 Architecture, Process, and Engagement

Viet Nam's coastal and marine governance framework exhibits a duality: it possesses robust "Good Governance" characteristics in its legal design yet retains structural risks that reduce coherence and predictability during implementation.

6.7.1.1 Architecture: Laws, Mandates, and Institutional Set-up

Strengths in Governance Design The architectural foundation has been significantly strengthened through recent legal and institutional reforms:

1. Unified Legal Foundation: A consolidated legal basis now exists for integrated management. The *Law on Marine and Island Resources and Environment* (2015) provides the framework for integrated coastal management (ICM), while the *Law on Environmental Protection* (2020) modernizes pollution control through permitting and economic instruments.
2. Dedicated Fisheries Governance: The *Law on Fisheries* (2017) provides a specialized legal basis for sustainability, establishing mandates for compliance (IUU control) and traceability that align with international standards.
3. Spatial Framework: The adoption of the National Marine Spatial Planning (MSP) (*Resolution No. 139/2024/QH15*) creates an overarching spatial constitution. By design, this instrument guides all lower-level sector plans, theoretically resolving conflicts between development and conservation.

4. Institutional Consolidation: The establishment of the Ministry of Agriculture and Environment (MAE) in 2025 represents a major architectural improvement. By merging agriculture/fisheries (formerly MARD) with environment/sea management (formerly MONRE), the design reduces the historical fragmentation between "resource exploitation" and "resource protection," placing climate change, disaster preparedness, and marine economy under a single roof.

Structural Risks in Governance Design Despite these improvements, two critical architectural flaws persist:

1. Persistent External Fragmentation: "Multi-actor governance" remains an unavoidable reality. Critical drivers of marine pressure—including maritime transport (Ministry of Transport), offshore energy (Ministry of Industry and Trade), and maritime security (Ministry of National Defence)—remain outside the MAE's direct mandate. Consequently, cross-sector coordination remains a core design requirement, not a solved problem.
2. The Inspection Gap: While the *mandate* for management is unified, the *enforcement capacity* is structurally limited. Public reporting on the national marine environment (2016–2020) explicitly identifies the absence of a dedicated specialized inspectorate for integrated marine resource management as a binding constraint (MONRE, 2021). Without a specialized force empowered to inspect across sectors (capable of checking both fisheries gear and pollution discharge), enforcement risks being inconsistent and lacking in deterrence.

6.7.1.2. Process: Planning Cycles, Information Systems, and Implementation Routines

Strengths in Governance Processes Viet Nam has established robust procedural mechanisms for monitoring and assessment, increasingly aligning with international standards.

- Institutionalized Analytical Reporting: The governance system now supports periodic, evidence-based assessments. The *National State of Sea and Islands Environment Report (2016–2020)* utilizes the DPSIR (Drivers–Pressures–State–Impact–Response) framework. This indicates maturity in governance process, moving beyond simple data collection to an analytical approach that links monitoring results directly to risk framing and policy responses (MONRE, 2021).
- Digitization of Compliance: Fisheries governance shows increasing formalization through digital process tools. National authorities operate a 24/7 Vessel Monitoring System (VMS) to track disconnections and are actively integrating e-traceability into port and landing routines. This creates a continuous data stream for compliance, replacing sporadic paper-based checks (Directorate of Fisheries, 2024).

- Targeted Investment Cycles: Implementation processes are supported by dedicated capital investment cycles. Projects funded by development partners (World Bank) in coastal cities provide a structured operational pathway for upgrading sanitation and wastewater infrastructure, ensuring that pollution control planning translates into physical assets (World Bank, 2024).

Process Vulnerabilities and Operational Fragility Despite clear high-level designs, the practical execution of governance processes exhibits significant fragility.

- Implementation Heterogeneity: Process efficiency varies drastically across provinces, even within the same national project. For instance, in the *Coastal Cities Sustainable Environment Project*, while three cities met targets, Nha Trang faced major delays. These bottlenecks were linked to site unavailability, land acquisition challenges, and safeguard compliance issues (World Bank, 2024). This illustrates a systemic risk: the "process" of clearing land often lags behind the "process" of mobilizing finance, delaying environmental benefits.
- Regulatory Tooling Lags: There is a documented disconnect between the issuance of mandates and the availability of enforcement tools. Public reporting on the marine environment indicates that specific sanctioning regulations and technical guidelines were still under development during the reporting period. This "tooling lag" limits the ability of inspectors to process violations efficiently, effectively stalling the enforcement cycle (MONRE, 2021).

6.7.1.3. Engagement: Participation, Stakeholder Roles, and Accountability

Strengths in Engagement Design The governance architecture provides a strong statutory basis for stakeholder inclusion, moving beyond ad-hoc consultation.

- Statutory Embedding: Participation is codified as a core legal principle. The *Law on Marine and Island Resources and Environment* (2015) explicitly frames community participation as a requisite component of integrated management. Similarly, the *Law on Environmental Protection* (2020) institutionalizes oversight roles for mass organizations, embedding accountability directly into state policy.
- Structured Dialogue Platforms: Engagement is increasingly operationalized through structured national–partner platforms. UNDP reporting highlights the success of national dialogues involving fishers, associations, and managers. These forums serve a critical function in sharing knowledge on co-management replication and addressing complex technical issues like fishing port management (UNDP, 2023).

Engagement Limitations and Governance Quality Despite robust legal design, the quality and uniformity of engagement face systemic constraints.

- Institutional Unevenness: Engagement is not uniformly institutionalized. As noted in the stakeholder analysis, participatory mechanisms are often "project-dependent" promoted and sustained in pilot provinces with donor support, but lacking the local capacity and financing for autonomous replication elsewhere (UNDP, 2023).
- The "Transactional" Trap: In many sectors, engagement is constrained by compliance-driven priorities. For example, in fisheries, interactions between the state and stakeholders frequently focus on enforcement (IUU controls, traceability checks) rather than co-production of management measures. While necessary for legality, this transactional approach can undermine perceived legitimacy if stakeholders feel they are only "targets" of regulation rather than partners in governance.

6.7.2 Effective Governance Diagnosis

In the context of the National TDA, "Effective Governance" is assessed not by the existence of laws, but by tangible results. Effectiveness is evaluated through a three-tiered hierarchy: (i) Behavioral Change (compliance and enforcement); (ii) Pressure Reduction (reduced loads/effort); and (iii) Environmental State Improvement.

For Viet Nam, publicly available evidence is significantly stronger for compliance processes than for ecosystem-state improvements. This reflects a common governance reality where administrative outputs (inspections, VMS tracking) are generated daily, while ecosystem variables (biomass, coral cover) require long-term, spatially dense monitoring to attribute change.

6.7.2.1. Pollution Control and Marine Environmental Quality

Evidence of Effectiveness: "Maintained Fairly Well" Official reporting suggests that the governance system has succeeded in preventing broad-scale degradation of nearshore waters.

- State Indicator: The Government's public summary of the *National Marine Environment Report (2016–2020)* concludes that overall nearshore seawater quality was "maintained fairly well." Results from multi-source monitoring points (nearshore and offshore) were broadly within national quality standards.
- Governance Implication: This indicates that the outcome assessment is anchored in actual monitoring evidence, providing a baseline of effectiveness for general water quality management.

Evidence of Continuing Pressure: The "Hotspot" Reality Despite acceptable averages, effectiveness is compromised by persistent localized failures.

- Localized Pollution: The same summary acknowledges pollution episodes in specific high-pressure zones: aquaculture areas, river mouths, and port clusters.

- Source Attribution: It explicitly identifies aquaculture and coastal tourism as high-impact marine sources, alongside land-based waste discharged through river mouths—particularly near coastal cities.
- Emerging Risks: The report highlights rising risks from industrial discharge incidents and oil spills, exacerbated by climate change. This suggests that while "average" quality is maintained, the system struggles to manage peak pressures in high-growth zones.

Spatial Pattern of Effectiveness The effectiveness gaps map directly to the economic drivers identified:

- Gulf of Tonkin & Southeast Coast: Pollution hotspots correlate with river mouths and large port/industrial clusters.
- South-Central Coast: Localized degradation is linked to bays and lagoons with high tourism and aquaculture intensity.

6.7.2.2 Fisheries Sustainability and Compliance (IUU)

Evidence of Improving Systems: Behavioral Change Fisheries governance shows the strongest evidence of behavioral transformation, driven by digitization.

- Digital Compliance: National authorities report on the operation of a continuous monitoring system for VMS disconnections, alongside expanded training on electronic traceability. This represents a shift from "paper-based" to "real-time" governance (Directorate of Fisheries, 2024).
- Positive Trends: Official communications report a decrease in IUU-related violations compared to the previous period (2024), specifically noting reductions in foreign water encroachments and VMS non-compliance. While qualitative, this indicates a positive directional trend in fleet behavior (Directorate of Fisheries, 2025).

The External Accountability Benchmark: The "Yellow Card" Despite these improvements, effectiveness remains incomplete when judged against international standards.

- Persistent Warning: Viet Nam has remained under the European Commission’s "Yellow Card" since 2017. As of late 2025, official communications frame this as a continuing challenge requiring high-level political direction.
- Governance Implication: The persistence of the Yellow Card suggests that while *domestic inputs* (laws, VMS) have improved, the *transboundary outcome* (full assurance of legality) has not yet reached the threshold required to lift the warning. However, the reported reduction in foreign incursions strengthens the inference that compliance improvements are beginning to reduce international conflict risks.

6.7.2.3 Climate Resilience and Adaptation Finance

Evidence of Institutional Prioritization The 2025 institutional consolidation creates a robust design for resilience. By placing disaster preparedness, climate change, and marine management under the Ministry of Agriculture and Environment (MAE), the system theoretically aligns coastal risk management with environmental protection.

The Finance-Policy Divergence However, a disconnect exists between policy intent and financial reality. Public finance tracking indicates that the share of government spending dedicated to climate change adaptation declined between 2018 and 2020 (UNICEF, 2021).

- Effectiveness Risk: This serves as an early warning indicator. Long-term coastal resilience cannot be achieved through institutional mergers alone; it requires sustained, increasing investment in local adaptation infrastructure. The decline in adaptation finance suggests a "Resource Gap" that may undermine the effectiveness of the new institutional arrangement.

6.7.2.4 Social Justice and Human Well-being Links

Outcome-Oriented Engagement Mechanisms Governance effectiveness for human well-being is best evidenced where the state actively supports co-management. UNDP (2023) reports structured dialogues focused on replicating co-management models and improving the governance of ports and landing sites.

- Governance Implication: These dialogues are not merely technical; they are directly relevant to governance legitimacy. By involving small-scale fishers in decisions about their immediate infrastructure, the system builds social capital and secures livelihoods against displacement.

The Distributional Impacts of Compliance The push for modernization creates distinct social risks.

- Market Access vs. Compliance Costs: Reforms such as VMS installation and electronic traceability are essential for maintaining market access (reducing conflict risks and securing export revenues). Indirectly, this supports the macro-stability of the sector.
- Equity Concern: However, the distribution of these compliance costs can be uneven. While large offshore vessels may absorb these costs, smaller operators may face disproportionate burdens. Notably, Viet Nam-specific quantitative evidence on the *distributional impact* of these reforms (impact on net income of smallholders) is not publicly synthesized in the reviewed sources. This represents a significant data gap for assessing the social justice dimension of the "Blue Economy" transition (Directorate of Fisheries, 2024; 2025).

Table 8. Governance Design vs. Effectiveness in Key Domains

Domain	Governance Design Signals	Effectiveness Evidence	Main Limitations for Attribution	Transboundary Significance
Marine Pollution Control	Strong Legal Basis. *Law on Environmental Protection (2020)* + National Reporting Cycles + Standards-based assessment.	Partial Success. Overall seawater quality is "maintained fairly well," but persistent hotspots exist in aquaculture zones, river mouths, and ports	Data Granularity. Public summaries provide limited time-series data and lack sub-regional disaggregation, making causal attribution difficult.	High. Litter and oil spill impacts move across borders via ocean currents and international shipping routes.
Fisheries Governance	Modernized Framework. *Fisheries Law (2017)* + 24/7 VMS Monitoring + Electronic Traceability Systems.	Behavioral Improvement. Reported reduction in IUU-type violations (foreign incursions) compared to 2024; improved monitoring routines.	Ecological Data Gap. Lack of published national indicators on stock recovery (biomass) or catch-per-unit-effort (CPUE) in reviewed sources.	Critical. Directly affects shared stocks, incursions into foreign waters, and regional compliance expectations (EC Yellow Card).
Coastal Sanitation	Investment Pathways. Clear project pipelines exist for urban pollution reduction	Implementation of Fragility. Progress is spatially uneven. Delays in cities like Nha Trang illustrate persistent bottlenecks in land acquisition and safeguards.	Scale Mismatch. City-level project outcomes do not automatically equate to national trend improvements; benefits depend on long-term O&M.	Medium/High. Reduced nutrient discharges support water quality in semi-enclosed bays and the Gulf of Tonkin.

Climate Adaptation	Institutional Alignment. 2025 Merger (MAE) consolidates climate, disaster, and marine management under one roof.	Financial Divergence. Public spending analysis suggests the share of funding for adaptation actually *declined* (2018–2020) (UNICEF, 2021).	Outcome Gap. Expenditure shares track "effort," not "resilience." Local project-level evidence is required to prove safety improvements.	High. Coastal hazards affect shared disaster response capacity and regional economic stability.

6.7.3 Cross-Cutting Constraints and Enabling Conditions

This subsection synthesizes the recurring factors that explain the divergence between *Governance Design* (often strong) and *Governance Effectiveness* (often uneven). It identifies the structural impediments that limit performance and the enabling conditions that offer pathways for improvement.

6.7.3.1 Cross-Cutting Constraints

1. Structural Integration and Enforcement Limits Despite the 2025 institutional consolidation, cross-sector integration remains structurally demanding. Marine outcomes depend heavily on sectors—Transport, Industry, Defense—that remain outside the mandate of the Ministry of Agriculture and Environment (MAE). Furthermore, the *official communication on marine environment governance* identifies a critical enforcement gap: the absence of a dedicated specialized inspection force for integrated marine management. This limits the state's ability to conduct comprehensive oversight across the full spectrum of marine resources (MONRE, 2021).

2. Asymmetric Implementation Capacity Implementation performance is highly variable across localities, even within standardized national investment programs. The *Coastal Cities Sustainable Environment Project* serves as a key indicator: while some cities progressed effectively, Nha Trang faced major delays due to land acquisition and safeguard compliance challenges (World Bank, 2024). This suggests that high-pressure growth zones (tourism hubs in the South-Central Coast) face complex trade-offs that often overwhelm local implementation capacity.

3. Evidence Deficits and Data Aggregation Risks While national reporting has improved, public summaries provide limited disaggregated time-series evidence at the sub-regional level. The reliance on provincial data submissions for national reporting creates a "weakest link" risk: the quality of the national assessment is constrained by the reporting completeness of the 28 coastal provinces (CEM, 2025).

4. Fiscal Composition and the "Opex" Trap Public finance tracking reveals a structural bias. While environmental spending exists, it is dominated by waste management infrastructure (Capex). Conversely, spending on climate change adaptation—which often requires recurrent operational expenditure (Opex) for resilience—declined as a share of the total between 2018 and 2020 (UNICEF, 2021). This constrains the system's ability to fund the continuous "soft" operations (monitoring, maintenance) required for effective governance.

5. The "Compliance Crowding-Out" Effect In fisheries, the urgent need to meet strict external market requirements (the EC Yellow Card) creates a trade-off. Resources are prioritized for enforcement and traceability to secure market access, potentially "crowding out" broader Ecosystem-Based Management (EBM) initiatives. The sustained focus on the Yellow Card indicates that this compliance agenda will continue to dominate administrative bandwidth (Directorate of Fisheries, 2025).

6.7.3.2 Enabling Conditions

1. The Spatial Governance Framework The adoption of the National Marine Spatial Planning (MSP) (*Resolution No. 139/2024/QH15*) provides, for the first time, a comprehensive framework to align lower-level sector plans. If implemented with strong coordination, this is the primary mechanism to reduce spatial conflict and increase investment predictability.

2. Institutional Consolidation (The MAE Merger) The 2025 merger places integrated marine management, environment, fisheries, and climate/disaster functions under a single ministry. Over time, this design should reduce the transaction costs of coordination, allowing for more coherent policymaking across the land-sea interface.

3. The Institutionalized Reporting Cycle Viet Nam has successfully delivered its first *National Marine Environment Report (2016–2020)* and initiated the 2021–2025 cycle. This regularity is a critical enabler, progressively improving data consistency and establishing a baseline against which policy effectiveness can be measured (CEM, 2025).

4. Digitization of Compliance The operationalization of VMS monitoring routines and e-traceability systems represents a technological leap. These digital tools reduce the cost of monitoring and are essential enabling conditions for reducing IUU fishing behaviors in the vast maritime zones of the South China Sea (Directorate of Fisheries, 2024).

5. External Leverage and Finance Targeted international finance (World Bank sanitation investments) continues to provide a pathway for measurable pollution reduction. Furthermore, stakeholder dialogue processes supported by international partners (UNDP) provide essential channels for strengthening legitimacy, particularly in small-scale fisheries management.

6.8 Recommended Priority Actions

The priority actions below address the principal governance risks identified earlier: (i) limited transboundary integration at Large Marine Ecosystem (LME) scale (as indicated by TWAP), (ii) uneven provincial implementation capacity, (iii) incomplete outcome evidence for pollution and ecosystem states, and (iv) persistent compliance pressures in fisheries, including IUU-related risks (Fanning et al., 2015; Directorate of Fisheries, 2024; European Commission, 2017). The actions are framed as measures within Viet Nam's national mandate, while also supporting stronger regional cooperation in the South China Sea and Gulf of Thailand contexts.

6.8.1 Strengthen cross-sectoral and multi-level integration

Priority 1. Translate national marine spatial planning into operational cross-sector rules and routines.
The adoption of national marine spatial planning (MSP) provides an integrating framework at national level (National Assembly of Viet Nam, 2024). Implementation priorities could include:

- An inter-ministerial implementation protocol that links national MSP to sector decisions affecting marine space (ports and shipping, fisheries, tourism, coastal infrastructure, conservation). This would operationalize MSP as a conflict-reduction instrument rather than a standalone planning document.
- Provincial alignment guidance specifying how coastal provinces incorporate national MSP into provincial planning, licensing conditions, and inspection priorities, with explicit attention to subregional hotspots (port clusters in the Gulf of Tonkin and Southeast Coast; tourism bays and lagoons in the Central and South-Central Coast; mixed fisheries–aquaculture systems on the Southwest Coast).

Priority 2. Strengthen land–sea integration for pollution control through shared planning and shared data.

The Law on Environmental Protection establishes a multi-level environmental monitoring system and assigns monitoring and reporting responsibilities to central and provincial authorities. The Law on Marine and Island Resources and Environment also assigns responsibilities for marine data systems and reporting across ministries and coastal provinces. Building on these mandates, priority actions could include:

- A common coastal water-quality and pollution-load reporting template is used across coastal provinces to improve comparability and trend tracking, aligned with the national marine environment reporting cycle.
- A joint land–sea pollution "pressure map" (river mouths, ports, aquaculture zones, tourism hotspots) that links monitoring outputs to provincial inspection planning and targeted investment decisions.

Priority 3. Clarify coordination arrangements between MAE and other ministries that remain central to marine outcomes.

The creation of the Ministry of Agriculture and Environment consolidates several key lands–sea drivers (environment, sea–island administration, fisheries). However, effective implementation continues to depend on structured coordination with transport/port authorities and maritime enforcement forces. Priority actions include:

- Standard operating procedures (SOPs) for information exchange and case coordination among MAE agencies, provincial authorities, and maritime enforcement forces for: (i) environmental violations in maritime zones, (ii) pollution incidents, and (iii) fisheries violations where multiple agencies may have sanctioning jurisdictions.
- A shared enforcement reporting dashboard (administrative cases, inspections, sanctions) to reduce duplication, support consistent deterrence, and enable cross-province comparability at subregional scale.

6.8.2 Improve legal and policy coherence

Priority 1. Strengthen regulatory coherence at the land–sea interface for pollution control. Official reporting from the 2016–2020 national marine environment assessment highlights persistent constraints in oversight and enforcement for integrated marine environmental protection. Priority actions include:

- Review implementing regulations and standards applicable to coastal discharges and nearshore water quality. The objective is to ensure that sector rules for key sources (industry, aquaculture, tourism facilities, ports) align with national environmental requirements and are enforceable at provincial level.
- Clarify enforcement pathways and evidentiary guidance for marine-related environmental violations in maritime zones. This should align administrative sanctions under the environmental penalty decree with the operational responsibilities of relevant authorities and forces.

Priority 2. Reduce fragmentation and improve consistency in fisheries compliance policy tools. Fisheries enforcement in Viet Nam involves multiple sanctioning authorities, while compliance systems rely on vessel monitoring systems (VMS) and traceability processes. Priority actions include:

- Issue unified operational guidance to harmonize case handling and penalty application across sanctioning authorities for core IUU-related violations (VMS disconnection, fishing in restricted areas, port documentation). This would improve predictability and deterrence.
- Align domestic fisheries policy tools with accepted international disciplines (UNFSA obligations and port-based controls). The focus should be on practical instruments for shared and migratory stocks and for transboundary supply chains.

Priority 3. Align marine litter instruments across upstream and downstream control measures. Viet Nam has adopted a national action plan on marine plastic debris and has introduced extended producer responsibility (EPR) through environmental law and its implementing decree. Priority actions include:

- Develop operational guidance linking EPR to coastal leakage reduction, including transparent reporting on collection and recycling outcomes in coastal provinces with high tourism and port activity.
- Conduct consistency checks between marine litter actions and provincial solid waste/wastewater planning to avoid parallel plans that do not reinforce each other and to strengthen implementation.

6.8.3 Strengthening provincial implementation capacity

Priority 1. Establish a simple national benchmarking approach for implementation capacity across coastal provinces.

A recurring constraint is the absence of consolidated, comparable indicators on enforcement effort, monitoring frequency, and staffing across coastal provinces (MONRE, 2021). A practical priority action is to establish a limited national indicator set, reported annually by coastal provinces, for example:

- frequency and parameters of coastal water monitoring.
- number of inspections in priority coastal sectors.
- number of administrative cases related to marine pollution and fisheries violations.
- patrol days/hours (by responsible force, where reportable);
- operational status of wastewater and solid waste infrastructure relevant to coastal discharges.

This benchmarking can be anchored in existing reporting mandates under environmental and marine laws.

Priority 2. Target technical assistance and training based on subregional pressure profiles. Because pressure profiles differ across subregions, capacity-building measures should be tailored accordingly:

- Gulf of Tonkin and Southeast Coast (South China Sea): strengthen port and industrial compliance monitoring, spill-readiness interfaces, and waste control systems linked to urban–industrial growth corridors.
- Central Coast and South-Central Coast (South China Sea): strengthen monitoring and permitting compliance in bays and lagoons where tourism and aquaculture pressures are documented as localized pollution drivers (MONRE, 2021).
- Southwest Coast (Gulf of Thailand): strengthen fisheries compliance coordination (including port and border-enforcement interfaces) and integrate aquaculture effluent controls with livelihood considerations.

Priority 3. Strengthening provincial project execution capacity for pollution-reduction infrastructure.
Investment effectiveness depends on local delivery capacity. Experience from

the World Bank coastal sanitation project indicates that implementation delays can occur due to land acquisition/site clearance and safeguards compliance challenges, even where financing is available (World Bank, 2024). Priority actions include:

- Strengthen provincial project preparation and safeguards capacity for wastewater and sanitation investments in coastal cities, including standardized mitigation and consultation procedures under environmental law.
- Strengthen operations and maintenance (O&M) planning and financing for completed systems to ensure that investments translate into sustained reductions in coastal pollutant loads.

Priority 4. Consolidate fisheries MCS technical capacity and data systems at provincial level.
Official fisheries reporting describes a 24/7 monitoring approach for VMS disconnections and ongoing e-traceability capacity building. Priority actions include:

- Provincial VMS follow-up protocols with defined response times and clear handover rules among fisheries authorities, border forces, and port management boards.
- Digital traceability training and support for fishers, ports, and processors in high-risk provinces to reduce compliance gaps and transaction.

6.8.4. Enhance inclusive participation and equity

Priority 1. Institutionalize community-based fisheries co-management where conditions allow, using Fisheries Law provisions.

Viet Nam's Fisheries Law provides a formal basis for co-management organizations to be recognized, granted management rights in a defined area, and engaged in local monitoring and protection. Priority actions include:

- Replication through provincial co-management plans where evidence indicates feasibility and stakeholder demand, using documented approaches supported by structured dialogue and technical assistance.
- Clear guidance on roles and operating arrangements, including patrol/monitoring responsibilities and coordination protocols between co-management groups and competent authorities. This helps avoid informal arrangements that lack legal standing.

Priority 2. Strengthen transparency and feedback channels already provided under environmental law.

The Law on Environmental Protection includes provisions on consultation (including within EIA processes) and responsibilities to receive and respond to community reports and recommendations through online systems. Priority actions include:

- Standardized disclosure and consultation practice for coastal projects with marine impacts (ports, coastal tourism infrastructure, aquaculture clusters, coastal industrial zones), including clear documentation of how public comments are addressed.
- A functional coastal grievance and response channel linked to provincial environmental authorities, with routine reporting on response times and resolution outcomes.

Priority 3. Address distributional considerations explicitly within compliance programmes, where feasible.

Fisheries compliance reforms (VMS and traceability) may impose uneven costs across fleet segments. Viet Nam-specific public evidence on distributional impacts is limited in the sources used for this NTDA. A practical priority action is:

- Routine collection and reporting of participation and compliance costs by fleet segment and community, including (where feasible) sex-disaggregated participation in consultations and co-management bodies. This is framed as a data improvement measure to identify vulnerable groups and reduce unintended inequities, rather than as an assessment of current outcomes.

6.8.5 Sustainable financing and PPP approaches

Priority 1. Improve the visibility of coastal/marine-relevant public spending through budget tagging and tracking.

Public spending evidence indicates a strong emphasis on solid waste and wastewater management within environment and climate spending, while adaptation spending represented a smaller share and declined over 2018–2020 (UNICEF, 2021). Priority actions include:

- Introduce a marine-relevant expenditure tag within existing budget classifications (environmental monitoring, enforcement, wastewater, solid waste, coastal resilience). This would improve transparency and performance tracking and help identify funding gaps, particularly for monitoring and enforcement.
- Track operations and maintenance (O&M) budgets separately for wastewater and solid-waste systems serving coastal cities and tourism hubs, given that O&M is a common determinant of sustained outcomes.

Priority 2. Strengthen economic instruments and producer responsibility for marine litter reduction. Viet Nam has a national action plan on marine plastic debris and EPR-related measures under environmental law and its implementing regulations. Priority actions include:

- Link EPR performance reporting to leakage-risk areas (tourism centres, ports, river mouths) to better connect upstream financing with downstream marine litter outcomes.

- Review revenue instruments and incentives (including environmental taxes), with attention to whether revenues support waste systems and enforcement that are material to marine outcomes.

Priority 3. Use PPP and blended finance selectively for bankable coastal services.
The Law on Public–Private Partnership Investment provides a legal pathway for PPPs. Evidence from fisheries dialogue processes suggest PPP mechanisms are not yet well established for recurring fishing port and landing-site management challenges (UNDP, 2023). Priority actions include:

- Pilot PPP models for port reception and waste services where revenue and service-payment structures are feasible, supported by clear performance standards and monitoring arrangements.
- Deploy blended finance and green capital market instruments for wastewater, sanitation, and climate-resilient coastal infrastructure, building on emerging green and sustainability bond frameworks described in World Bank technical assistance documentation.

6.8.6 Regional and transboundary cooperation priorities

TWAP indicates very low integration for both the South China Sea and Gulf of Thailand LMEs, even where engagement levels are relatively high (Fanning et al., 2015). Regional priority actions therefore focus on strengthening operational cooperation by connecting existing arrangements into more coherent routines.

Priority 1. Harmonise monitoring and reporting for marine pollution and marine litter through existing regional platforms.

Viet Nam participates in regional seas cooperation under COBSEA and has long-standing engagement with PEMSEA processes relevant to integrated coastal management. Priority actions include:

- Agree a shared core set of indicators for coastal water quality and marine litter that enables cross-country reporting and comparability, aligned with national monitoring and reporting cycles.
- Conduct joint technical exchanges on source-to-sea approaches for priority hotspots (river mouths, ports, tourism bays), supporting comparable datasets and more coordinated prevention measures.

Priority 2. Strengthen transboundary fisheries cooperation through treaty-based and regional mechanisms.

Viet Nam's accession to UNFSA strengthens the international legal basis for cooperation on highly migratory and straddling stocks. Port-based controls are supported by PSMA principles and mechanisms. Priority actions include:

- Establish information-exchange protocols on port and vessel compliance (alerts on VMS issues, port inspection results, traceability concerns) through bilateral and regional channels where feasible.

- Focus cooperation in boundary and high-risk areas, including the Gulf of Tonkin where a bilateral fisheries cooperation agreement exists.
- Promote technical alignment and capacity sharing via SEAFDEC on monitoring approaches and data compatibility.

Priority 3. Improve transboundary incident preparedness for shipping-related risks.

Shipping corridors in both LMEs create shared risks, including oil spills, ship waste, and invasive species. Viet Nam has adopted an implementation plan for ballast water management through a Prime Minister decision, providing an operational policy tool in this area. Priority actions include:

- Regional exchange on ballast water compliance and inspection capacity in major ports to reduce invasive species risks.
- Coordinate marine pollution incident response exercises (where cooperative frameworks exist), including protocols for notification and mutual assistance that are consistent with national mandates.

Priority 4. Align ASEAN and wider regional cooperation with national priorities on marine litter and coastal resilience.

ASEAN platforms provide a channel for shared agenda-setting on coastal and marine environment issues. Priority actions include:

- Connect Viet Nam's marine plastic action plan to regional initiatives through comparable indicators and shared learning on implementation tools.
- Link coastal resilience priorities with shared disaster risk considerations, particularly where extreme events can trigger pollution releases and disrupt fisheries and port operations.

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