IMPACTS OF URBANIZATION AND TOURISM ON THE EROSION AND ACCRETION OF EUROPEAN, ASIAN AND AFRICAN COASTAL AREAS AND POSSIBLE SOLUTIONS

Huu Duy NGUYEN
PhD, Faculty of Geography, Vietnam National University, VNU University of Science, Ha Noi, Viet Nam, 10000, e-mail: nguyenhuuduy@hus.edu.vn

Walid HAMMA
Associate Professor, PhD, Laboratory of Archaeological Heritage and Its Enhancement, Department of Architecture, Faculty of Technology, University of Tlemcen, Tlemcen, Algeria, 13000, e-mail: walid.hamma@mail.univ-tlemcen.dz

Mari-Isabella STAN
Assistant Professor, PhD, Department of Administrative and Social Sciences, Faculty of of Law and Administrative Sciences, Ovidius University of Constanța, Constanța, Romania, 900470, e-mail: isabella.stan@365.univ-ovidius.ro

Van Truong TRAN
PhD, Faculty of Geography, Vietnam National University, VNU University of Science, Ha Noi, Viet Nam, 10000, e-mail: tranvantruong@hus.edu.vn

Roxana AŞTEFĂNOAIEI
Department of Marketing and Management in Tourism, National Institute for Research and Development in Tourism, Bucharest, Romania, 50741, e-mail: roxana.astefanoaiei@incdt.ro

Quang-Thanh BUI
Professor, PhD, Center of Applied Research in Remote sensing and GIS (CARGIS), Faculty of Geography, Vietnam National University, VNU University of Science, Ha Noi, Viet Nam, e-mail: thanhbq@vnu.edu.vn

Dragoş-Florian VINTILĂ
Assistant Professor, PhD, Department of Civil Engineering, Faculty of Civil Engineering, Ovidius University of Constanța, Constanța, Romania, 900470, e-mail: vdragos@univ-ovidius.ro

Quang Tuan PHAM
Associate Professor, Faculty of Geography, Vietnam National University, VNU University of Science, Ha Noi, Viet Nam, 10000, e-mail: phamquangtuan@hus.edu.vn

Cristina LIXĂNDROIU
Department of Marketing and Management in Tourism, National Institute for Research and Development in Tourism, Bucharest, Romania, 50741, e-mail: curea@incdt.ro

Quang Hai TRUONG
Professor, PhD, Institute of Vietnamese Studies & Development Sciences, Vietnam National University (VNU), Hanoi, 10000, Vietnam, e-mail: haitq.ivides@gmail.com

Diana-Doina ȚENEA
Assistant Professor, PhD, Department of Civil Engineering, Faculty of Civil Engineering, Ovidius University of Constanța, Constanța, Romania, 900470, e-mail: dianat@univ-ovidius.ro

Ioan IANOŞ
Professor, PhD, Interdisciplinary Centre of Advanced Research on Territorial Dynamics, University of Bucharest, Bucharest, Romania, 050663, e-mail: office@cicadit.ro

Abstract. Coastal areas are very important due to the ecosystem services provided to the inhabitants. However, these advantages have resulted into an increasing attraction, especially in the recent centuries. The human pressure determined numerous impacts on the ecosystems and ultimately on the safety and welfare of the coastal inhabitants, aggravated by the consequences of the global changes. The present study aims to explore two particular impacts, erosion and accretion, based on statistical data and unpublished studies, in an effort to increase the awareness towards the fact that the issue has a global extent. In addition, possible solutions are examined. The results indicate that erosion and accretion are present in all the three countries examined, and their extent tends to increase. Our findings suggest a need to act urgently; the phenomena need to be stopped first using engineering solutions, but a careful planning is needed in the long run, especially through restrictions meant to stop the "derogatory planning". Last but not least, the conservation of fragile ecosystems by including them in natural protected areas is a possible solution.

Key words: accretion, erosion, land cover and use changes, civil engineering, urban sprawl, wetlands

1. Introduction

The coastal areas are under pressure from economic and human growth (Allen et al., 1999; Gkoltsiou and Terkenli, 2012). According to the World Bank, the tourist industry will be the leading sector of economy in 2030 (Hwang and Lee, 2019; Manzoor *et al*., 2019), accounting for around 20% of the worldwide GDP. The tourist activities bring jobs, commerce and an understanding of other cultures in the world. However, tourism growth can negatively impact the environment and lead to conflicts in different sectors (Colavitti *et al*., 2018). The attraction of the coastal areas for humans in general and tourist activities in particular leads to degradation of the environment in these areas.

The attraction of the coastal areas on humans resulted also into adverse outcomes. Although the coastal areas are dynamic and complex adaptive systems (Nicholls *et al*., 2007; Newton *et al*., 2012), they are among the most ecologically critical and threatened ones (Salm *et al*., 2000; Mee, 2012). The human presence in the coastal areas generates complex interactions of the impact drivers (Newton *et al*., 2012), in addition to the high spatiotemporal variability (Pérez-Ruzafa *et al*., 2007) and natural hazards including storms, hurricanes, and tsunamis (Yelles-Chaouche *et al*., 2009; Shepard *et al*., 2011), all together decreasing the resilience of the coastal areas (Cordes and Yezer, 1998; Mee, 2012).

Many coastal areas countries have witnessed a rapid and chaotic development (Tibbetts, 2002), and the coastal populations on each continent have grown up tremendously as the global trade created jobs and fostered economic growth in numerous competing economic sectors (Kitsiou *et al*., 2002; Parravicini *et al*., 2012; Aivaz *et al*., 2019), e.g., tourism, fisheries, agriculture, aquaculture, forestry, manufacturing, oil and gas extraction, waste disposal, marine transportation, and real estate development (Tibbetts, 2002; Buhociu *et al*., 2013a, b). Furthermore, in contrast to their high ecological value, coastal areas have been often utilized for a number of destructive and consumptive uses, not necessarily specific to them, such as ports, waste dumping, land reclamation, aquaculture ponds, and dredging for navigational channels and marinas (Lee *et al*., 2006; Vasconcelos *et al*., 2007). Last but not least, climate change increased sea level and coastal erosion (Mimura and Nunn, 1998; Antunes do Carmo, 2018), contributing to the degradations of coastal areas (Hildebrand, 2013; Diop *et al*., 2014), and constituting, together with the rise of sea level, the main obstacle to their maintenance and extension in the ocean space. Human pressure has changed the physical and ecological characteristics of coastal areas across time (Apostol and Gaceu, 2011; Mee, 2012; Kara, 2019), and the fast urbanization and economic development of coastal areas resulted into complex resource-use conflicts and environmental degradation problems (Chua, 1993).

In the recent years, the international scientific community has highlighted the problems posed by the decline of coastlines in the world. The pressures of human activities on coastal areas are grouped into two types, direct and indirect (Richardson, 2012). For the first, waterproofing the soil in the process of urbanization and building infrastructure leads to the loss of soil functions, considered one of the most threatening degradation processes in the world. This has a significant influence on coastal areas around the world where urbanization and tourism are growing faster. This growth shows an increasing trend (European Environment Agency, 2006b; Wilby and Perry, 2006). Indirect pressure is described as the type of undesirable actions against the natural systems, for example domestic and industrial discharges that influence the structure of the coast (Richardson and Ternes, 2011; Brausch *et al.*, 2012).

The urban pressure affects the seas and oceans health, by accelerating the population increase, by the new economic and especial industrial and transport activities, which require a permanent monitoring of coastal areas, and building of sustainable marine infrastructures (Wiltshire, 2017). In such conditions, a key priority is to conserve the urban area and the newly-created shorelines (Lai *et al.*, 2015) by the means of ecological engineering, which could find solutions for limiting the action of natural hazards (Boştenaru Dan, 2006, 2018; Boştenaru Dan *et al.*, 2014). It is clear that the rapid urbanization of the coastal areas complicates the future development of local communities, due to high disorder induced in a very fragile ecological environment (Zhou *et al.*, 2014).

The literature analysis exhibits different drivers of urbanization; if government policies account for urbanization in China (Müller, 2007) and Vietnam, tourism urbanization is the way in which tourist cities and towns envelop significant parts of coastal Europe and the United States (Mullins, 1991; Dolana, 2018). The pressure of urbanization is greater in the coastal areas due to their attractiveness, and results into the impacts discussed before (Cicin-Sain and Belfiore, 2005; Newton *et al.*, 2012; Hildebrand, 2013; European Environment Agency, 2006a).

Regions and governments have sought for solutions to the degradation of coastal areas. Their management is made more difficult by the fact that the resources on which such communities rely for their social, cultural, and economic well-being are subject to a mix of jurisdictions, i.e., municipal, provincial, and federal (Bowen and Valiela, 2001). The coastal management embraces engineering and socio-economic aspects (Turner, 2000; Pranzini *et al.*, 2015). The first protection structures described in the literature are dikes, rip-raps and detached breakwaters, followed by seawalls, revetments, then detached breakwaters, beach dewatering, surfing reefs, beach nourishment, and dune stabilization (Mimura and Nunn, 1998; Nicholls *et al.*, 2007; Shepard *et al.*, 2011; Pranzini *et al.*, 2015). Although the technical solutions are similar due to the limited type of available material, the variety of physical, political, economic and cultural attributes along the different coasts around the world has led to different national management approaches to coastal protection (Pranzini *et al.*, 2015).

There are several widely used approaches: (1) the integrated coastal management, a set of standards and principles devised in response to coastal environmental degradation (Turner, 2000; Tibbetts, 2002; Cicin-Sain and Belfiore, 2005; Pranzini *et al.*, 2015); (2) the coastal protection ecosystem service, defined as the natural defense of the coastal zone against inundation and erosion from waves, storms or sea level rise (Liquete, 2013); (3) coastal eco-engineering through vegetated coastal ecosystems (Fritz and Blount, 2007; Duarte *et al.*, 2013); and (4) establishment of protected coastal areas (Stan *et al.*, 2013), which allow users to become actively involved in planning and management (Tundi Agardy, 1994; Martínez *et al.*, 2007), but can generate additional conflicts (Petrişor, 2016;

Petrişor *et al.*, 2016). In general, all solutions must account for the variation of temporal and geographical scales (Mee, 2012) and engagement of the stakeholders (Newton *et al.*, 2012).

The new forms and intensities of tourism activities, due to the high demands, especially for exotic areas, have modified the natural configuration of the coastal areas (Nitivattananon and Srinonil, 2019). A rapid urbanization has accompanied the tourism activities, so that today we are witnessing a continuously built space (cities and resorts) alongside of the entire seaside of the attractive isles and gulfs. This built space has become less resilient to extreme climate phenomena, which destroy through floods and coastal erosion the technical and social infrastructures. The increasing of protection costs and higher and higher frequency of such events ask for rethinking the urban planning of coastal areas (Ayatac *et al.*, 2018; Isa *et al*, 2020).

At the same time, the coastal cities have a complex economy, including industrial activities (oil refining, machine building, metallurgy etc.), and a generous physical infrastructure. In such conditions the main challenge is to find solution for a sustainable reconciliation between coastal urbanization and quality of ecosystem services (Baird, 2009; Mora-Garcia *et al.*, 2020). This implies the depiction of the real ecological, economical, social, and cultural values, and their integration in the equation of developing the coastal areas through an effective dialogue between government, companies, NGOs, and local communities (Bai *et al.*, 2015).

This study aims to integrate the results of several research projects and previous dealing with the urbanization of coastal areas with information on its impacts and possible solutions derived from the literature or unpublished research. We specifically emphasize that carrying out new analyses on the effects and potential solutions is beyond the scope of research, but their results are an absolute requirement for deriving planning recommendations, and for this reason the results of other studies need to be integrated.

2. Materials and methods

Spatial tools such as the Geographical Information Systems (GIS) allow for the management of large amounts of spatially related information and the ability to integrate and analyze multiple layers of information (Pourebrahim *et al.*, 2011). In the study of coastal areas, the use of GIS has provided a receptacle for scattered data from diverse sources and an improvement of the visualization of such data (Kitsiou *et al.*, 2002), but at the same time the lack of available research prevented its use for all case studies.

The relationship between the urbanization and erosion processes in the Romanian coastal areas are much differentiated from one place to another, taking into account the local influences of tourism-related buildings, hydro-technical works made to protect some segments of the coastline, harbor technical constructions, works aimed at decreasing the sediment amount and other natural phenomena (Maximov *et al.*, 2008). The most important changes on the coastal circulation are due to drastic human interventions: the building of huge industrial platform from Midia, of the harbor aquatorium Midia-Navodari, of the Constanța Port development, and the impact of Danube-Black Sea Canal. Permanent reduction of Danube sediments and the buildings of lot of dikes protecting the beaches have induced an alternation between small protected sectors and high eroded others (Gâştescu, 2005; Romanescu *et al*., 2018).

The elaboration of the Master Plan for the protection and rehabilitation of the Black Sea coastal areas carried out the analysis of the changes of the coast, which allowed for identifying the critical points of coastal erosion (Halcrow Romania, 2012). Immediately after, a special project supported by the European Commission through the European Maritime and Fisheries Fund, titled "Cross-border Maritime Spatial Planning for Black Sea – Bulgaria and Romania", coordinated by the Romanian Ministry of Public Administration and Regional Development, was implemented in order to carry out geospatial analyses related to the degradation of the Romanian (and Bulgarian) coastlines, and propose adequate measures for stopping the environmental degradation and start the rehabilitation works. The article also includes results of these previous projects, which were not published before, in order to provide overall figures on the extent of the erosion process.

Previous studies have investigated the erosion problem in Vietnam. However, the relationship between erosion and the growth of urbanization and tourism has not been analyzed. For this reason we have integrated data from a national project for the development of sustainable tourism in coastal areas, coordinated by the Institute of Vietnamese Studies and Development Sciences, developed with the aim of analyzing geospatial data related to tourist developments and urbanization in the coastal areas, and their relations with the degradation of the Vietnamese coasts, in order to propose appropriate measures for the sustainable development of tourism and protection of the environment.

The urbanization is analyzed via the index of urbanization, linked to the construction of holiday homes, and tourism growth, via the tourism development index linked to the increase in the number of visitors.

In Algeria, statistical data were analyzed for the entire coast and in detail for each coastal department in order to make a comparison which indicates the driver of land use change. The study of the degradation of coastal areas also involved an analysis of accretion and marine erosion during the periods 1989-1999 and 1999-2009, taking into consideration the rocky or sandy coastal nature, and whether the department has a gulf or not. The information was gathered from the report on the National strategy for the integrated management of coastal areas in Algeria, in particular its diagnostic part, drafted by the Ministry of Spatial Planning, the Environment and the City.

The consequences of degradation were studied from an economic, social and environmental point of view. The economic part focused on the identification of economic entities, agricultural activity and fishing in the northern departments in order to understand their development or regress. Another analysis tackled with the density and movement of the population between the coastal cities and those in the interior of the country. For the environmental consequences, an analysis looked at the quality of beach water in 2008, 2009, and 2011, based on a physical and chemical analysis performed by the National Observatory for the Environment and Sustainable Development. The statistics on the discharge of industrial and wastewater, the management of solid waste, the consumption of drinking water (in particular the development of seawater desalination stations), and the morphological change of wetland cover were also used in the analysis; data on environmental statistics comes from the Technical Department in charge with Regional Statistics and Cartography. Another analysis focused on the pressure exerted by tourists on the Algerian coast, based on data on the official and illegal accommodation capacity for the year 2009, and on the 2011 policy of the State, from the Ministry of Tourism and Handicrafts.

3. Results and discussions

3.1. Degradation of the Romanian shoreline

3.1.1. Accretion and erosion

Along the Romanian coastline, the withdrawal of the shoreline has taken place at a rapid pace, especially in the last decades. Previous studies (Filip *et al.*, 2016a, b; Halcrow Romania, 2012; Marsplan, 2020a, b; Stan, 2014; Stan *et al.*, 2014a; Stan *et al.*, 2019) showed that the Romanian coast was in a serious state regarding the extent of erosion (about 60-70% of the length of the shore).

In the Danube Delta Biosphere Reserve, the shoreline has lost in the last 35 years, more than 2400 ha (about 80 ha / year), while the accumulations were only 200 ha (about 7 ha / year). The coast has withdrawn on various distances from one sector to another, with values between 180 and 300 m, among which the maximum withdrawal exceeded 400 m at some points. The critical points of coastal erosion, presented in Fig. 1, were identified as part of the elaboration of the Master Plan for the protection and rehabilitation of the Black Sea coastal areas (Halcrow Romania, 2012). Later, the project *"Cross-border Maritime Spatial Planning for Black Sea – Bulgaria and Romania"* (Marsplan, 2020a) identified the areas where erosion and accretion occur (Fig. 2).

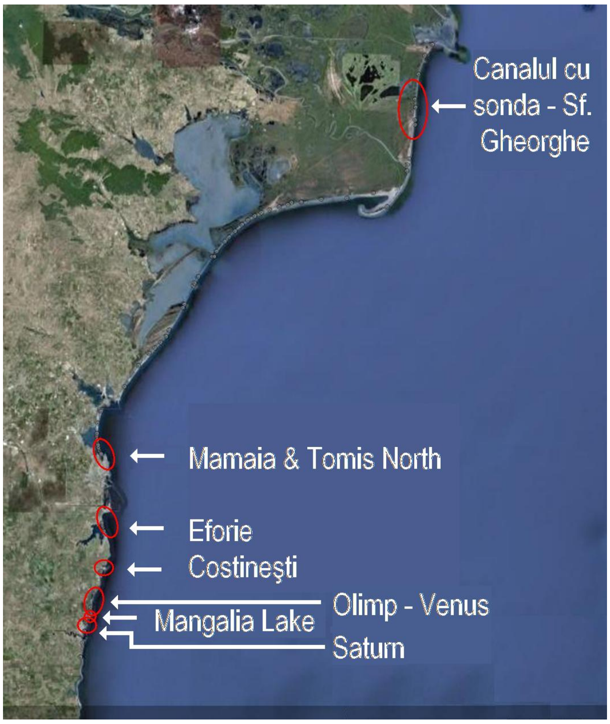

Fig. 1. Critical areas of the Romanian coastline. Adapted from the Master Plan for the protection and rehabilitation of the Black Sea coastal areas (Halcrow Romania, 2012).

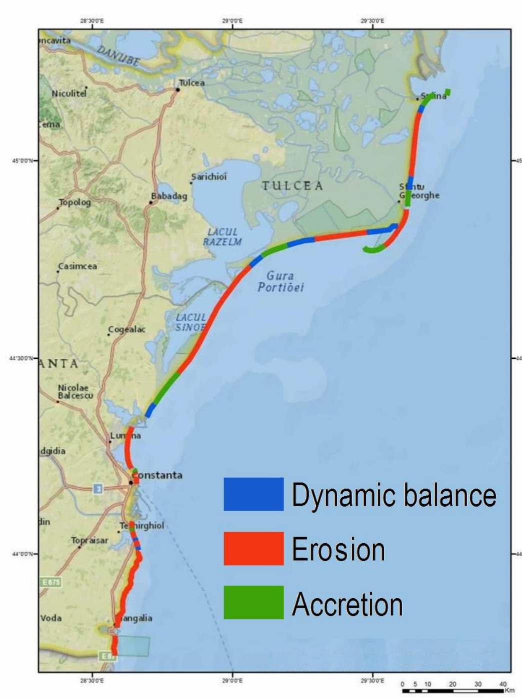

Fig. 2. Accretion, erosion and dynamic balance across the Romanian coastline. Adapted from the project "Cross-border Maritime Spatial Planning for Black Sea – Bulgaria and Romania" (Marsplan, 2020b).

Understanding the coastal erosion process requires an insight into all the natural and anthropic factors that interact along the shoreline (Stan, 2014). The results indicate that the erosion processes are determined by the *major human activities* in the coastal and sea areas (Maximov *et al*., 2008). The use of coastal land triggers the main threats posed by man, such as the coastal urbanization as a result of the concentration of buildings very close to the sea (mostly vacation homes); the development of uncontrolled tourism and recreational facilities with an increased pressure on the ecosystems, which leads to habitat loss; the destruction of the natural protection of the shore (dunes, etc.); hydro-technical constructions, such as the sea sand extensions in the ports, which resulted into the loss of coastal areas; increased risk of water pollution in residential areas (Breenner *et al*., 2019), despite the improvement of municipal wastewater treatment plants; and the development of maritime transport and activities in the coastal areas, including uncontrolled recreational activities in the Danube Delta, generating the discharge of significant quantities of waste on the seabed and beaches (Marsplan, 2020b).

3.1.2. Consequences of the degradation (economy, society, environment)

The Romanian coastal zone is subject to different anthropogenic pressures. The southern part is characterized by a high level of urbanization (Constanța city). Its effects on the coastal areas, especially the erosion of beaches, are determined by the development of civil constructions (residential complexes, neighborhoods of vacation homes, extension of old and historical buildings) and constructions with different destinations (commercial, administrative, social-cultural, industrial) with the development of the related infrastructure in the tourist areas (Stan, 2014).

The erosion of beaches and cliffs leads to the loss of territory, but especially to irreversible effects on the coastal marine ecosystems and the socio-economic and environmental value of the coastal areas, which brings significant damage to the national economy and compromises the sustainable development goals assumed by the national policies.

3.1.3. Solutions for stopping the degradation

According to the study developed in activity 1.1 of the first MARSPLAN-BS project, the Romanian southern coast is built on several types of coastal constructions, including extended hydro-technical structures designed to protect the tourist beaches and urban settlements against the impact induced by human activities and maritime navigation works or port extensions (Marsplan, 2020a).

The coastal protection approach consists of designing and implementing the measures resulted from a series of "hard" and "soft" structural rehabilitation solutions introduced by coastal engineers, aimed to provide solutions for the integrated management of the coastal zone (Văidianu *et al.*, 2020). For the coastal protection, a large number of technical solutions against the coastal erosion are used along the Romanian shoreline: offshore breakwaters, coastal transversal breakwaters, detached breakwaters / jetties, groynes, sea walls, stepped seawall, etc. (Stan and Vintilă, 2006, 2016; Stan *et al.*, 2014a, b).

Between 2013 and 2015 the works were completed on the southern part of the Romanian Black Sea coast, in five areas, namely Mamaia Sud, Tomis Nord, Tomis Centru, Tomis Sud and Eforie Nord, and aimed to create a coastal protection system against erosion. This project allowed for reducing the coastal erosion in the most exposed risky areas of the Black Sea coast by implementing appropriate structural and non-structural prevention measures for the protection of 7.3 km of beach. In 2018, the financing contract for the project "Reduction of coastal erosion Phase II (2014-2020)" was signed; the project will carry out works to reduce the coastal erosion for the following sectors: the coastal areas (between Stăvilar Periboina and Stăvilar Edighiol) and southern area of the coastal zone, respectively Mamaia Centru and Mamaia Nord, up to the limit of Năvodari, Agigea, Eforie Center, Eforie Sud, Costineşti Sud, Mangalia (Olimp, Neptun, Jupiter - Venus, Saturn, Mangalia), 2 Mai, Tomis Port, to Constanța Port at Balta Mangalia. These measures are necessary to protect and improve the quality of the environment and the life standards along the Romanian Black Sea coast, as well as to increase the safety in the south coast, seriously threatened by coastal erosion.

3.2. Degradation of the Vietnam shoreline

3.2.1. Erosion and accretion

Similar to other coastal countries, coastal erosion has become an important issue in Vietnam, resulting in a degradation of coastal ecosystems and an imbalance in the living conditions of population (Le *et al*, 2014). In the studies of erosion, there is an ongoing debate on the relative influence of natural and human factors (tourism development and urban growth) on the coastline erosion. Human activities, such as the construction of dike networks, dams, reservoirs in mountain area and urban amenities, coastal tourism (Strady *et al.*, 2017; Vu, 2014), extraction of river bed aggregates and replacement of protective mangroves by shrimp farms (Besset *et al.*, 2016; Kustanti, 2019), as well as the climate change-related effects including sea-level rise and increased frequency of storms, typhoons (Do *et al.*, 2012; Yasuhara *et al.*, 2016) are important drivers. Some researchers have analyzed the dynamic of the coastline in relationship to the natural and human factors, such as the study of Le *et al.* (2014), aimed at evaluating the erosion of the Vietnam coastline and determining of the causes of erosion. The results show that the causes include rising sea levels, poor erosion management, over-exploitation of natural resources in the coastal areas, and mangrove deforestation. In addition, other works, such as the study of Do *et al*. (2012) on the Red River Delta from 1930 to 2001, indicate that the dynamic of coastlines is influenced by a rate of accretion on the estuaries of about 100 m per year, and even stronger in the Hai Hau area (Nam Dinh province). The causes are the tropical conditions that determined the Red River to produce a significant amount of sediments. However, the sediment supply has been very uneven, i.e., increased in the estuaries, causing accretion in this region. An uneven distribution of sediments causes local erosion on the Red River Delta coast. Erosion is caused by wave-induced sediment transport and sediment supply deficit at the mouth of rivers.

The work of Duong *et al*. (2019) examined the evolution of the coastline over 20 years in the district of Ngoc Hien (Ca Mau province) in the southern region, from 1990 to 2010, in relation to the meteorological conditions and human interventions using the Land Use Map (Landsat TM) and a questionnaire. The results of the analysis of technical and questionnaire data show that during 1990-1995 1675 ha of surface area was lost due to erosion, while about 795 ha of surface area were gained from the sea because of the accretion. Meteorological conditions and human interventions interacted to produce these changes. Although the impacts of individual factors can not be easily quantified, the most important factors driving shoreline changes are forest area depletion, watercourse dredging, and aquaculture and infrastructure development.

Nguyen *et al*. (2019) studied the shoreline dynamic during 1966-2014 based on satellite imagery of Tra Vinh Province, explaining that the coastline had an average accretion rate of about 5 to 10 m per year on the coast, and was eroded with an average rate of about 5 to 8 m per year; this is related to the many human buildings and the construction of new dike.

The erosion processes in the northern region are very complex and depend on the coastal structure and marine processes, and on human activities. Areas most affected by erosion are Tien Hai in Thai Binh and Giao Thuy district in Nam Dinh province (Do *et al*., 2012; Nguyen *et al*., 2013; Le, 2014). In addition, some regions show a more intense accretion process, e.g. Ha Long, Cam Pha, Yen Hung (Quang Ninh province) and the estuaries of the rivers Tra Ly and Ba Lat. From the satellite image analysis, during 2001-2018 the average accretion rate in this region was 18-25 m/year and the erosion rate was 15-18 m/year in the Quang Ninh province.

Table 1 shows the dynamic of the coastline in the North Vietnam region, mainly related to accretion. Much of the coast in this region was accumulated because of urban development, aquaculture etc. in this period. Fig. 3 shows the dynamic of the coastline of Quang Ninh province, which is related to urbanization and tourism, especially in the cities Bai Chay and Cam Pha, which are tourist destinations.

In the coastal areas of Central Vietnam, the erosion and accretion processes are very complicated, but erosion dominates. According to the results of the KC.09.05 project study (Pham *et al*., 2005) carried out in the central region, more than 50% of the coast is eroded over a length exceeding 1 km, while 10.6% of the coast has been eroded over more than 200 m (Table 2).

Table 1. Area of erosion and accretion in North Vietnam (Nguyen *et al.*, 2013; Nguyen, 2015).

Province	District	Erosion/ Accretion (ha)	Surface (ha)
1990-2013			
Quang Ninh	Mong Cai	Accretion	762.94
		Erosion	2623
	Hai Ha	Accretion	260.90
	Van Don	Accretion	251.16
	Cam Pha	Accretion	1218
	Ha Long	Accretion	1465.91
	Quang Yen	Accretion	1160.10
1998-2008			
Hai Phong	Kien Thuy	Accretion	501.10
	Tien Lang	Accretion	1452
Thai Binh	Thai Thuy	Accretion	641
		Erosion	88
	Tien Hai	Accretion	1593
		Erosion	64.52
Nam Dinh	Giao Thuy	Accretion	3694.51
		Erosion	256.35
	Nghia Hung	Accretion	2122.7
		Erosion	37.83
Ninh Binh	Kim Son	Accretion	517.6
	Nga Son	Accretion	139.94

In general, the average erosion rate in this region is 5-15 m/year with a maximum of 15-30 m/year, e.g. Quang Binh province, Thua Thien Hue, Da Nang etc. (Pham *et al.*, 2005). Some regions are eroded more than 100 m/year. In addition, the process of accretion has occurred in estuaries, such as the Han Estuary in Da Nang Province, the Gianh Estuary in Quang Binh Province, and the Ba Estuary in Phu Yen Province.

According to a report from the Ministry of Agriculture and Rural Development (2018), the central region includes 13 provinces with 1,700 km of coastline that were eroded 88 times with a total length of 120 km along the central coast. The province of Quang Ngai is affected more, with 27 zones totaling 35 km in length. 48 areas in the Center region with a distance of 91.6 km are considered *"erosion hotspots"* that require immediate interventions by the government. Consequently, the government has built more than 121 protective works including dikes and forests. Despite these, erosion is still occurring on the coast.

Table 2. Surface of erosion in Central Vietnam during 1993-2000 (Pham *et al.*, 2005).

Province	Erosion (ha)
Thanh Hoa	1019.5
Nghe An	1109.2
Ha Tinh	382.6
Quang Binh	349.3
Quang Tri	185.7
Thua Thien Hue	709.7
Quang Nam	790
Quang Ngai	778.8
Binh Dinh	600.9
Phu Yen	848.4
Khanh Hoa	697.9
Ninh Thuan	722.4
Binh Thuan	674.5

Fig. 4 shows the dynamic of the Da Nang city coastline; this is a highly urbanized city and a tourist destination. For this reason, Han River estuary has been accumulated because of the new sea shore. However, the shoreline was erected 7 km in the past because of typhoons, waves and currents (Le *et al.*, 2014); from the satellite image analysis, the average accretion rate in this region was 15-25 m/year during 1990-2018, and erosion was 10-15 m/year, although in the recent years the area has been relatively stable.

The Southern region is characterized by a coastal erosion common to many tropical deltas (Marchesiello *et al.*, 2019). Since the mid-twentieth century, conditions in the economy have changed and this area was affected by human activities, including soil subsidence through groundwater extraction, sand extraction, reduction of protected coastal mangroves, and development of aquaculture. According to the Ministry of Natural Resources and Environment reports and satellite imagery, shorelines in the southern region were eroded during 1940-1950, but the rates were still low. However, since the 1960s, the coasts have been eroded much stronger (Pham *et al.*, 2005), especially in the 1980's, for example the province of Ba Ria-Vung Tau (10-15 m per year), the coast of Can Gio (20 m per year), Ho Chi Minh City, Dong Hai in Tra Vinh province, Ngoc Hien, Dam Roi and Tran Van Thoi in Ca Mau province. Moreover, the process of accretion is also present in this region, which is mainly located on the estuaries of the rivers in the Mekong Delta. For example, the estuaries of Ba Sac (Soc Trang) and Ba Lai (Ben Tre province) have totally disappeared due to the urban constructions and transport network.

According to Vu (2014), during 1965-1990, most of the coast in the southern region accumulated a total area of 26011.6 ha and 12991.4 ha of erosion. Ca Mau is the province with the largest area of accretion: 8,775 ha, while the province of Ba Ria-Vung Tau and Ho Chi Minh City are eroded with an area of 397.1 ha and 123.5 ha (Table 3). During 1990-2010 period, most of the coastline was eroded, with a total area of 19530.3 ha and 13398.2 ha of accretion, mostly in the province of Ca Mau (7903 ha). Over the 20 years from 1990 to 2010, the coast of the southern provinces has continued to accumulate, but the rates are only about 1/2 (6887.9 ha) compared to the period 1965-1990.

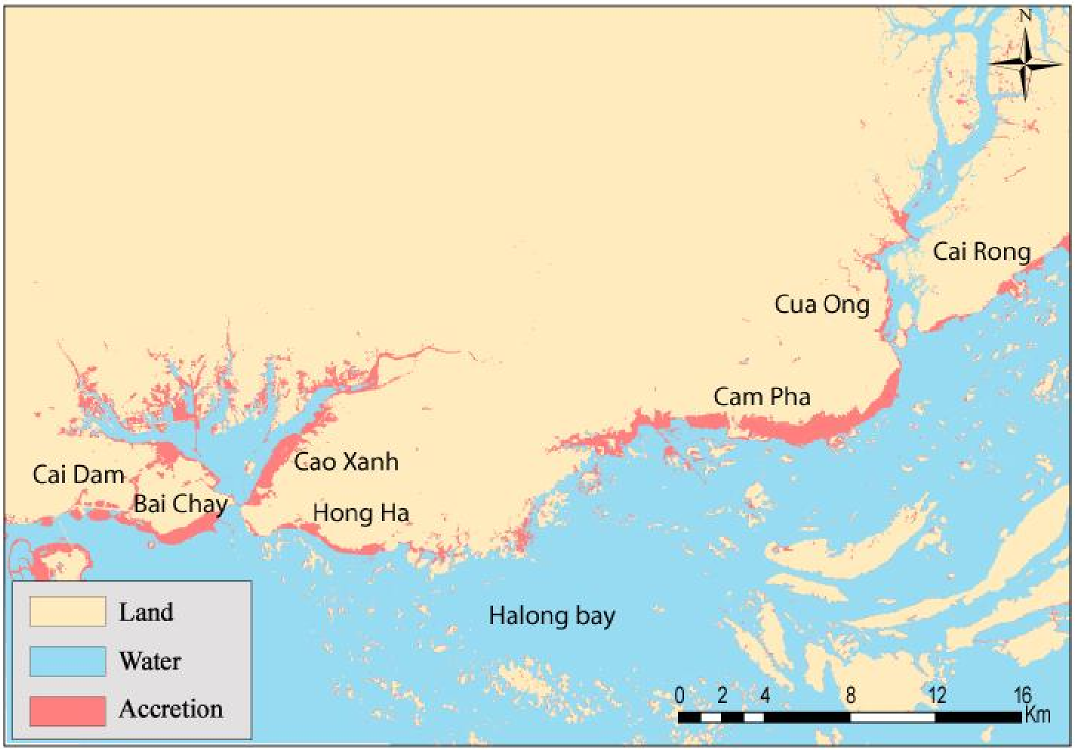

Fig. 3. Accretion in Cam Pha in Quang Ninh province, northern Vietnam during 2001-2018.

Table 3. Surface of erosion in Southern Vietnam during 1965-2010 (Vu , 2014)..

City/Province	1965-1990		1990-2010	
	Accretion (ha)	Erosion (ha)	Accretion (ha)	Erosion (ha)
Ba Ria Vung Tau	397.1	765.7	330.3	474.3
Ho Chi Minh	123.5	1212.0	468.2	711.2
Tien Giang	1591.0	1107.0	543.6	899.0
Ben Tre	3384.0	2367.0	3758.0	1330.0
Tra Vinh	2116.0	2093.0	1051.0	1088.0
Soc Trang	3321.0	1515.0	838.2	1185.0
Bac Lieu	1660.0	1391.0	775.9	1298.0
Ca Mau	8775.0	1774.0	3091.0	7903.0
Kien Giang	4644.0	766.7	2542.0	4642.0

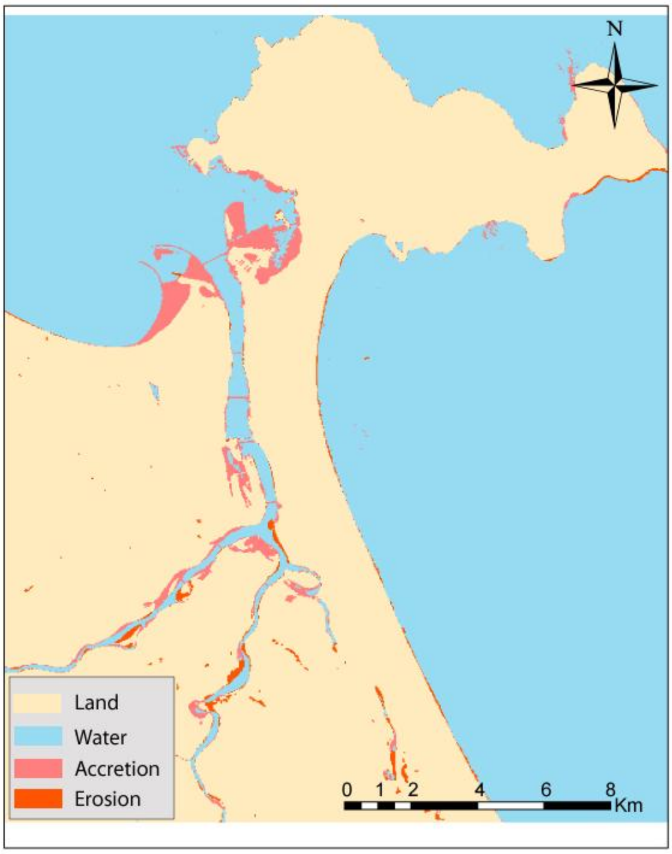

Fig. 4. Erosion/accretion of the coastline in Da Nang province, Vietnam during 1990-2018.

Fig. 5 shows the dynamic of the coastline of Ba Ria Vung Tau Province in the Southern Region. This province has 305.4 km of coastline, and was relatively stable in the past. However, from the satellite image analysis, it has been eroded with the rate of about 10 to 15m per year in the recent years, with significant impacts on tourism in this area. On the other hand, the government has laid out new neighborhoods towards the sea in the district of Rach Dua; consequently, the coastline has been accumulated in this area.

The Southern part of Vietnamese coast shows another extremely important problem for the highly populated areas. For example, in the Mekong Delta and in particularly the case of Ho Chi Minh City, the land subsidence is very consistent, accentuated by different processes, among which the most important is the extraction of groundwater (Erkens *et al*., 2015).

3.2.2. Causes of the erosion and accretion of Vietnam coastline

Coastal erosion results from a combination of many factors of both natural and human origin, operating at multiple scales of time and space (Balasuriya, 2018). Winds and storms, coastal currents, changes in the sea level in the more or less long term are the main "natural" causes of erosion phenomena. Coastal works, drying up of coastal basins, dams and irrigation works, dredging operations and clearing of coastal lands constitute the main human causes of erosion (Rameli and Jaafar, 2015). The causes that affect the nature of Vietnam's coastline are natural and anthropogenic. However, the analysis of all causes related to the dynamic of the coastline is not possible due to the time and data needed. For these practical purposes, the analysis was limited to three issues that change the shoreline.

The first cause is related to hydrological meteorological factors such as wave actions, currents, typhoons. Every year, many typhoons cause great material damage and human victims on the Vietnamese Coast (Larson *et al*., 2014). According to data from the Ministry of Natural Resources and Environment, the typhoons have been increasing in intensity and number since 2005, from 14 in 2009 to 19 in 2013 (Fig. 6). Typhoons cause many problems challenging human activities, causing damages to ecosystems and land, and eroding the coastal areas, affecting the livable area (Cong *et al*., 2019). The tides go up during the typhoon, so the effects are pushed back deeper into the continent, causing more and more damage, e.g. the destruction of infrastructures and dike. During the typhoons, the sea level can rise up to 2-3 m, e.g. the 1995 hit of Quang Ninh province, or the 2013 hit of the central region of Vietnam. Overall, typhoons increased the erosion level.

The second cause is the flat relief of the coastal zone. This area is the most developed and urbanized with economic activities that yield a high income compared to the mountain areas, mainly due to the shopping centers, services, seaports and tourism. Economic activities such as trade, fishing, and industry yield more money, in addition to rice growing. In this global context, urbanization and industrialization promote economic and population growth. The living conditions are better than those in the mountainous area. This is why the economic activities have impacts on the coastline.

In addition, human activities affect the coastline through the pressure of population, urban and tourism growth in the lagoon (Tomilina *et al*., 2016), and also constructions, dams and reservoirs, use of construction materials (sand, gravel, gravel) in rivers and streams, reducing the amount of water and sediment supplied to the coast and modifying the coastline in the Red River and Mekong Deltas, and coastal activities including mining, construction of civil engineering works, and coastal protection. For example, in the Cam Pha district in Quang Ninh province, the process of coastal erosion is stronger, especially through accretion due to urban development, tourism and mining. In the Thang Nhat commune, Vung Tau city, and Ho Chi Minh City in the south, the inhabitants expanded over the sea to develop the urban area and build the port – see Fig. 7, presenting the development of new neighborhoods over the sea in Ho Chi Minh and Ba Ria Vung Tau.

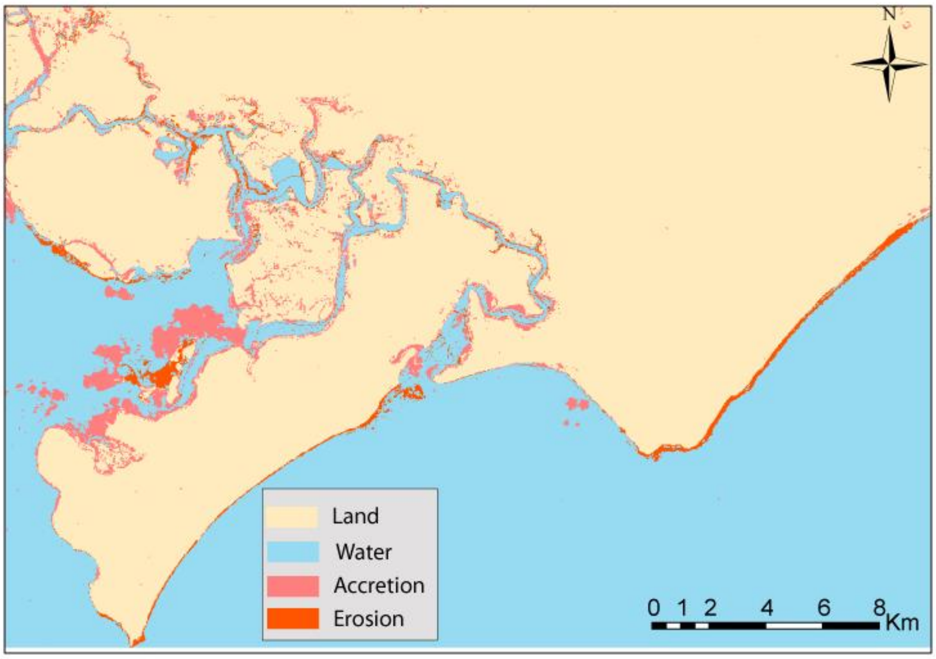

Fig. 5. Coastline dynamic in Ba Ria-Vung Tau province, Vietnam during 2008-2018.

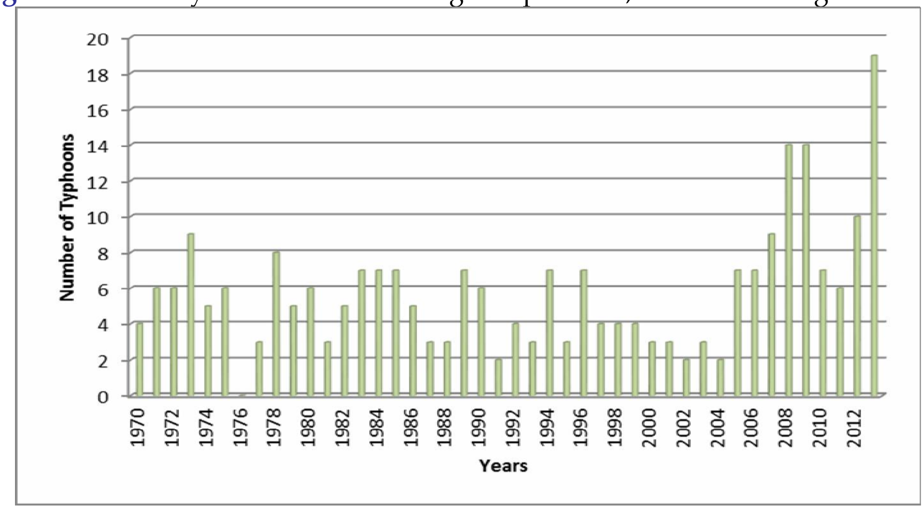

Fig. 6. Coastline dynamic in Ba Ria-Vung Tau province, Vietnam during 2008-2018.

A

B

Fig. 7. Dynamic of the coastline in Ho Chi Minh city (A) and Ba Ria VungTau province (B), Vietnam: new neighborhoods are built over the sea. Source: (A) – Google Earth (2019); (B) – Construction Department in Ba Ria Vung Tau (2019).

Mangroves provide numerous ecosystem services, including climate regulation, storm limitation and dike protection in the littoral zone (Koh *et al.*, 2018). However, mangroves have been subjected to intense exploitation and deforestation around the world. Vietnam is no exception in this regard since it saw its mangrove forests shrinking to 155,290 hectares in 2007, with a 50% decrease from 1980 (UNEP, 2007). Due to the country's renewal policy, Vietnam is engaged in a process of transition and development, while urbanization becomes stronger and coastal aquaculture develops rapidly, all leading to the destruction of mangroves. The decrease of mangrove area is related to the growth of aquaculture due to shrimp farming revenues (Tran *et al.*, 2012).

According to Phan *et al*. (2015), there is a relationship between the width of mangrove and the status of Vietnam coastline. This is why there is significant coastal erosion in some municipalities where the surface of the mangrove has been reduced, e.g. Hai Linh (Tinh Gia-Thanh Hoa), Nghi Yen (Nghi Loc-Nghe An), Thanh Trach (Quang Trach-Quang Binh), Binh Phu (Binh Son-Quang Nam) (Le, 2001), Can Trach (Duyen Hai-Ho Chi Minh City), Nguyen Huan, and Ngoc Hien (Ca Mau). For these reasons, in order to reduce the erosion, the Vietnamese government replanted nearly 53,000 ha of mangroves in 1990 as a result of Decision 286/QD-TTG and Decision 661/QD-TTG (Van *et al.*, 2015), and NGO projects rehabilitated about 14,000 ha of mangroves during 1991-2002 in Quang Ninh, Hai Phong, Ninh Binh, Thanh Hoa, Nghe An, Ha Tinh, Thai Binh, and Nam Dinh.

3.2.3. Consequences of the degradation of Vietnam coastline (economy, society, environment)

The coastal areas of Vietnam are densely populated and are very important economic regions of the country. In addition, there are many low-lying areas, for example, in the Red River Delta and the Mekong Delta, where the tide is below the sea level (Takagi *et al.*, 2015). Rising sea levels increase the amount of extreme water conditions, which translates into higher waves near the coast. All these phenomena cause coastal erosion and affect the dike systems, destruct the infrastructure of the coastal zone and cause flooding in the deltas. Vietnam is one of the countries most affected by climate changes (Thinh and Hens, 2019). According to the Government of Vietnam, if the sea level raised about 75 cm above the average level during 1980-1999, then about 20% of the Mekong Delta was flooded by tides (Government of Vietnam, 2011).

Erosion and accretion cause significant equipment, human, and environmental damage. Each year, the government assigns several budgets to fight against erosion, by building dikes in the coastal region where the density of population is high. However, every year typhoons hit the coast, causing the breaking of dikes and great human damages. In September 1955, inhabitants died due to a dike breach during a typhoon. In 2010 the typhoon that hit Hai Phong province in Thanh Hoa caused the dam to break causing significant loss to the economy, i.e., a loss of about 650 billion USD.

From an environment perspective, erosion causes the destruction of mangroves. Sediments can cause water pollution during the erosion process, with negative impacts on the beaches. In addition, sediments from coastal erosion lead to the accretion of shipping channels, e.g., in Haiphong Harbor and Hai Thinh Port in the North region. In Bach Dang estuary in the Quang Ninh Province, the volume of dredged sediment for the shipping channel is between 3 and 5 millions tons, out of which the volume due by coastal erosion is about 2 million tons.

3.2.4. Solutions for stopping the degradation for Vietnam coastline

The protection of the coastal zone plays a vital role due to the high population density and the growth of tourism in this region (Le *et al.*, 2014). From experience in the other country and Vietnam also on the prevention of erosion of the coastal zone show that it is a complicated task. This is why several projects have been carried out in Vietnam to find the requests to reduce coastline degradation in Vietnam such as project KC.09.05 on the assessment of coastline erosion in the southern region of Vietnam, or in the project of KC.09.09 / 16-20 on spatial organization, model establishment and recommendations for sustainable tourism development in the coastal areas, sea and islands of Vietnam. In general, the solicitations were divided by two main measures: Structure and non-structure (Do *et al.*, 2012; Le *et al.*, 2014).

For structural measurements, there are several solutions, such as Slope embankments, Seawall, wave- and wind-breaker (Do *et al.*, 2012; Nguyen, 2019). In addition, the Vietnamese government also protects the coast by strengthening raw materials such as gravel, pebbles, coarse sand or by planting halophilic plants. Depending on specific conditions, these solutions can be combined or combined with other solutions.

For example, the protection and development of mangroves, focusing on the coastal areas of the North and South; plant trees on land; protect coral reefs, focus on the central coast (Pham *et al.*, 2002).

In 2006 and 2009, the Vietnamese government issued Decision no. 58/2006 / QD-TTg and no. 667/2009 / QD -TTG approving the program of strengthening, protection and modernization of sea dikes in the provinces of Quang Ninh in Quang Nam and Quang Ngai in Kien Giang.

For non-structural requests, currently, the Vietnamese government has carried out the construction of a database for the management of erosion events or the development of erosion mapping in detail to the critical region to have prevention plans and control. The set up a network of periodic monitoring and surveillance of accretion-erosion to detect and alert timely application solution disasters, especially in the context of climate change.

3.2.5. Impact of tourism on the environment in Vietnam

Tourism has both positive and negative impacts on the environment. Tourism development contributes positively to preserving the environment through environmental management and land use planning related to the tourist activities. The coast of Vietnam has a diverse ecology (flora and fauna). One of the positive impacts on the ecological system of Vietnam is the preservation of the different life forms in the national marine reserves. However, according to the owners of the hotels, tourism has also a negative influence on the environment through several impacts, i.e., water pollution, change of landscapes etc.

Table 4. Erosion and accretion of the Algerian coast during the periods 1989-1999 and 1999-2009. Source: National Statistics Office of Algeria.

Department	Marine front (km)	1989-1999		1999-2009	
		Accretion (km²)	Erosion (km²)	Accretion (km²)	Erosion (km²)
Tlemcen	73	0.042	0.29	0.049	0.34
Ain Temouchent	80	0.085	0.595	0.098	0.686
Oran	124	0.044	0.399	0.048	0.437
Mostaganem	229,73	0.127	1.145	0.139	1.253
Chlef	129	0.043	0.309	0.05	0.352
Tipaza	145,81	0.149	1.343	0.172	1.548
Algiers	107	0.125	1.132	0.137	1.239
Boumerdes	80,33	0.128	1.154	0.140	1.263
Tizi Ouzou	61,43	0.018	0.164	0.02	0.182
Béjaia	110,83	0.112	1.012	0.124	1.117
Jijel	123,90	0.141	1.276	0.156	1.409
Skikda	250,19	0.219	1.975	0.24	2.162
Annaba	122,5	0.076	0.692	0.086	0.777
El Taref	90	0.038	0.346	0.042	0.379

The interviews with hotel managers show that 26% of managers believe that tourism causes environmental degradation, including pollution of maritime waters, by directly discharging wastewater into the sea.

According to Cantini *et al*. (2019), the increase of the number of tourists leads to worsening the quality of water because the wastewater treatment system is not sufficient. Wastewater pollution influences coastal resources due to the lack of suitable environmental standards. For example, Con Dao Island in Ba Ria - Vung Tau province currently produces around 72,000 tons of untreated waste. Moreover, additional 20 tons of waste is generated every day on the island and not treated, which directly threatens the lives of people and the tourist environment. 38% of the managers said that tourism destroyed the scenic beauty of the maritime area by building hotels on the beach. 36% indicated that tourism increased the urbanization, considered one of the reasons for the degradation of the coastline in Vietnam.

3.3. Degradation of the Algerian shoreline

3.3.1. Accretion and erosion

Marine erosion in Algeria is not only caused by rising sea levels, storms and sea swells, but also by the excessive extraction of sand for construction. The reduction in the solid inflows carried by the various rivers which lead to the sea which is due on the one hand to the construction of dams upstream of these rivers, and on the other hand to prolonged periods of drought.

During the period from 1989 to 1999 the accretion varies, on average, between 0.2 to 0.35 m / year and the erosion between 1.7 to 2.22 m / year (Chemrouk and Chabbi, 2016; Atroune *et al*., 2018). We can notice an increase of the accretion during the second period, 1999-2009, which varies between 0.38 to 0.56 m / year, and of erosion between 1.96 to 2.43 m / year (Table 4).

3.3.2. Consequences of the degradation of Algerian coastline: economy, society, and environment

Fig. 8 shows that the most affected departments are those with a gulf and those with sandy coastline, more than those with a rocky nature. During the first period, Skikda is the department most affected by the two phenomena, followed by Mostaganem, Tipaza, Algiers, Boumerdes, Béjaia and Jijel. The least affected departments are Tlemcen, Oran, Chlef, Tizi Ouzou and Taref, where the rocky nature of the coast is dominant. During the second period (Fig. 9), we note that the phenomena increased for all the departments. Tipaza moved to second position after Skikda in terms of the two phenomena, while, Jijel's accretion moved it to the third rank.

The northern region of Algeria is a large economic center which hosts many activities, notably industrial. In 2011, the country had 934,250 economic entities (Table 5). The coastal departments have 406,426 entities, or 43.50% of Algeria's economic infrastructure (Blake, 1974; Arnone, 1990). Algiers and Oran are the first with 10.38% and 5.66% of all the economic entities (Fig. 10). Industrial activity represents 43,162 units, or 45.22% of the national total 95,445 (Maouche *et al.*, 2009; Ghazi and Khadir, 2012; Ghodbani *et al.*, 2015, 125; Khelil *et al.*, 2019).

In the recent years and due to the pollution of the coastline by large factories and refineries, the government has decided to develop factories in the interior departments and provide benefits for industrialists (land and tax), hence the establishment of assembly plants cars in Ghélizane (Volkswagen, Skoda, Seat), Batna (Kia), Tiaret (Hyundai) and household appliances on board Bou Arreridj (Condor, Stream, Cristor, Media, Iris) and Sétif (Brand).

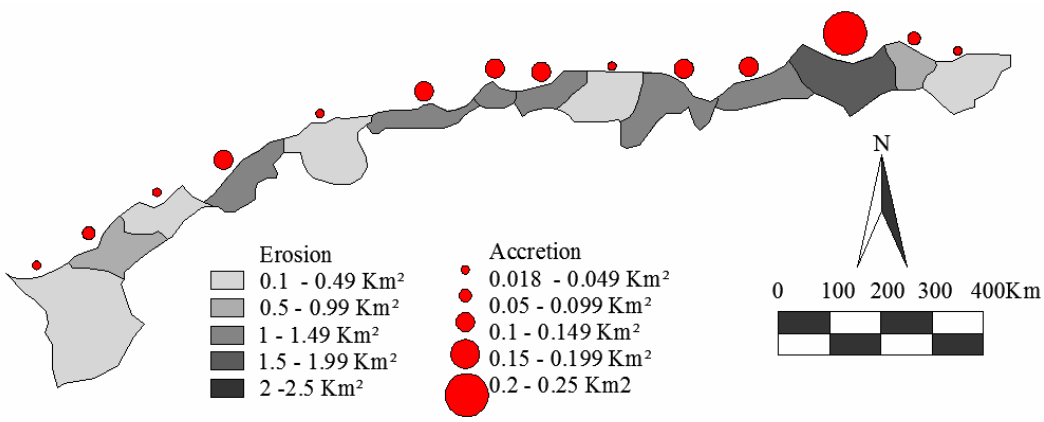

Fig. 8. Erosion and accretion of the Algerian coast during the period 1989-1999. Source: official data.

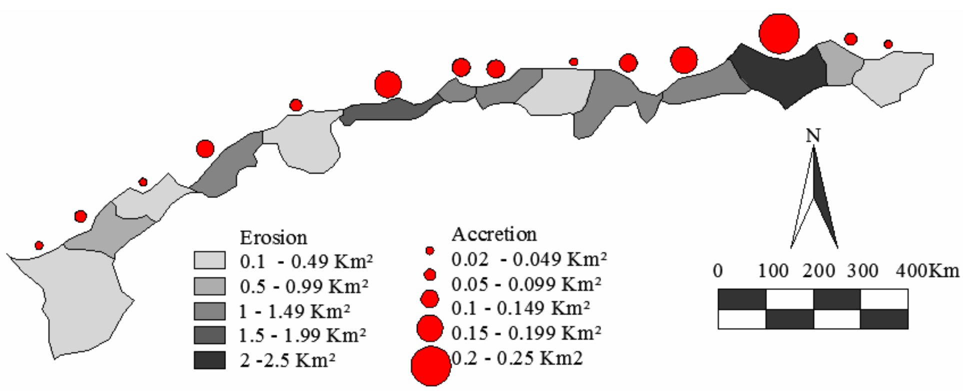

Fig. 9. Erosion and accretion of the Algerian coast during the period 1999-2009. Source: official data.

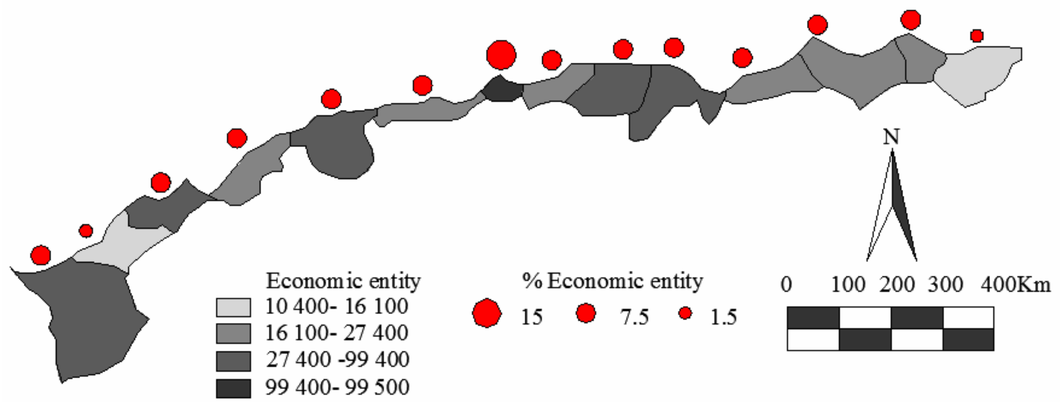

Fig. 10. Distribution of economic entities on the Algerian coast in 2011. Source: official data.

Table 5. Current number of economic entities on the Algerian coast compared to 2011. Source: National Statistics Office of Algeria.

Department	No. of economic entities	% economic entities	Construction	Trade	Industry	Service
Tlemcen	30086	3,22	222	16938	3298	9628
Ain Temouchent	10670	1,14	61	5647	964	3998
Oran	52852	5,66	530	30577	5270	16475
Mostaganem	16742	1,79	152	9722	1800	5068
Chlef	26410	2,83	239	14633	2607	8931
Tipaza	15845	1,70	147	8959	1596	5143
Algiers	97019	10,38	1048	54632	8892	32447
Boumerdes	20572	2,20	224	10529	2314	7505
Tizi Ouzou	37276	3,99	588	17363	5092	14233
Béjaia	31197	3,34	773	14384	3887	12183
Jijel	16220	1,74	116	8319	2104	5681
Skikda	21701	2,32	289	11111	2455	7846
Annaba	19608	2,10	255	10256	1917	7180
El Taref	10228	1,09	86	5263	966	3913
Overall, coast	406 426	43.50 %	4700	218333	406426	406426
Overall, national	934 250	100	9117	511700	95445	317988

Table 6. Density of the coastal population compared to Algeria. Source: National Statistics Office of Algeria.

Department	Density in 1998 (inhabitants / km²)	Density in 2008 (inhabitants / km²)
Tlemcen	93,16	104,75
Ain Temouchent	137,59	156,05
Oran	570,99	685,56
Mostaganem	290,58	338,90
Chlef	179,08	208,99
Tipaza	274,32	320,16
Algiers	3144,57	3666,44
Boumerdes	435,03	539,03
Tizi Ouzou	310,47	316,03
Béjaia	262,19	279,25
Jijel	222,34	247,17
Skikda	195,27	223,22
Annaba	387,64	423,56
El Taref	105,60	122,32
Algeria	**12,22**	**14,30**

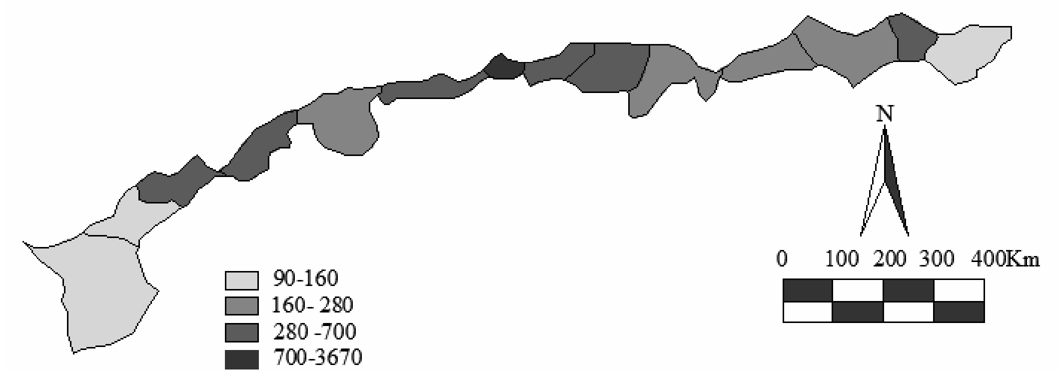

Fig. 11. Population density of the Algerian coast in 2008. Source: official data.

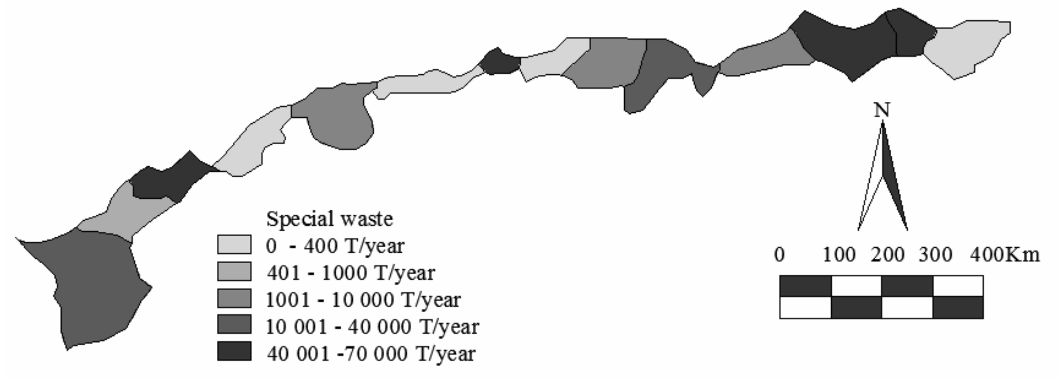

Fig. 12. Production of special hazardous waste on the Algerian coast. Source: official data.

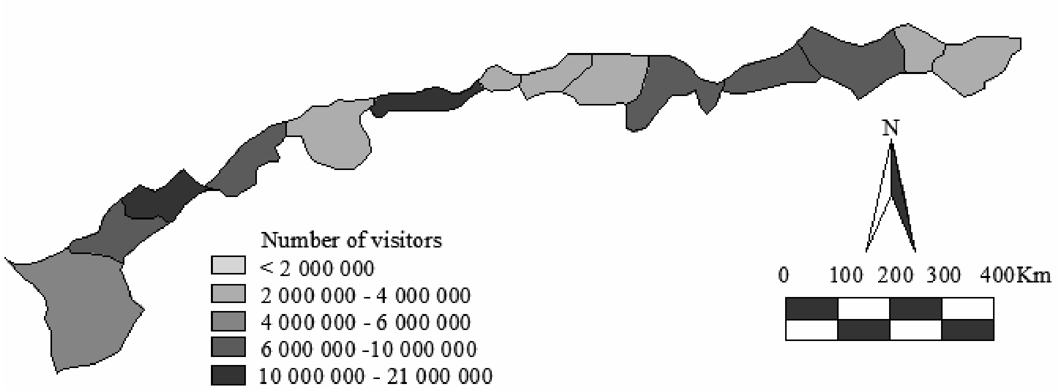

Fig. 13. Number of tourists visiting the beaches (summer of 2011). Source: using official data.

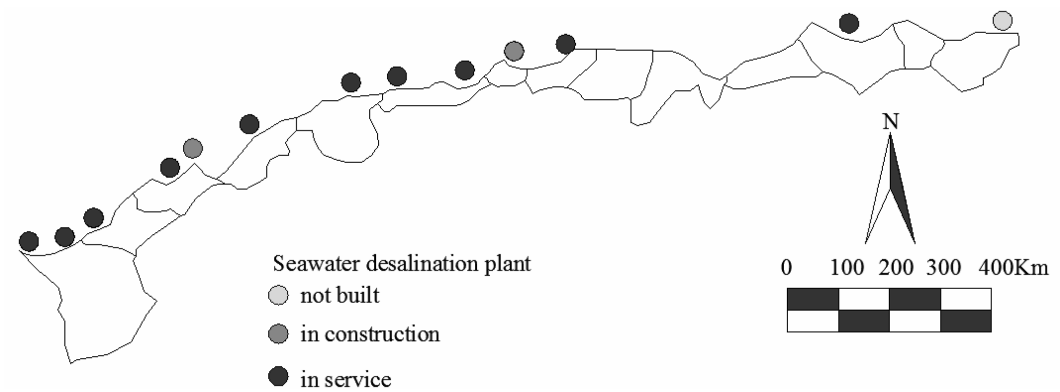

Fig. 14. Seawater desalination plant in Algeria. Source: official data.

The advance of the sea affected the economy by the disappearance of many agricultural lands located near it. This phenomenon is visible in the departments which have a gulf, such as Skikda, Béjaia, Boumerdes, Algiers, Tipaza, and Mostaganem. The most affected is Bejaia because the waves are approaching the national road and the land has disappeared over a linear distance of 35 km.The deterioration of the coastal landscape, in particular the non-observance of the easement of 300 m from the coast line, has reduced the number of tourists from certain places, increased the pollution of the marine environment and decreased the fishing income, causing all together a severe decrease of the local economy.

The strong urbanization and economic attraction pushed many inhabitants of the other interior departments and rural ones to settle in the coastal cities, causing a demographic explosion and the proliferation of precarious and illicit habitat, which caused the loss of 20% of tourist land. In 2020, 14,485,539 people live in the North (Millot, 1990; Noureddine *et al.*, 2003; Nouaceur *et al.*, 2013), or 35.71% of the total population of Algeria (40,559,735). Compared to 2008 (39.61%), the rate has dropped due to its deterioration and the privileges given by the state to the interior departments (salaries and housing), and the improvement of their infrastructure (especially highways program). The coastal departments are the most dense in the country, 281 inhabitants / km² compared to 12 inhabitants / km² at the national level (Table 6), e.g.: Algiers, the capital, with 3666.44 inhabitants / km² followed by Oran (685.56 inhabitants / km²), Boumerdes (539.03 inhabitants / km²), and Annaba (423.56 inhabitants / km²) (Fig. 11).

The environment has been greatly affected by degradation, in particular by the pollution of marine waters. Even if the number of beaches authorized for swimming increased from 323 in 2008 to 352 in 2010 (Table 7), the water quality is in decline (according to the physical-chemical analysis of the National Observatory of the Environment and Sustainable Development); 81 beaches had good water quality in 2009, and only 44 in 2010 (Millot, 1985; Kies and; Kerfouf, 2014; Mihoubi *et al.*, 2014). The number of beaches that had poor water quality increased from 0 in 2009 to 12 in 2010.

Table 7. Beaches authorized for swimming and their water quality. Source: National Statistics Office of Algeria.

Department	2008	2009	2010
Tlemcen	8	8	8
Ain Temouchent	20	20	20
Oran	31	33	31
Mostaganem	21	21	23
Chlef	22	24	25
Tipaza	44	43	43
Algier	47	54	56
Boumerdes	18	25	26
Tizi Ouzou	8	8	8
Béjaia	30	34	35
Jijel	22	23	23
Skikda	20	20	20
Annaba	19	21	20
El Taref	33	13	14
Overall coast	323	347	352
Good water quality	-	81	44
Acceptable water quality	-	18	108
Inadequate water quality	-	26	0
Poor water quality	-	0	12
Overall	**-**	**125**	**164**

The strong anthropization of the land has caused pollution of groundwater, rivers, and the sea through the direct discharge of used and industrial water without being treated. The smoke from factories and refineries has caused extensive damage to flora, fauna and human health. The twelve main generators of special hazardous waste are all located in the coastal municipalities of Algiers, Bejaia, Skikda, Annaba, Ghazaouet, Arzew and Oran (Figure 12). They alone produce 87% of waste at national level, or 282,800 t / year and hold 95% of waste in stock, or 1,905,200 t. Of the 136 coastal municipalities, 20 have a treatment plant and 116 discharge their wastewater into the sea (Kacemi, 2011; Ghodbani and Berrahi-Midoun, 2013). With regard to solid waste, 39 discharge into technical landfills and 94 into uncontrolled landfills near the sea. The population produces more than 8,684 tons of solid urban waste, evacuated to 380 dumpsites located on the coastal strip.

Table 8. Accommodation offer by type in 2009. Source: Algerian Ministry of Tourism and Handicrafts.

Youth hotels / hostels	Number of beds
Urban	57419
Seaside	16551
Saharan	10635
Thermal	3757
Climatic	332
Total	**88694**

The pressure on ecosystems is also caused by the large influx of summer visitors to the coastal areas (Figure 13), in particular the overcrowding of beaches and wild tourism (setting up tents, illegal residences etc.), since Algeria has a deficit in the supply of seaside accommodation. There were only 16,551 beds in 2009 (Kacemi, 2009; Hafferssas and Seridji, 2010; Kermani *et al.*, 2016; Hamma and Petrişor, 2018), i.e., 18% of the national capacity (Table 8). This shortcoming has prompted investors to build cabins and apartment hotels (several studios) without a building permit, in most cases, in order to rent them illegally. Some people have even rented their house or garage. These constructions have caused a degradation of the natural coastline landscape, because they are built in an anarchic manner, without an overall plan.

The accommodation offer is not balanced on the Algerian coast. Algiers has 18,954 hotel beds more than the three largest departments all together, i.e., Béjaia, Oran and Annaba, with 10,766 beds. With respect to other types of accommodation than hotels, Béjaia and Boumerdes are classified properties with 16,817 and 15,421 beds (Table 9). If we compare Table 21 and Figure 30, it can be noticed that the first two cities that exceed the 10 million summer visitors, Oran (20 million) and Tipaza (17 million), have a low accommodation capacity, which confirms that the residences compensate the deficit more or less.

In order to compensate the accommodation deficit, the Ministry of Tourism and Handicrafts has created tourist areas to allow investors to build tourist infrastructure as part of an organized development plan. Unfortunately, the occupancy rate in these areas is low and in several cases the land use has been changed to other functions (Table 10).

Moreover, fishing in the shallows, non-compliance with the market sizes of fish species, unconventional fishing and the use of non-selective fishing techniques and over-exploitation have reduced the fishing resources. The affected species are the shrimp (*Aristeus antennatus*, *Parapenaeus longirostris* and *Penaeus kerathurus*) which have diminished their populations, and the monk seal, that has disappeared (Ghodbani, 2005; Djouder and Boutiba, 2017).

The excessive consumption of drinking water and drought has prompted the state to build many seawater desalination plants (Figure 14). The departments of Tizi Ouzou, Béjaia and Jijel are not affected because they have a high rainfall and supply the other interior departments.

The uncontrolled urbanization of the coastline has caused a significant morphological modification of the land, construction of buildings in the flood zones and on steep slopes, which have caused important landslides and floods. The greatest disasters occur in coastal departments such as Algiers, Béjaia and Annaba (Ghodbani, 2010; Ghodbani and Semmoud, 2010).

Marine erosion and the illegal and abusive removal of building materials, particularly sand, have reduced the surface of beaches and sometimes caused their disappearance, and, in addition, the degradation and partial or total disappearance of the dune cords.

Table 9. Accommodation offer in the Algerian coast in 2011. Source: Algerian Ministry of Tourism and Handicrafts.

Department	Number of hotels	Number of beds in hotels	Accommodation (other structures)	Number of beds (other structures)
Tlemcen	45	3.311	12	2.625
Ain Temouchent	17	2.286	21	6.452
Oran	143	5.636	14	5.636
Mostaganem	16	-	34	8.783
Chlef	12	601	22	6.203
Tipaza	9	2.714	30	8.770
Alger	153	18.954	4	1.500
Boumerdes	17	3.169	35	15.421
Tizi Ouzou	60	1.393	-	-
Béjaia	61	4.022	42	16.817
Jijel	52	2.124	27	5.879
Skikda	31	2.027	24	8.200
Annaba	40	4.048	8	1.290
El Taref	20	1.615	17	2.350
Overall	**676**	**51.900**	**290**	**89.926**

Table 10. Occupancy rate of tourist areas in 2011. Source: Ministry of Tourism and Handicrafts.

Department	Number of zones	Surface in hectares	Occupancy rate	Remaining area
Tlemcen	9	549.05	39%	428.50
Ain Temouchent	10	1901.00	9%	1799.50
Oran	9	1727.00	19%	1505.35
Mostaganem	16	4724.80	7%	4485.79
Chlef	10	1691.50	9%	1799.50
Tipaza	22	1950.00	19%	1456.29
Alger	13	2737.75	58%	1562.38
Boumerdes	11	4738.00	37%	3408.57
Tizi Ouzou	8	1973.00	11%	1832.67
Béjaia	14	1254.50	12%	1134.34
Jijel	19	4232.00	42%	3150.44
Skikda	9	2082.00	17%	1673.74
Annaba	5	2436.00	14%	2187.18
El Taref	5	5010.00	2%	4902.50
Overall	**160**	**37006.60**	**21%**	**31094.45**

Deforestation had a negative effect on the environment of the Algerian coast, notably the rise in temperatures and the upsetting of ecosystems. It is caused by fires; nearly 100,000 ha of coastal forests and scrub have been subject to forest fires over the past decade (2001-2011) (Yelles-Chaouche, 1992; Snoussi and Tabet Aoul, 2000; Rabehi *et al.*, 2019). This constitutes almost half of all the forests in the national territory which were affected by fires during the same period.

3.3.3. Solutions for stopping the degradation of Algerian coastline

The fight against degradation involves mastering urbanization, but also limiting the anthropization of coastal lands. This can be done by improving the urban planning tools (Petrişor and Meiță, 2017) and involving the stakeholders and citizens in all phases of planning. Algeria must also put to an end the derogatory urban planning (Hamma and Petrişor, 2018), which allowed for building sized in general 4 floors to be built up illicitly. A compact city may help preserving the soil.

The preservation and protection of the natural and cultural resources of the Algerian coastline involves the creation of marine and protected coastal areas (Saadaoui *et al.*, 2018), the construction of dikes, the construction of seawater desalination stations, the monitoring of fishing, the protection archaeological, architectural and underwater heritage. Strengthening the impact assessment on the environment and the cultural heritage will limit further degradation.

There is a need for improving the human and material resources of different national observatories, in particular the national coastal police station. This will improve the collection of information, expertise, monitoring, intervention and monitoring of each coastal protection action.

The fight against pollution must take place through the construction of new technical landfill centers, waste recycling centers and wastewater treatment plants, and also by improving the waste collection and permanent beach maintenance.

There is a strong need for establishing good coastal and maritime governance and raising the awareness of all actors in society to protect the coastline. Strengthening the role of NGOs and establishing coastal preservation laws, along with its enforcement, might also help. There is also a need for promoting sustainable tourism and renewable energies. Finally, all these require the creation of a special coastal protection fund.

4. Conclusions

Each case study has provided significant insights. Vietnam is one of the countries most affected by climate change, especially since 2005, when the number of storms has increased together with their effects, causing human and economic damages, and increasing the coastal erosion. Within the framework of the 2020 national strategy for disaster prevention and mitigation, strengthening the cooperation with international organizations developing climate change-related programs and dealing with the management of coasts and estuaries in order to strengthen the administrative management capacity to reduce the coastal change are an absolute requirement (Rusu, 2019).

In Algeria, climate change caused an increase of the sea levels, which caused severe marine erosion, and resulted into the loss of many beaches and agricultural land. Accretion is very low on the Algerian coast, because the amount of sediments deposited by the many rivers decreased due to drought and the diversion of rivers through the construction of dams. The economic consequences of this deterioration include the decrease in agricultural activity in certain regions, a decrease of fishing revenues and the relocation of certain industrial activities to inner cities. From a social point of view, some cities suffer from the outcomes of a high population density, especially those with a high concentration of economic entities. The environmental quality was also affected by the discharge of waste and industrial water into the sea, the depositing of solid waste in illegal landfills, the over-consumption of drinking water, fires, deforestation, morphological modification of the soil, disappearance of certain marine species, and the encroachment of plant species. These degradations are also caused by the pressure of tourist activities, especially the construction of illegal residences.

Although Romania has a very short coastline of the Black Sea, the complexity of land-sea interactions is very high due to different natural and anthropic factors, and coastal condition. First of all, any territorial analyst can notice the opposition between the northern and southern parts of the Romanian Black Sea coast with respect to the urbanization and degradation of coastal areas. The Northern part is dominated by natural dynamics, especially after 1991, when the Danube Delta became a Biosphere Reserve. Despite a very low urbanization (although a century ago Sulina city, for example, played a European role for the navigation on Danube), the current degradation processes are connected in a large share with the effects of hydro-technical works done along the Danube and in its hydrographic basin. The multitude of dams on Danube and its tributaries drastically reduced the amount of sediments, which had maintained the equilibrium of land-sea interactions. The alternation between large eroded beach segments and small ones, where the coastline advances, equally attract the interest of scientists and planners. Even if the European and Romanian legislation try to protect the Danube Delta (Stan, 2013), the pollution due to agriculture and industrial activities, especially with heavy metals, affects natural fluvial and marine ecosystems. The Southern part of the Romanian Black Sea coast is strongly affected by urbanization (Petrişor, 2010, 2012; Petrişor *et al*., 2010, 2014, 2020a, b). The construction of the Danube – Black Sea Canal and the increasing role of Constanta port, serving the entire Central Europe, accelerated the demographic increase of the whole urban system alongside of the sea. The anthropic activities were amplified by industrial activities, oil exploitations on the continental shelf, oil refineries, and maritime transport. The pollution generated by these activities, especially during the transport and industrial accidents, poses a real danger for the local communities, but especially for tourism during the summer season. In order to protect beaches and cliffs against erosion, protective dikes have been built between Navodari and Vama Veche. The specific infrastructures to facilitate the transport from the Black Sea to Central Europe, using the

Danube-Black Sea canal and its branch (to Midia refinery) have modified the original configuration of the coastline. This part of Romanian Black Sea coast is the most attractive area for tourism during the summer. For instance, there is a balance of industrial, urban, and tourism activities, but there are signs of incompatibilities between them, which implicitly reduce the sustainability of coastal areas. A new administrative framework can play an important role in harmonizing these activities, by defining compatibility limits and developing appropriate physical infrastructures. In more detail, the future functional Metropolitan area will allow for developing joint projects for all administrative units, which now operate independently. Otherwise, local decisions may accentuate the degradation of coastal areas due to overpopulation and increasing diversity of incompatible activities in some areas.

Acknowledgements

The Romanian case study has been partially supported by the European Commission through the European Maritime and Fisheries Fund, Cross-border Maritime Spatial Planning for Black Sea – Bulgaria and Romania (MARSPLAN-BS II), EASME/ EMFF/ 2018/ 1.2.1.5/ 01/ SI2.806725-MARSPLAN-BS II and the University of Bucharest project UB-2008 "*Trans-scale analysis of the territorial impact of current climate change and globalization*". The Vietnam case study has been supported by the Vietnam national project "*Scientific rationale for spatial organization, model establishment and recommendations for sustainable tourism development in the coastal areas, sea and islands of Vietnam*" (grant number KC.09.09/16-20).

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Received: 12 August 2020 • **Revised**: 8 September 2020 • **Accepted**: 18 September 2020