International Journal of Ecosystems and Ecology Science (IJEES) **Vol. 15 (1):** 299-308 (2025)
https://doi.org/10.31407/ijees https://doi.org/10.31407/ijees15.1

COASTAL MANAGEMENT PROBLEMS ALONG THE BLACK SEA COAST OF TURKEY

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Received January 2025; Accepted February 2025; Published March 2025;

DOI: https://doi.org/10.31407/ijees15.134

ABSTRACT

Coastlines, where the sea meets the land, are characterized by significant ecological and environmental fragility. Ineffective management of the unique attributes of these regions can lead to potential hazards and other issues that become priority concerns requiring prompt resolution. The Black Sea Coastal area is one of the important regions of Turkey in term of settlement, agriculture, tourism and trade. Due to the Geographical features such as situation of Pontit Mauntains that are ly in parallel to the shoreline and their sharp topography and hydrological patterns the settlement areas particularly city centers are concentrated on shoreline or neighboring lowland areas very close to shoreline. Thus, the coastal management issues posed several environmental problems which resulted serious demages along the coast. The aim of study is to present environmental problems related coastal management of the shoreline along the mid and eastern Black Sea Coast of Turkey.

Keywords: Coast, Coastal Management, Black Sea, Sustainability

INTRODUCTION

Approximately two-thirds of the world's population lives in coastal areas or near the coast. The remaining one-third visit coastal areas regularly (Sorensen, 2002).
In this respect, integrated management of coastal cities is absolutely necessary.
Turkey's total coastline measures 8,330 km, and 19.3% of the population resides in coastal areas (Yıldız & Karakulak, 2010). Along the Black Sea coast, Turkey has the second-longest shoreline among the littoral states. Notably, 86% of the nation's coastal population is concentrated in the Black Sea coastal region. Figure 1 and Table 1 illustrate Turkey's Black Sea coastal cities and their respective coastline lengths.
Antonidze (2010) highlights abundant natural and historical attractions along the Black Sea coast. Numerous specially protected areas safeguard lakes and ports, which serve as habitats for various migratory bird species.
The primary goal of sustainable development in Black Sea nations is to enhance living standards while conserving the region's unique ecosystems.

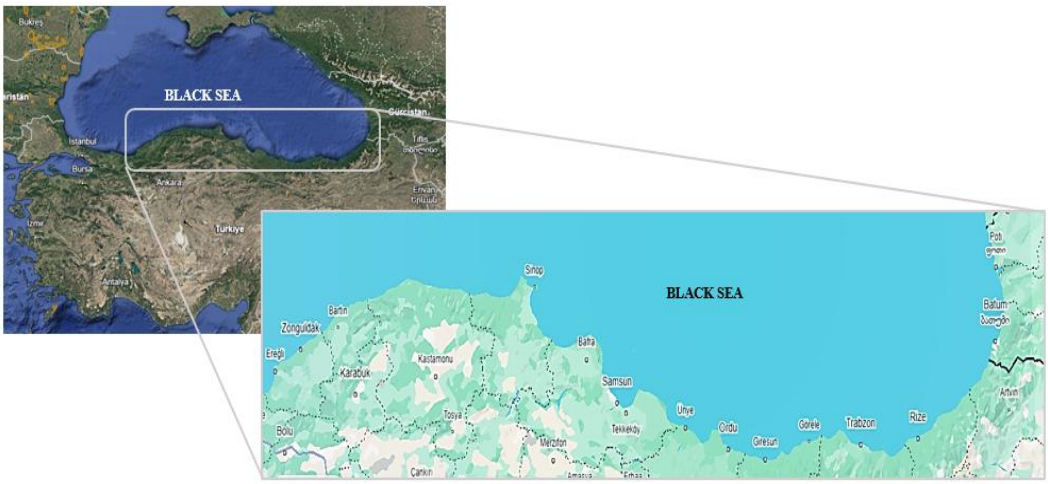

Figure 1. A map depicting the provinces of Turkey that border the Black Sea. *(https://earth.google.com/web/).*

Table 1. Coastline Lengths of Black Sea (Turkey) Coastal Provinces

Province	Coastline Length (km)
Artvin	34
Trabzon	135
Rize	80
Giresun	122
Ordu	100
Samsun	213
Sinop	175

In contrast to inland areas, population growth and demographic changes in coastal regions increase during the summer months. Particularly, coastal cities conducive to recreational activities experience substantial population shifts, with significant rises in summer compared to winter. The lack of recorded data on this seasonal increase presents a critical issue, as it can disrupt municipal infrastructure projects. Moreover, this absence of planning challenges all aspects of coastal zone management. Failing to incorporate sudden population changes into environmental and coastal planning processes results in regional social, economic, and physical infrastructure problems. This situation is particularly complex for coastal areas, such as those along the Black Sea, characterized by distinctive topographical and meteorological features.

Population growth in coastal areas has two main causes. First, it reflects the general trend of population growth in developing countries, linked to rural-urban migration; and second, the migration from inland areas to the coast, which often offers people more economic, social and recreational opportunities than inland areas (Goldberg, 1994; Kay and Alder, 2002).

An analysis of the 2023–2030 population projections for the Black Sea coastal provinces estimates an overall potential increase of 6.33% between 2023 and 2030. For example, projections for 2030 indicate increases of 0.83% for Samsun (TurkStat, 2023). Notably, these figures pertain solely to the resident population, and, as previously mentioned, there are no available data regarding seasonal population fluctuations.

City Planning Strategies and Embankments to obtain lowlands

The coastline responds to wave action through processes such as erosion and accretion, ultimately attaining equilibrium only over extended periods—on the order of thousands of years. Any intervention along the coast, including illegal residential development, extraction of sand and gravel from the sea (Yüksek et al., 1995), land reclamation followed by improper use, and the construction of various irregular structures, disrupts this equilibrium by altering wave conditions and the natural structure of the shoreline.

In Turkey, under Coastal Law No. 3621, the shoreline in marine areas is defined as the zone extending at least 100 meters inland from the coastline. The depth of the coastline varies from country to country. In our country, this depth is accepted as the limit of the natural coastal zone and this value is accepted as 100 m (Clark, 1992). This zone is divided into two sections of 50 meters each. In the first 50 meters closest to the sea, the construction of green spaces, children's playgrounds, promenades, rest and recreational areas, and pedestrian walkways is permitted. In the second 50 meters, structures defined in Article 8 of the Coastal Law—namely, day-use facilities open to public benefit—may be constructed, along with roads, parking lots, and wastewater treatment plants.

Infill areas may accommodate the following structures and facilities: those already permitted on the shore; infrastructure and facilities serving the public interest and aimed at protecting the coastline (e.g., piers and lighthouses); treatment plants; structures and facilities that cannot be constructed elsewhere other than on the shore (e.g., shipyards and marinas); beaches and associated amenities that may be developed without an urban plan; transportation-related infrastructure; green spaces; sports fields; restaurants; casinos and tea gardens; as well as fairgrounds, picnic areas, and entertainment venues.

All modifications and structures proposed within coastal areas require the preparation of a zoning plan. According to the relevant provisions of the law and its regulations, in addition to permissible structures along the shore, fill areas may also be developed with roads, squares, open parking lots, parks, green spaces, fairs, playgrounds, as well as sea, air, and land transportation facilities. Consequently, in planning these areas—and, if necessary, the associated fill—it is essential to prioritize the required and minimal superstructure components. An example illustrating fill areas in coastal zones over the years is provided in Figure 2.

Figure 2. (a) 2009 satellite image of Samsun (Batıpark); (b) 2024 satellite image of Samsun (Batıpark)-coastal change *(https://google.com/earth)*

When buildings in coastal cities are constructed, a view of the sea is often preferred. For this reason, building facades are built facing north, towards the sea. In addition, the fact that land suitable for settlement in coastal cities is scarce and expensive causes buildings to be built in adjacent layouts and narrows the street and avenue systems (Bekdemir, 2007).

Similar to other coastal cities, urban development in Black Sea coastal cities extend along roads parallel to the shoreline. Consequently, land prices within the coastal zone and adjacent areas are elevated, with prospective homebuyers typically prefer seafront properties offering sea views. This preference fosters contiguous, multi-story construction, accelerating unplanned urban expansion along the coast.

Furthermore, in the Black Sea coastal region, the prevalent use of contiguous building layouts and the lack of regulations governing building heights result in several adverse outcomes: narrow and dead-end streets hinder transportation, buildings cast shadows upon one another, and exacerbated by high humidity levels, airflow is restricted. As a result, air pollution increases along the coast, and the trapped air fails to disperse from the city center.

The obstruction of clean air currents from the Black Sea hinders the rapid dispersion of polluted air, particularly chimney flue gases, during the winter season in coastal cities along the Black Sea. Figures 3 and 4 illustrate the land reclamation and urban development changes in these coastal cities over time.

Figure 3. Satellite imagery of Sinop's coastal development: example of coastal area development and green space loss (a) 1994 (Baki and Ergun, 2016) (b) image dated 29.07.2024 *(https://earth.google.com/web/)*

Local residents' strong preference for sea views significantly increases building floors. In many city centers along the Black Sea coast, buildings have already reached twenty stories (Yılmaz, 2008). However, the Black Sea coastal areas, prone to erosion, are unsuitable for such unregulated development.

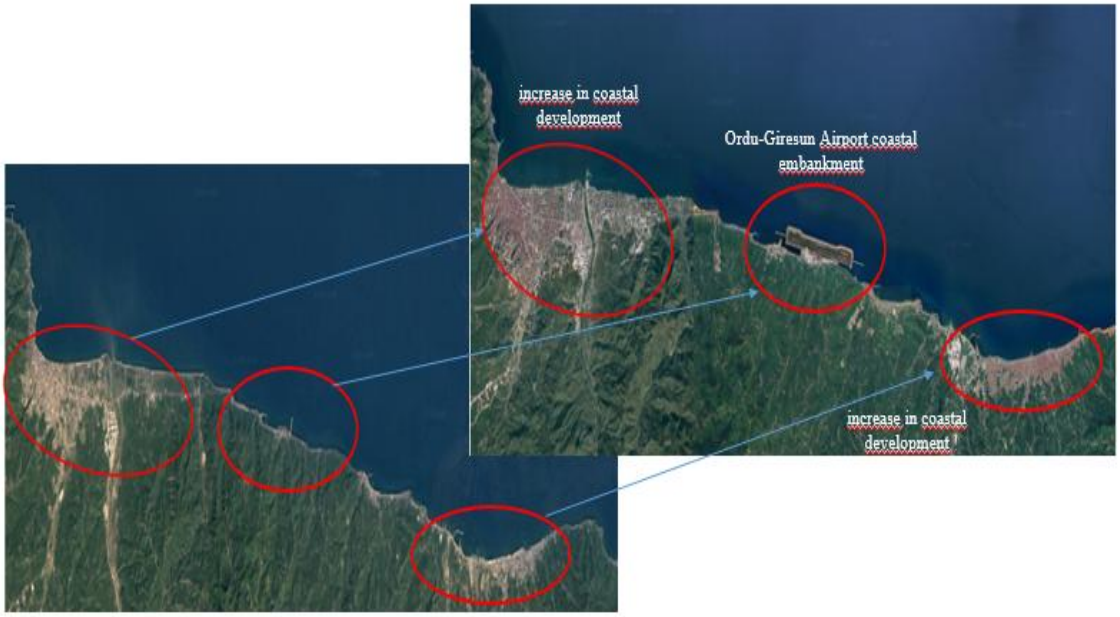

Figure 4. Satellite imagery of the Ordu coastal zone and Ordu Airport and change in coastal development *(https://earth.google.com/web/)) Coastal view dated December 31, 2000 b) Ordu Airport and associated development image dated May 08, 2024*.

Sea wave barriers

In the Black Sea region, the dominant wave direction is northwest–north, while the general orientation of the coastline is east-west. Retaining structures—often composed of large stone blocks—are commonly built to protect highway embankments; however, they alter wave mechanics along the coast, causing scouring at their bases and compromising their stability. One of the most prominent examples of this issue can be observed in some retaining structures along the Black Sea coastal highway (Figure 5).

Figure 5. A visual of the groin and jetty structures-sea wave barriers along the Black Sea Coastal Road.
(first image dated February 23 2024; second image is original).

The primary drawbacks of the fortifications located along the Black Sea coasts are as follows:
- Hindering access to the coastal area and disrupting its visual aesthetics,
- Causing shoreline erosion, which leads to the disappearance of beaches used for recreational purposes,
- Altering the natural dynamics of coastal currents
- Acting as triggers for disaster events.

The Black Sea Shoreline Highways

The Black Sea Coastal Road is one of Turkey's most significant infrastructure projects, consisting of three segments and 27 sections totaling 1,474 km (Anonymous, 2024) (see Figure 6). Since its inauguration in 2007, the Black Sea Coastal Road has generated numerous challenges. One major issue is the increased population mobility in the region, which has accelerated migration from rural villages to urban areas. Consequently, urban infrastructure along the coastline has been inadequate for many years due to a lack of prior planning, leading to distorted urban development associated with rapid urbanization. Additionally, the linear expansion of cities along the coast and the decreasing distance between them have begun to create a new and distinct urban landscape that extends over hundreds of kilometers.

Figure 6. Route of the Black Sea Coastal Road (modified from, Yılmaz, 2008).

Along the Black Sea coastal highway, roads adjacent to the Black Sea are generally constructed at elevated levels to accommodate the slight elevation differences between the sea surface and the surrounding land. Consequently, the frequency and severity of floods and the associated damages in coastal cities are increasing (see Figure 7).

Figure 7. Condition of Elevated Roads in the Coastal Areas of Black Sea Cities During Rainfall.

As illustrated in Figure 8, heavy rainfall has resulted in flooding along the Black Sea coastal highway situated on the Black Sea shoreline. These flood events, occurring on various dates, have damaged the roads, sewage systems, and drinking water networks of the coastal cities. Factors such as elevation differences, the impact of elevated roadways, and structures constructed on reclaimed land play significant roles in these occurrences.

Wastewater Discharges

Changes in water quality can be attributed to several sources: sewage outfall from primary and secondary treatment directliy into the oceans or via river systems, storm water drainage, industrial wastes, runoff from pastoral lands and groundwater inputs (Kay and Alder, 2002).

Infrastructure, defined as the basic services required for cities to function, grow and develop, is also one of the criteria used to distinguish between urban and rural settlements. If the basic infrastructure services of any urban settlement such as transportation, water, sewage, electricity, communication and cleaning are completed, it means that urban infrastructure problems are also minimized and developed (Bekdemir, 2007).

Global climate change and the impacts of the ecological footprint, which are felt across numerous sectors globally and within Turkey, underscore the necessity for the sustainable and most efficient utilization of natural and renewable resources, particularly in coastal cities. This is primarily attributable to the fact that coastal cities have not incorporated population fluctuations between summer and winter, including seasonal population increases during the summer months, into their planning and management processes, and consequently have not effectively integrated these changes into infrastructure projects.

In treating wastewater and deep-sea discharge systems in coastal cities, it is imperative to include changes in summer populations within the project processes. Upon reviewing the Provincial Environmental Status Reports, no data regarding summer and winter populations are recorded for coastal cities along the Black Sea.

Figure 8 illustrates the distribution of wastewater treatment methods employed by municipalities from 2020 to 2022, which were planned solely based on the resident population.

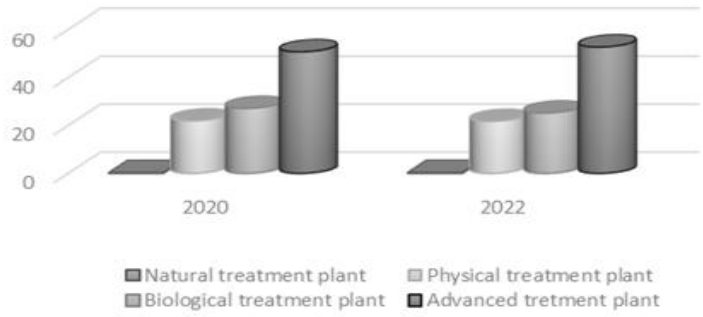

Figure 8. Distribution of the Volume of Wastewater Treated by Municipalities from 2020 to 2022, according to Facility Type.

In the Black Sea coastal cities, 15.3 billion cubic meters (m^3) of wastewater, including 9.5 billion m^3 of cooling water, were discharged directly into receiving environments in 2020. These discharges were carried out by municipalities at the industrial level, villages, manufacturing workplaces, thermal power plants, organized industrial zones (OSBs), and mining operations (TurkStat, 2022a). Of the wastewater discharged directly into receiving environments, 76.6% was released into seas, 19.3% into rivers, 1.1% into dams, 1.0% into septic systems, 0.4% into lakes or ponds, 0.2% onto land, and 1.4% into other receiving environments. Excluding cooling waters, 79.7% of the wastewater discharged directly into receiving environments was treated (TurkStat, 2022a). This indicates that 20.3% of the recorded wastewater was still discharged untreated into surface and groundwater. This case has also been identified in the provinces' Environmental Status Reports. Furthermore, only 1.6% of treated waters are being reused, demonstrating that the remaining 98.4% of treated waters ultimately mix with surface and/or groundwater. Discharging treated wastewater into surface waters, considered receiving environments, is neither appropriate nor sustainable regarding waste minimization. Given that the Black Sea is an inland sea where natural water circulation cannot be maintained, the likelihood of being affected by terrestrial-origin pollutants is very high. Therefore, it is necessary to urgently cease discharges and avoid using surface waters as final disposal sites for wastewater. Table 2 presents the ratio of municipalities with sewer networks in Black Sea coastal cities relative to the total municipal population.

Table 2. Percentile Municipal Population Served by the Sewerage Network in Black Sea Coastal Cities.

Year	Provinces	Artvin	Giresun	Ordu	Rize	Samsun	Sinop	Trabzon
2010		86	75	69	81	83	94	76
2012		87	77	71	82	83	95	77
2014		91	80	55	82	69	96	80
2016		91	81	79	81	78	98	80
2018		91	83	70	82	77	95	87
2020		92	85	73	81	78	92	89
2022		94	86	75	82	83	92	90

According to TurkStat (2022a), 77.7% of the municipal population resides in municipalities equipped with wastewater treatment facilities. Figure 10 illustrates sewage discharge from Black Sea coastal cities into the sea.

Table 3. Wastewater Management Data for Black Sea Coastal Cities (modified from the environmental status reports of the provinces 2022-2023).

Province	Discharged into the receiving medium ($m^3.year^{-1}$)	Discharged into the sewer system ($m^3.year^{-1}$)	Urban Reuse ($m^3.year^{-1}$)	Industrial Reuse ($m^3.year^{-1}$)	Environmental/Ecological Reuse ($m^3.year^{-1}$)	Water supply to another facility ($m^3.year^{-1}$)	Other Reuses ($m^3.year^{-1}$)	Total ($m^3.year^{-1}$)
Sinop	2294.510	52290		267795			10.45%	2614595
Samsun	77132.447	1370.776	-	901215	182050	-	-	79586956
Ordu*	-	-	-	-	-	-	-	-
Giresun	14191759	16605		1522379	2100	-	-	15716238
Trabzon	4423710	231410	-	836288	-	-	15.9%	41905666-
Rize	40152713	32379	-	1628.144	92430	-	-	
Artvin	3798443	2400	5400	620272	-	-	14.14	44265515

** No recorded information found.*

For instance, Artvin lacks wastewater treatment facilities, whereas, in Giresun, urban wastewater undergoes only physical treatment before being discharged into the Black Sea at specific points. Additionally, since 2022, the wastewater infrastructure system in Sinop, which was previously under planning and implementation, has transitioned to a separate system by 11%. In Trabzon, urban wastewater is released into the surrounding environment, specifically along the Black Sea shores, through physical treatment processes.

Waste Disposals

Sustainability is a fundamental principle of waste management, aiming to minimize waste production, recover waste, and dispose of waste without harming the environment. An analysis of cities along the Black Sea coast from

2010 to 2022 indicates that the proportion of the municipal population receiving waste services in all provinces generally exceeded 90% (see Tables 4 and 5).

In this context, "waste service" encompasses waste collection, accumulation, transportation, and final disposal. In contrast, "sustainable waste management" begins with minimization and includes processes integrating waste into the circular economy, such as recycling and recovery. Urban solid waste data for cities along the Black Sea coast are presented in Table 4.

Table 4. Municipal waste services statistics for Black Sea coastal cities, 2022 (TurkStat, 2022).

Province	Total municipal population	Total number of municipalities	Number of municipalities providing waste services	Population of municipalities served by waste services	Rate of the municipal population served by waste services in total municipal population (%)	Amount of waste collected (Tonnes)	Amount of waste per capita (kg/capita-day)
Türkiye	*80 785 141*	*1391*	*1389*	*80 319 403*	*99.4*	*30 283 757*	*1.03*
Artvin	107 965	9	9	107 965	100.0	61 276	1.55
Giresun	325 647	24	24	316 154	97.1	110 881	0.96
Ordu	763 190	20	20	717 497	94.0	224 191	0.86
Rize	250 776	18	18	247 307	98.6	71 662	0.79
Samsun	1 368 488	18	18	1 312 802	95.9	397 195	0.83
Sinop	139 531	9	9	138 787	99.5	62 942	1.24
Trabzon	818 023	19	19	812 248	99.3	213 415	0.72

In Turkey, the per capita waste generation is approximately 1.2 kilograms per day. When considering the national population and the waste quantities of cities within the Black Sea region alone, it becomes evident that these amounts differ significantly from those presented in Table 4. The total waste generated in the country is estimated to be approximately 87,550,000 kilograms per day. The discrepancies between the data in Table 4 and the provided values can be attributed to the lack of accurately recorded data and a comprehensive database.
Modern waste management encompasses practices aimed at waste minimization and the economic recovery of waste. Wastes not included in these activities are subjected to final disposal methods, such as regular storage and incineration. An examination of the data for the year 2022 reveals that the total amount of collected waste was 30,283,757 tons (TurkStat, 2022). The quantities disposed of through recycling and regular storage facilities are presented in Table 5. Methods of disposal of solid waste, according to the Turkish State Statistical Institute's 2022 database, are shown graphically in Table 5.

Table 5. Quantities of Waste Disposed in Recovery and Regular Storage Facilities.

Disposal/Recycling activities	**Years**	
	2020 (tonnes)	2022 (tonnes)
Landfill	77,762,423	80,996,500
Incineration	570,980	449,532
Compost	127,046	120,096
Energy generation	1,298,579	3,154,270
*Other recycling activities	47,642,204	48,462,778
Total	127,401,232	133,183,176

**Identifies facilities that recycle waste materials such as metals, plastics, paper, minerals, and similar substances.*

Urban solid waste has undergone energy recovery through the incineration of 3.2 million metric tons in co-incineration facilities. Additionally, 120,000 metric tons of waste have been recovered in composting facilities, while other recovery facilities have processed 48.5 million metric tons of materials, including metals, plastics, paper, and minerals. In waste disposal and recovery facilities, out of the 133.2 million metric tons of waste processed, 81.4 million metric tons were disposed of, and 51.7 million metric tons were recovered (TurkStat, 2022). The recovery rates of packaging waste from Black Sea coastal cities are presented in Table 6.

Table 6. Recycling Rates of Packaging Waste in Black Sea Coastal Cities.

Province	Total Packaging Waste	Recycled Packaging Waste	Recycling Ratio (%)
Sinop	713584	19755	2.77
Samsun	17842628	-	-
Ordu*	-	-	-
Giresun	3384560	3384560	100
Trabzon	-	-	-
Rize	2970241	-	-
Artvin	164222	-	-

** No recorded information found.*

Only 22% of household solid waste undergoes disposal and recycling processes, while data on the final disposal and/or recycling of the remaining 78% are lacking. Currently, recycling in Turkey primarily focuses on packaging waste, constituting approximately 20–25% of urban waste nationwide. The remaining 75–80% consists largely of organic waste—approximately 50%—which, although representing a significant proportion at the provincial level, lacks consistent management across all provinces. Therefore, it is necessary to expand recycling practices and ensure their implementation across all provinces.

CONCLUSION

- The Black Sea coastline exhibits a notably high population density and extensive coastal utilization, intensifying pressure on these areas. The coastal cities along the Black Sea form a large, linear urban region characterized by proximity and continuity. These cities face numerous municipal challenges, including solid waste and wastewater management, drinking water supply, unplanned adjacent development, traffic congestion, land scarcity in the coastal zone, and various infrastructural issues.
- For coastal cities in the Black Sea provinces, relying solely on resident population data is insufficient for effective planning. Excluding sudden summer population increases from planning projects leads to inaccurate outcomes in waste management, infrastructure systems, and other environmental management mechanisms. To address the challenges arising from the Black Sea Coastal Highway, it is essential to foster unity among the municipalities through which the highway passes and to develop a standard management model to tackle shared issues. The most sustainable approach to achieving this is integrated coastal zone management, which requires vertical and horizontal integration. Additionally, land reclamation alters various ecological parameters in marine coastal areas.
- Effective waste management is crucial for achieving sustainable development's economic and environmental dimensions when it is well-planned and supported by robust methods. Through a better understanding of the relationship between the environment and the economy, sustainability equates waste management with resource management in contemporary contexts. When waste is recovered, it contributes to the sustainability of natural resources and the economy by reducing reliance on raw materials. While local governments bear primary responsibility, it is imperative that individuals, households, central governments, private sector representatives, civil society organizations, and volunteer groups also actively participate in the process. In the current context, where minimizing environmental impacts and waste is critically important, adopting a zero-waste philosophy and ensuring that all municipalities manage waste from this perspective has become mandatory. Furthermore, waste minimization, which is unequivocally the least financially demanding method among treatment technologies, must be adopted by all stakeholders in coastal cities.
- In Turkey, the recycling rate for packaging materials is approximately 30%. However, a substantial portion of these recycling activities is managed by individual collectors, and this data is not officially recorded. Although the recycling of packaging waste has become more regulated and has begun to be integrated into the circular economy by delegating it to the private sector through local governments' tender systems, institutional data indicate that the issue remains unresolved. This persistence is due to an unorganized and

robust recycling market, and, as noted in the country with limited economic power, the recycling process holds particular significance in solid waste management within coastal regions (Dölgen *et al.*, 2006).

- In the process of coastal management of Black Sea, some measures may be taken to provide increase in the effectiveness of practices and bring revenue. Taxing the polluters, taxation of manufacturing process, charges to collect from various economic activities or enterprises that may harm the environment or indirect taxes to be applied on use of motor vehicles and benefiting from coasts may be some of these measures. However, it can be said that measures such as these have not yet gotten a strong foothold in the process of coastal management and still in the development stage (Yüksek *et al.*, 1995; Yılmaz, 2008; Dölgen *et al.*, 2006; Baki-Gökkurt and Ergun, 2016).
- The problems emerging in the Black Sea coastal areas cannot be effectively addressed without adopting an integrated coastal zone management approach. In Black Sea coastal cities, capacity must be enhanced while remaining aligned with the characteristics of regional and local coastal areas.

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