Implications of Accelerated Sea-Level Rise (ASLR) for Bulgaria:
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Geographical data
Location and relief
Bulgaria is located between 41°14'-44°13' N and 20°21'-28° 36' E. Its area is 11,0988 km² and includes five hypsometric zones: low lands (0-200m) - 31.4%, uplands (200-600m) - 41%, low- mountain (600-1000m) - 15.3%, middle mountain (1000 - 1600 m) - 9.8 % and high-mountain zones > 1600m - 2.5%. These divisions are also valid for the Black Sea coastal region. The latter embraces the territory between Siviburun (the border with Romania) on the North and Rezovska river (the border with Turkey) on the South. The shoreline is 378km long with coefficient of identity 1.9 and a general eastward exposure. Active abrasion and landslides take place on 63% of the coastal zone and accumulation on the remaining 37%. The relief is complex due to various morphostructural formations such as the Danube plain, the geologically young Balkan Mountains chain and the Macedonian massif.

Climate
Bulgaria is located in the European temperate climatic zone. However, tropical air inflows are observed during warm seasons and Arctic ones - during the cold seasons. This results in a temperate climate with various nuances caused by local factors such as relief, and influences from the Mediterranean and the Black Seas. Mean monthly temperatures along the coast rise up to 2°C higher than those of the neighbouring continental zones. A similar temperature difference between the northern and southern coastal zones is observed. In January, temperatures reach 2-4°C (south) and -0/-2°C (north); whereas in July, temperatures increase to 23/24°C (south) and 22/23°C (north). The mean annual rainfall is 450/500mm, which is characteristic of a continental climate.

Vegetation
Steppe vegetation occupies the northernmost part of the Black Sea climatic zone. This is composed of grass communities dominated by cserophyte thick-tuft Gramineae. Mediterranean vegetation dominated by evergreen deciduous and coniferous trees and bushes (juniper, black pine, etc.) characterise the southernmost Black Sea climatic zone. Widespread urbanisation and agricultural utilisation of the land have led to significant anthropological changes of the local vegetation. The natural vegetation is only preserved in the southern coastal part and in several national reserves along the coast.

Fauna
The Black Sea fauna displays strong Mediterranean influences. A number of Mediterranean insect species dominate over Euro-Siberian and European ones. The ornithofauna is characterised by a high degree of isolation due to specific life conditions. A lot of (about 500) invertebrates, some particularly rare, can only be found there. Mammals live mainly in deciduous forests include mice, moles, hedgehogs, hares, polecats, martens, does, bats, etc.

Soils
There is great variety in soil types along the meridian. Soil types are distributed as follows: typical humus in the northern part, grey and brown forest soils in the central part, and yellow - in the south. About 12% of the soil area are eroded and almost all soils are either affected or endangered by erosion to a certain extent. Water erosion is predominant, although in the humus regions there is intensive deflation. A major part of the soils are anthropologically settled (density > 1.2 g/cm³) due to deteriorated structure and improper cultivation.

River systems
The more significant rivers flowing directly into the either Black Sea or the riparian lakes are: Provadiiska, Kamchia, Fandaklyiska, Karadere, Dvoinitsa, Vaya, Handjiyska, Ahloi, Aitoska, Rusokastrenska, Sredetska, Fakiyska, Ropotamo, Dyavolska reka, Karaagach, Lisovo dere, Veleka, Slistar, Rezovska.

Firths and Lagoons
These are typical of the Bulgarian coastal zone. Firth configuration almost repeats the contours of old river valleys drowned during the Holocene. The number of firths and lagoons are 26 and 5 respectively.
Coastal impact factors

Erosion
Observation and study of the scale and rate of erosion along the Bulgarian Black Sea coast began during the 1970s by various institutional organisations. These studies were initiated by the Institute of Geology in association with the Russian Academy of Sciences (Simeonova, Esin. 1972; Simienova, 1985; Shuiski, Simeonova, 1976, 1982). These were then continued by the Institute of Water Problems (Marinski, 1986, 1998) and the Institute of Oceanology (Banushev, Peichev, 1996; Peichev, 1998; Peichev, Solakov, 1999). Large-scale investigations started in 1980 by the newly formed Geozashtita organisation (Georgieva, 1985). These have now been terminated. However, as result of this research, the following results were obtained. The average rate of coastal erosion was established as well as the role of the geological structure and overall causes for erosional processes. Erosion was estimated to have affected 236.8km of the coastal area, at an average rate of 0.11m/yr. (eroded area 26,600m²/a and eroded volume 575,300 t/yr.). The rate of coastal erosion is highest in the loess parts of the north coastal zone (up to 1.5-2.0 m/yr.) and in the clayey alevrolites in the southern part (up to 2.0-2.5 m/yr.). A scour of the accreted sand coasts has further been recorded (Dachev, 1995). The latter embrace 139,000 m of the coastline (36.8%). On the basis of a 30-year investigation, it was established that 61,700 m of beaches (44.3 %) have been eroding at a mean rate of 0.385 m/yr. (total beach eroded area 4,466 m²/yr.).

Flooding

River inflows
Inflows are characteristic of the Bulgarian river regime. These increase water resources, but at the same time activate erosion and accumulation processes, and cause destructive floods. All over the Bulgarian territory, about 37 inflow occurrences have been recorded (annual mean) associated with 33mm precipitation. The frequency of rainfalls with intensity of over 0.6mm/min. is about 25 cases/yr. The maximum diurnal precipitation is 200-260 mm/d. Precipitation causes permanent marsh formation in the lower reaches of rivers (particularly rivers the beds of which have not been corrected), as well as temporary destruction of sand beaches in river mouth sectors.

Wind-wave and storm impact
Storms are closely related with the anemobaric atmospheric conditions over the water basin. Winds from the northern quarter prevail (63 %) in the Bulgarian sector of the Black Sea (Markov, Kostichkova, 1980). Wind waves with mean wave height of >200cm are characteristic for the March - October period. Extreme wind waves are the main cause of flooding in low-lying coastal land. These also cause increased salinity in most coastal firths, the activation of erosion, landslides.

Salinisation
Salinisation in low-lying coastal land is the result of periodical flooding caused by storms. This leads to degradation of agricultural lands as a result of repeated cycles of inundation-evaporation. The central sectors of the Bulgarian Black Sea coast are affected by salinisation (Bourgas region).

Socio-economic and ecological conditions of the coastal zone

Demographic Potential
The coastal zone encompassed 17 municipalities (i.e., communities: the smallest territorial administrative units) with a total area of 6,429 km². In 1994, the population of the Black Sea coastal zone amounted to 741,434 (in the northern half: 437,849 (60%) and in the southern half: 303,585 (40%)). Most of the population of the Black Sea zone lives in town. In 1992, total coastal population density was 115.9 persons/km², which is much higher than the national average. Compared to the beginning of the period, density numbers doubled (56 persons/km² for 1946). In contrast, the average density of rural populations was 25.7 persons/km², (i.e., lower than that the national density). 82% of the total coastal zone population concentrated in urban centres (national average: 67.8%). The census’ taken during 1946-1992 indicate that total population grew from 360,304 to 745,283, although the most substantial increase occurred prior to 1985. The coastal population is unevenly distributed over 20 urban centres, two big cities (over 100,000 people) and 18 small towns. There are no middle-size towns in the coastal zone. Urban agglomerations of monocentric type have been formed. These towns have contributed to considerable population growth as a whole. The Black Sea coastal zone incorporates 216 villages, 3/4 of which have been affected by population decrease during the period between 1946 and 1992.

Socio-economic aspects
Infrastructure is characterised by the presence of big, randomly located industrial, transport and tourist sites. Both major cities Varna and Bourgas are powerful industrial centres for chemicals and oil production. There are well-developed and up-dated national and international railway and airline connections with Black Sea resorts. The ferryboat link with Ukraine is currently not operating at full potential, however. The existing resorts are under reconstruction to comply with new European standards.
The natural beauty and moderate climate of Bulgaria are a perfect basis for the development of tourism, spa-treatment and recreation. Port infrastructure is being rapidly developed due to the implementation of Varna and Bourgas master plans. Significant foreign investments come through the Port of Bourgas, Solvay - Sodi Devnya, Cement Plant - Devnya, etc. There are currently real perspectives for construction of an oil pipeline between Bourgas - Alexandropolis, a gas pipeline for Turkey, gas production infrastructure on Galata field by Perteco Company, and the development of the transport corridor from Bourgas to Albania and Italy.

Accelerated sea-level rise (ASLR)

Long-term sea-level fluctuations of the western Black Sea have been studied by many authors for different time periods (Rozhdestvenski, 1964, Krasteva, 1969/1970, Markov, 1970, Mangov, Veselinov, 1979, Kostichkova, Cherneva, 1980, Kostichkova, Belberov, 1985, Markov et al., 1991, Veselinov, Mangov, 1998). On the basis of existing data from the marine stations of Varna and Bourgas, and after considering land vertical movements, a mean annual sea-level rise of 3.00 mm/yr has been estimated. This was later revised, after completion of a more precise but analogous study and the inclusion of additional data from Nessebar marine station. A new estimate of sea-level rise of 2.386 mm/yr. was then made. Natural and anthropogenic factors are pointed out as the main causes for sea-level rise. The natural factors involved include changing river discharge into the Black Sea, rainfall-evaporation balance and water exchange through the straights linking the Black Sea to the Mediterranean.

Vulnerability, sustainability and associated coastal problems due to ASLR

Sea-level rise has been considered in the Bulgarian scientific literature mainly as a result of "the greenhouse" effect. Most existing publications analyse the available sea-level measurements without considering the factors causing sea-level changes and projected trends. Few authors associate the activation of some unfavourable processes along the coast with sea-level rise. As an acceptable explanation for the current underestimation of the potential risks associated with accelerated sea-level rise, some natural features of the Bulgarian Black Sea coast can be pointed out. These include the significant altitude of the coast zone, the presence of stable lithological formations, etc., as well as the relatively low gradient of trends in sea-level rise (3 mm/yr.) established on the basis of long-term observations. About 10 % of the length of the Bulgarian Black Sea coast are vulnerable to flooding due to ASLR. About 63% of the coastal zone are vulnerable to erosion and land sliding processes. These risks are exacerbated by anthropogenic impact related to the growing urbanisation along the coast.

Institutional framework and aspects of adaptation

During the recent years of democratisation and reforms in Bulgaria, the normative base has been significantly developed. A number of laws, rules and norms related to the environment and its protection, were enforced. Various projects were supported by foreign investments (e.g., structural plans of the Black Sea municipalities, organisation of the coastal management, ecological assessment of the Black Sea, etc.). At present, in our opinion, it could be said that the problem of the expected impact of accelerated sea-level rise is unjustly underestimated. An overall assessment of its range and scale as a natural phenomenon and its possible impact on the socio-economic development is necessary since the adaptation depends on application of scientifically based approaches.

References

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