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Land – Sea Interaction in Eforie Study Case

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ABSTRACT. Eforie-North-Eforie South is a complex area, with hight touristic potential and natural values which have contributed to the development of important tourist resorts. In the north part of Eforie North sector is developed the Sputh sector of Constanta Port.The Eforie case Study is aimed to follow the land-sea interactions with a special focus on coastal erosion. The study is challenging to emphasize the interactions, conflicts and impacts between stakeholders and uses, both terrestrial and marine domain paying particular attention to – identification of main uses and natural risk (coastal erosion) and their impacts on the natural, social and economic environment (ex. urban and port development tourism), stakeholder involvement and recommendation and solution for key issues and conflict resolution.

KEYWORDS. DIRECTIVE 89/EU/2014; Black Sea; Maritime Spatial Planning; Romania; Bulgaria; marine monitoring; Eforie North and South; coastal erosion; stakeholders.

I. INTRODUCTION

The Eforie Case Study was undertaken by the National Institute for Marine Research and Development "Grigore Antipa", Constanta, Romania, as part of the EU co-funded project on cross border maritime spatial planning in the Black Sea, Romania and Bulgaria (MARSPLAN - BS).

The Eforie Case Study is aimed to follow the land-sea interactions with a special focus on coastal erosion within Eforie shore sector, thus identifying the impact of induced coastal erosion by built environment and port infrastructure on maritime space including the management of coastal zone (ICZM) and tourism activities. Suitable solutions for the harmonization of the tasks related environmental protection, mainly biodiversity conservation of all surrounding lakes, wetlands and effective use of natural resources have been identified. The study is challenging to emphasize the influence of the coastal erosions on the interactions and impacts between activities, sectors and interests, both in the terrestrial and marine parts.

II. GEOGRAFICAL COORDINATES, GENERALITIES AND DATA

The case study sector is located in the southern Romanian littoral (Figure 1), occupying a central position within it. The sector has a length of ~ 10 km, bounded to the north by Cape Agigea and to the south by Cape Tuzla. In administrative terms it is part of the SE development region, Constanta County, and at level of local administrative units (LAU) it overlaps entirely on Eforie town and partially on Techirghiol (Techirghiol Lake), Agigea and Tuzla local administrative units.

From the geomorphological point of view, it is included in the central - southern part of the littoral which is characterized by the presence of cliffs cut in loess and Sarmatian limestone, interrupted by a few short coastal belts barring old river coasts. The relief has the appearance

of a flat surface, slightly sloping towards the sea, where it ends with a high cliff of 15-30 m and 20-150 m wide beaches. The middle sector, linking Eforie North and Eforie South, around 2 km, corresponds to the coastal belt between the sea and Techirghiol Lake.

The regional climate is temperate continental moderate, with strong Black Sea influence, due to the location of the land extended out into the southern Dobrogea region, which induces a strong thermal inertia and a status of instability, cause of strong winds, waves, variability of temperature and salinity and vulnerability to coastal erosion.

The hydro-physical characteristics of Eforie Bay are a principal factor inducing the hydro-chemistry of the region, biochemical processes and marine organisms' behavior, and vessel loads design as well. Southern currents of Eforie Bay are influenced anyway by wind variability, N, NE and E, and by the marine/rim current, which is anticlockwise. The local coastal currents are also affected by marine obstacles such as dikes orientation and Danube river inputs.

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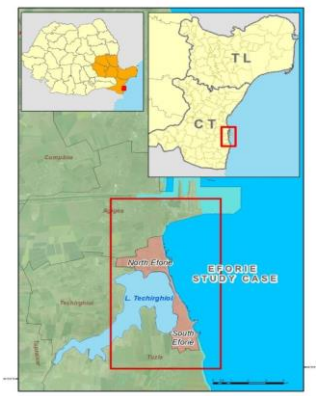

Figure. 1. Geographic position of Eforie in Romania

Figure. 2. Map of natural values (SCI under Habitat Directive, SPA under Birds Directive, Ramsar Wetland convention)

III. ECOLOGICAL FEATURES

Eforie North - Eforie South is a complex area, with diverse natural habitats (marine, fresh, brackish and very salty waters) which have contributed to the development of important tourist resorts. In the north part of the Eforie North sector is the Danube - Black Sea Channel and Agigea Harbor, as an extension of the Constanta Harbor.

Three MPAs are situated in the study case area (Figure 2).

- **ROSPA0076 Black Sea:** site of Community importance, according to the 79/409/EEC Birds Directive, directly nominated Special Protectiona Area for birds - SPA - 147,242.9 ha; 10 bird species in Annex 1 of the Birds Directive; 20 migratory species listed in the Appendices of the Convention on Migratory Species; 2 globally endangered bird species.
- **ROSCI0197 - Submerged beach from Eforie North - Eforie South** - 141 ha; it is the only beach not affected by anthropogenic impact. It hosts three habitats of Community interest (1110 - Sandbanks which are slightly covered by sea water all the time, 1170-Reefs and 1140 - Mudflats and sandflats not covered by seawater at low tide). It is the only place in Romania where there are significant populations of the bivalves *Donacilla cornea* and *Donax trunculus*.
- **ROSCI0273 - Marine area from Cape Tuzla** - 1,738 ha; Natural Habitats: 1110 - Sandbanks which are slightly covered by sea water all the time, 1170-Reefs and 1140 - Mudflats and sandflats not covered by seawater at low tide.

Both Eforie sites also preserve unique species and protect two mammalian species of Community interest (*Phocoena phocoena relicta* and *Tursiops truncates ponticus*) and two fish species of Community interest (*Alosa tanaica*, *Alosa immaculata*), added to other rare species with economic value (beluga, sturgeon, garfish, mullet, mackerel, sprat, etc.).

IV. ECOLOGICAL CARACTERISTICS

The baselines of the economy area of interest is the tourism potential, provided by the proximity of the Black Sea, the existence of accommodation and catering, the presence of natural lake with therapeutic unique properties with international resonance (Techirghiol), which facilitated the development of spa tourism. Eforie has an intense tourist activity that generates economic growth year after year, representing a successful open door to the world. Another traditional economic direction is represented by port activity. The seaport, Constanta South Agigea, rank the 4th place in Europe, a veritable gateway to the world, annually an impressive amount of goods being transited through them, in both ways. Port activity is complemented by a diversity of opportunities offered by the Danube-Black Sea Canal and Constanta shipyard (Figure 3).

Regarding the **primary economic sector** (obtaining and refining raw materials), in Eforie activities concerning **agriculture** (26 ha agriculture land, of which 22 ha arable land and 4 ha orchards and nurseries and 6 ha waters and swamps) and **fishery** (aquaculture and fisheries) were reported (2014).

There are different types of fishing gears for the active and passive fishery practiced in the inshore and offshore coastal fishery in the Eforie sector:

- Passive fishing gears include the equipment for catching in general the fish migrating for spawning and feeding in shallow waters, namely: long lines and bottom lines, gillnets for the Danube shad, turbot, mugilidae and gobies, sea pound nets.
- Active fishing gear: beach seine, beam trawl, pelagic trawl.

Marine aquaculture in the Black Sea area is a relatively recent developed and is still not widespread. At present, in Romania, the only private company dealing with the culture of the Black Sea mussel *Mytillus galloprovincialis* is located in the Eforie sector (SC Maricultura Ltd.). The farm consists of 10 long-line system structures. The company can obtain a maximum 150 tones/year of mussel prouction. 2002 was the first year for the marketable production: about 100 t mussels and 1 t oysters. For future is planned a demonstrative mussel center to be developed in Romania for the whole Black Sea, as was established at the last GFCM-WGBS meeting (Working Group for the Black Sea of the General Fisheries Commission for Mediterranean).

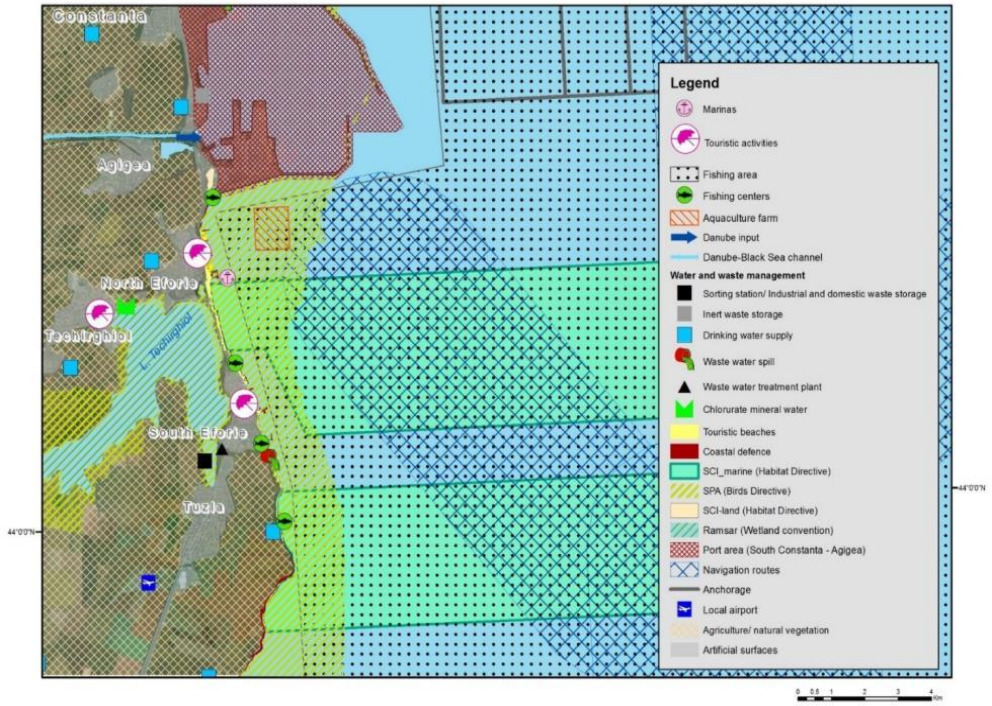

Figure. 3. Uses of marine and coastal space in Eforie area

The secondary economic sector is represented mainly by constructions - generally private funds, dominating by buildings for residential purpose and trade.

The main threats for the Eforie marine and coastal area were identified as follow:
- **Coastal urbanization**, mainly as a result of *population concentration*, *holiday houses*, *uncontrolled tourism development* and *growth of recreational activities*. The uncontrolled development has negative effects on the marine environment and landscape and it increases the pressures on the coast and on the ecosystem, which lead to the loss of habitats ultimately.

- The population in Eforie increased since 2002 from ~ 9,500 inhabitants to ~11,000 inhabitants due to migration from the main urban center (Constanta) and urban development of the city by building new houses. In the last 20 years, the city expanded with more than 30%, being focused on residential and tourism development related to the coastal strip in close proximity of the Black Sea or Techirghiol Lake.
- Added to the strong erosion pressure, the urban development of coastal strips reduce the coastal strength and can cause the destruction and fragmentation of habitat by illegal constructions, changing currents and sediment dynamics, but also through pollutants and wastewater discharges during construction and during operation of these buildings.
- The number of tourists has increased with pronounced seasonality resulting in a concentrated impact during summer months when the population grows in the area several times.
- The high density of tourists on the beach can cause nutrients or chemical pollution, direct destruction of shellfish populations by trampling, generation of non-degradable dangerous wastes (plastic bags).

- Pollution is one of the most critical problems in this case due to the development of the urban center. The uncontrolled disposal of the solid waste and sewage discharge have a negative impact on the quality of sea water taking into account that seawater recovery time is slow and the consequences on the marine environment are obvious. The Eforie area is currently served by one wastewater treatment plant located in Eforie South, with mechanical and biological treatment facilities, rehabilitated in 2010-2015 (maximum capacity of 745 liters second), compared with 2010, with only mechanical treatment and discharged directly into north of Cape Turcului Bay.

- Increasing the impact on the environment - in the Eforie zone there are three Natura 2000 sites (two under Habitats Directive and one under Birds Directive). Coastal protection works, beach nourishment, the increasing demand for space for touristic activities, nautical sports, new constructions - mainly holiday houses, increasing port traffic negatively influenced the functions of natural habitats and species.

- More than 1.2 km of shore was already subject to coastal protection works (more than 1 km of new or rehabilitated dams/dikes and beach nourishment) witch impacts on the marine habitats and species/aquatic ecosystems through morphological change, physical parameter change, pollution, change in sediment composition etc. For the next years the coastal protection works will extend to another 4.5 km, including the Natura 2000 site **Eforie submerged beach (ROSCI0197),** which is the only place in Romania where there are significant populations of the bivalves *Donacilla cornea* and *Donax trunculus*.
- In 2014, the Port of Constanța (Figure 4.6) handled a total traffic of 55,641,910 tones (54,763,130 long tons; 61,334,710 short tons) of cargo and 668,293 twenty-foot equivalent units (TEU). According to the NSI, ~ 32 million tons of goods where transported in the maritime sector transportation by the end of 2010 and the traffic increased to more than 50 - 60 million tones until 2014, part of the traffic being represented by ores, coal and crude oil and oil products, and chemical products.

- Decrease of biotic resources together with the alteration of key **ecological processes**;

Marine fish populations are shared natural resources for the Black Sea countries. Romanian coast has an open continental underwater platform wich is area of fish migration, feeding and breeding. The marine fishery was the most affected sector by the dramatic changes produced in the Black Sea ecosystem, due to freshening and terrestrial impact, habitats degradation, feeding sources diminishing and over-fishing, including in Eforie area, adding climate changes.

- Increasing environmental and other risks due to climate change and sea level rise - increasing of extreme storms, coastal erosion, increase of seawater temperature, changes of salinity and biological diversity reduction.

Anthropogenic activities that impact the coastal zone resulted in a substantial reduction of the sediment flow system on the Romanian seaside. This severe reduction of sediments led to coastal erosion and retreat of the shoreline since 1850, rapidly accelerating in the past four decades.

The Eforie area is affected by erosion of beaches and cliffs degradation. Analyzing the maps from different periods together with current measurement (GPS and aerial photos), it was found that the shore has retreated about 40 - 50 m in the last 75-100 years.

Infiltration of surface water to the clay and direct wave abrasion on the base of the cliffs caused the shore erosion, in parallel with the gradual collapse of the cliffs. This land loss threats locals and tourists and the stability of the buildings located at the top of the cliffs, thus preventing the socio-economic development of the entire area.

The rate erosion in Eforie is variable along the beach, averaging 0.5 m/ year, depending on the presence of coastal protection works (Figure 4). This means that, without coastal protection works, buildings in the vicinity of the beach, several major hotels and commercial buildings, will be degraded or destroyed in the near future.

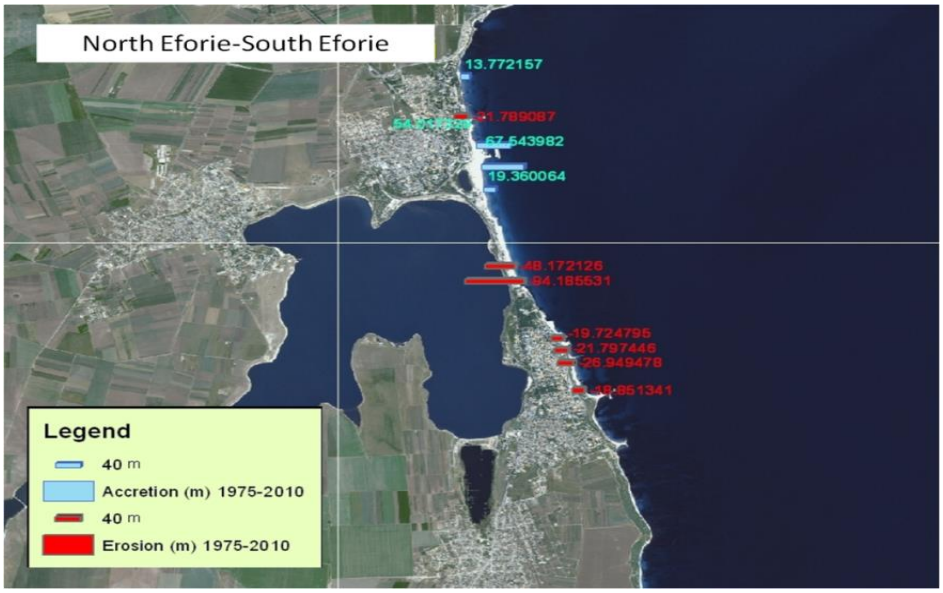

Figure. 4. Shoreline changes in the last 25 years

The erosion processes caused the decrease of the beach width corresponding to the Techirghiol coastal belt, especially in the southern sector (Sanatorium area), where there were withdrawals approx. 50-60 m in the period 1981-present.

The coastal belt was heavily affected since 1990 - present due to human activities - the dunes were destroyed by buildings erected on the beach.

After 1990, the need for space for new constructions, especially private homes and small accommodation units, resulted in city expanding, especially in the area near the sea. Several buildings appeared in the area adjacent to the Lake Techirghiol sector, which gradually destroyed the dune system. The constructions were carried out at less than 100 meters from the shoreline, in some cases even less, and are heavily damaged during storms.

In order to reduce the risks from coastal erosion, a **strategic coastal Master Plan for Coastal Protection** was elaborated in 2011 to protect the environment from erosion risks in the most affected areas. Feasibility Studies, Strategic Environmental Assessment and Environmental Impact Assessment for four priority areas, followed by the Master Plan, the first phase of priority projects was executed in 2014-2015 in Mamaia, Coonstanta, Eforie North. The coastal protection works achieved in Eforie: rehabilitation of dikes/groynes perpendicular to the shoreline with more than 500 m, construction of new break-wave dikes parallel to the shore - 675 m, artificial nourishment of beach on 1.2 km, over one million cubic meters of sand (Figure 5 a.b).

The conflict between activities for coastal protection (sand nourishments) and touristic navigation and port activities is very clearly emphazised in the case of the Belona Marina, a small port, originally a sheltered area for boats used for the extension of the Constanta-Agigea port jetties. Due to its placement at small depths, the inner part of the marina is filled by the adjacent sediment deposits drived by waves and currents. This unsuitable location is giving lot of problems for fishing and small recreation boats, due to the formation of a bar at the port mouth.

Figure. 5. a.b. Eforie North before and after coastal protection works (2015/ 2016)

The matrix of conflicts was analyzed and quantified by means of the GeoReference Interactions Database (GRID) appositely developed in the framework of the COEXIST project. The maritime activities identified for the analysis are organized in five main categories of uses: maritime transport, tourism; fishery and aquaculture, environmental protection, coastal defense and military use (Figure 6).

Uses	Coastal constructions	Coastal protection	Harbors	Navigation routes	Anchorage	Urban residues	Urban development	Dumping	Pelagic trawl	Stationary uncovered pounds	Pots and traps	Set gillnet	Manual rapana harvesting	Mussel farm	Natura 2000 sites	Refurbish beaches	Ship wrecks	Beach tourism	Recretional diving	Nautical sports	Marinas	Recretional fishing	Military areas
Coastal constructions		0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	0	2	0	0	0	0	0
Coastal protection	2		2	3	3	0	0	0	0	0	0	0	0	3	5	3	0	3	0	1	3	0	0
Harbors	3	3		3	0	5	0	0	0	0	0	0	0	2	6	0	0	5	1	1	3	3	0
Navigation routes	5	0	0		0	0	2	1	5	5	5	5	2	3	3	0	0	0	1	3	2	1	3
Anchorage	0	0	0	0		0	2	1	5	5	5	5	2	3	6	0	2	2	1	3	3	2	3
Urban residues	0	0	0	0	0		0	0	0	0	0	0	0	4	6	0	0	5	5	5	2	5	0
Urban development	0	0	0	0	0	0		0	0	0	0	0	0	2	6	0	0	5	0	0	5	0	0
Dumping	3	3	3	3	3	3	3		3	3	3	3	3	3	6	2	4	1	4	2	2	2	3
Pelagic trawl	4	4	4	4	4	4	4	3		4	4	4	4	5	3	0	4	0	1	0	0	1	5
Stationary uncovered pounds	4	4	4	4	4	4	4	3	4		4	4	4	5	3	0	3	0	5	0	0	5	5
Pots and traps	4	4	4	4	4	4	4	3	4	4		4	4	5	3	0	5	0	5	0	0	5	5
Set gillnet	4	4	4	4	4	4	4	3	4	4	4		4	5	3	0	3	0	5	0	0	5	5
Manual Rapana harvesting	5	5	5	5	5	5	5	3	5	5	5	5		5	3	0	3	0	4	3	0	4	5
Mussel farm	3	3	3	3	3	3	3	3	3	3	3	3	3		3	0	4	0	5	5	5	5	5
Natura 2000 sites	5	5	5	5	5	5	5	3	5	5	5	5	5	5			3	5	2	3	2	3	6
Refurbish beaches	2	3	3	0	2	0	0	0	0	0	0	0	0	0	3		0	5	0	0	2	0	0
Ship wrecks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0		0	4	2	0	3	4
Beach tourism	5	3	5	0	2	0	0	0	0	0	0	0	0	0	5	5	0		0	2	0	2	2
Recretional diving	1	1	1	1	1	5	5	2	1	5	5	5	5	5	2	0	4	0		2	0	2	4
Nautical sports	1	3	3	3	3	5	5	2	0	0	0	0	3	5	3	0	2	0	2		2	2	4
Marinas	3	3	3	2	3	2	5	2	0	0	0	0	0	5	2	0	0	0	0	2		0	3
Recretional fishing	0	0	3	1	2	5	0	2	1	5	5	5	4	5	3	2	3	2	2	4	0		2
Military areas	0	0	0	3	3	0	0	3	5	5	5	5	5	5	6	0	4	2	4	4	3	2	

Figure. 6. Interaction matrix of the human activities carried out in the coastal area of the Eforie case study obtained through the GRID WebGis application; red squares: conflicts; green squares: synergies; white squares: no interaction. The level of interaction is scored between 0 and 6.

Important conflict in the area:

- fishing and aquaculture; and commercial and touristic navigation; for continuous and seasonal intervals, respectively,
- military operations, with all other activities and uses, during winter and spring trainings,
- the incompatibility between MPAs and all sort of activities in the area, respectively, in order: protection works/activities, tourism and navigation, aquaculture and fisheries,
- often opposite activities represented by housing, also, including the coastal protection, and architectural landscape arrangement, forgotten in many Eforie's areas,

- conflict between social-cultural activities and mass-tourism and its aggressive commerce, often in associated during summer time with noise pollution,
- social impacts of mass tourism is becoming a wide-spread problem in the whole coast.

The stakeholders consultation, realized through Sketch Match planning method, was a necessary objective to priorities problems, to identify land - sea interaction, to score conflict among uses.

The Sketch Match is a method that is used to identify and visualize potential development paths and so facilitate the decision-making process for managers, policymakers and local stakeholders. The general objective was to identify necessary elements for the elaboration of the development plans along the coastline of Eforie North and South, aiming to find potential solutions for integrating protective measures for coastal areas in the Maritime Spatial Planning context.

The workshop was organized in 2 groups with the following topics: natural capital & spatial planning and socio-economic development.

The results presented by each group gave an overview of the problems and potentials of the area to our main topic: Eforie North and South coastal area. Further, the SWOT analysis for the pilot case was done (Figure 7) together with the layers resulted from stakeholder drawn on prepared maps representing the areas they considered important for economic development and spatial planning, the vulnerable one in terms of biodiversity and socio-economics (maps of natural values, activities and uses). The information analyse was made by DDNIRD Tulcea and NIMRD Constanta.

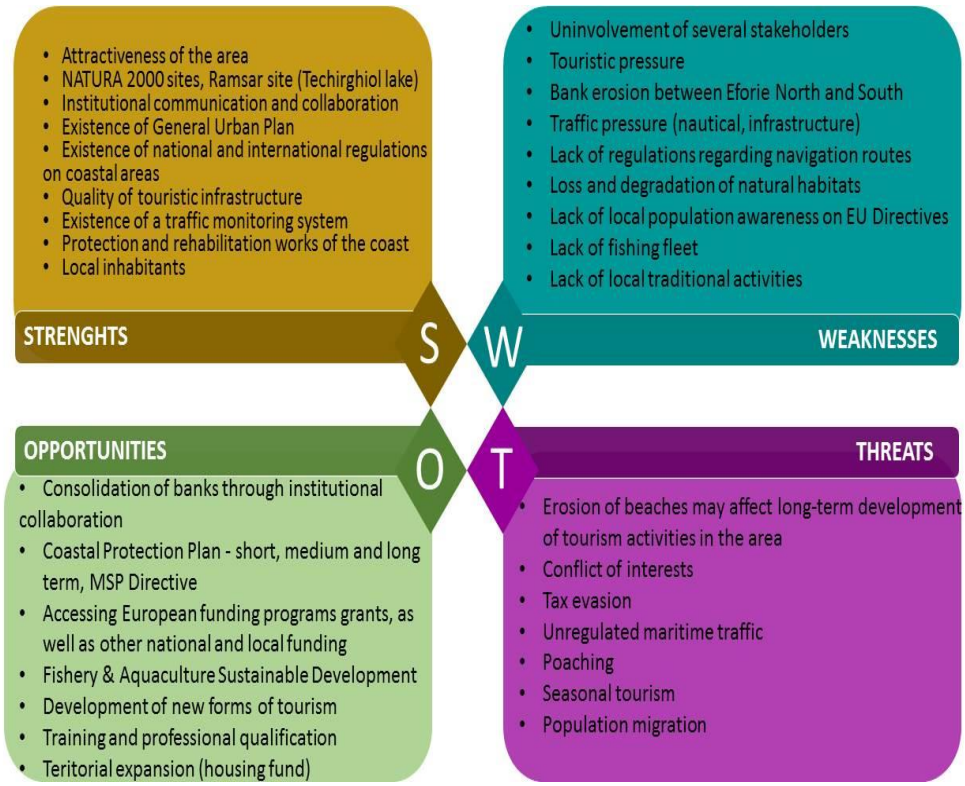

Figure. 7. SWOT analysis for the Eforie North and South coastal area (DDNIRD, Tulcea)

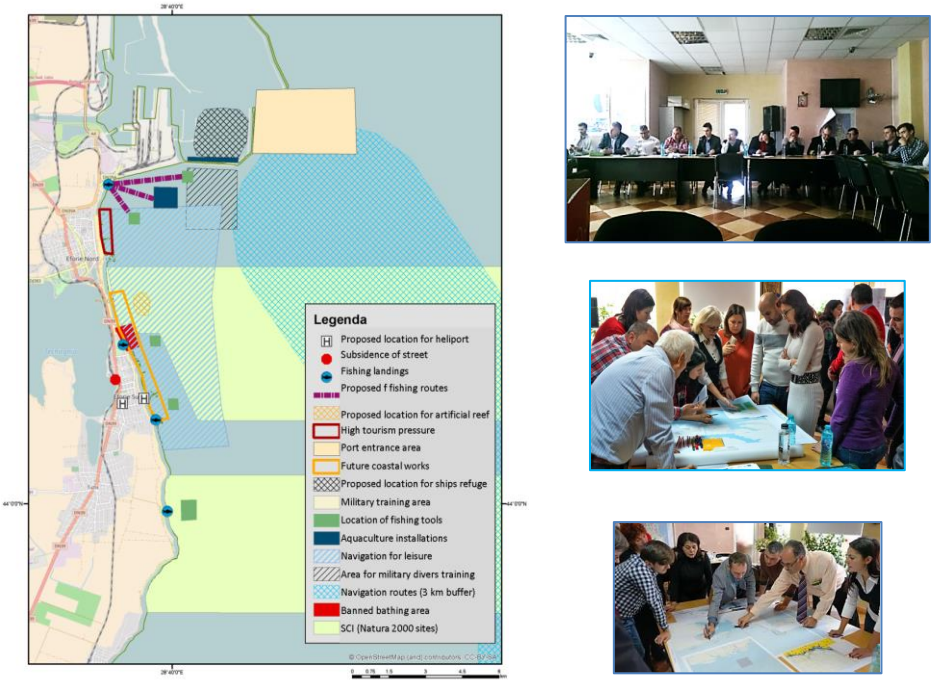

Figure. 8. Stakeholders meeting workshop groups and resulted layers

In consequences:

- The study proves the existence of a significant pressures from the coastal erosion, and need for a good beach and cliffs management is quite imperative. Despite the new implementation of the coastal protection, the nearshore areas remain under the risk of coastal erosion. The need for the coast maintenance is continue, added to the initiatives to identify complementary ways and possibilities for coast consolidation.
- The coastal erosion, emphasizing an unbalanced sediment situation in the area, adjacent to the Constanta Port, has a strong negative effect on economic aspects encompassing the effect on human activities and nature attractiveness, sometimes significant affected by the landscape damaging, also habitat losses during major hydro-meteorological events.
- The influence of the coastal erosions, on the socio-economic activities, is reflected in associated interactions, conflicts and controls between stakeholder's various activities developed in coastal and marine areas.
- The continue implementation of the coastal protection actions is required by the actual stage of erosion phenomena extension, despite its environmental impacts; for its mitigation are necessary the environmental friendly solutions to be taken in consideration.
- The new extensions of the beach surfaces (as action for the coastal protection) produced for the moment, a small impact on local tourism industry/economies developments related to the tourists number, due to a delay in the recreational and service facilities areas.
- The new development opportunities could be related to the extension of the tourist season activities through cultural, recreational and balneary activities, in tourist facilities such thermal aqua-parks, aquarium and marine science museum.

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14. Studiul provind analiza si revizuirea planului integrat de dezvoltare Constanta

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