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Coastal protection example programme for Lithuania

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Abstract

Lithuania has one of the shortest coastlines among all European countries, the length of the shallow sand Baltic coast shaped by wave induced processes being only 90.6 km (Gudelis 1967, Boldyrev et al. 1976). Intensifying use of coastal resources mostly because of the port development and increase in recreational activities, is one of the most important factors causing coastal erosion and resulting in application of coastal protection measures. Although coastal protection has a long history on the Lithuanian coast first coastal protection measures were not aimed to stop erosion but rather to mitigate the impacts of eolian processes (Žaromskis 2007). Current coastal management practices in Lithuania are implemented in accordance with existing international legislative documents: HELCOM recommendation 16/3 „On preservation of natural coastal dynamics“ (1995), European Parliament and Council recommendation „Concerning implementation of integrated coastal zone management principles“ (2002). According to the Lithuanian Law on the coastal strip (IX-1016, 2002-07-02), approved by Lithuanian Parliament in 2002 coastal protection measures are envisaged in Coastal Strip Management Programs which specify the application of coastal protection measures according to the functional priorities and natural coastal dynamics. Coastal segments are distinguished by their functional destinations, rates of coastal erosion, recreational load, etc. in order to identify the most problematic sectors. Afterwards, final coastal protection and management measures are agreed (Gulbinskas et al. 2009).

1 Background and Motivation

First Coastal Strip Management Programme was approved in 2003 by the Order Nr. 442 of Lithuanian Minister of Environment and served as a basis for the implementation of coastal protection projects during 2004-2007 period. Until the beginning of 2008 several big projects were successfully implemented in Lithuanian coast (nearshore nourishment in Melnrage – Giruliai sector, Palanga beach nourishment, reconstruction of groine near Palanga pier, maintenance of protective foredune) giving positive results. The latest coastal management programme was approved by the Order Nr. D1-88 of Lithuanian Minister of Environment in January 2008. The document appeared as a continuation of previous programme in order to further mitigate the intensive degradation of Baltic Sea coasts by applying the concrete tools of coastal protection until the year 2013. Coastal protection measures were specified for separate coastal segments, which were defined according to the state of the coast, most problematic areas, possibilities and priorities of use of different type of coastal protection and management measures. Beach and nearshore nourishment are currently defined as priority measures.

From the beginning of 2013 the implementation of coastal protection measures will be done in accordance with newly elaborated Coastal management programme, covering the period from 2013 up to 2018. In order to prepare the basin for the development of new coastal management programme for the period until 2018 coastal protection example programme was prepared by Klaipeda University Coastal Research and Planning Institute in frame of Baltic Green Belt initiative.

2 Objectives

The objective of this research is to prepare Coastal protection example programme for Lithuanian coasts following national regulations, territorial planning documents, international recommendations and common world practices. Following factors were taken into consideration:

1. Current state and geodynamic tendencies of separate coastal sectors
2. Type of coastal usage and intensity
3. Anthropogenic factors, having potential impacts on coastal formation processes
4. Climate change impact

3 Location and Methods

Analysis of mentioned factors was conducted for the whole length of Lithuanian Baltic Sea coast (from the border of Latvian Republic until the border of Russian Federation) including the nearshore zone up to 20 meters depth and extending not less than 100 meters inland in accordance with the regulations set in Lithuanian Law on coastal strip. It is important to note that relatively short Lithuanian coast geologically and geomorphologically divided into two different parts: sand peninsula (Curonian Spit) – largest accumulative coastal landform in the Baltic Sea region, which was formed on the remnant of a glacial moraine as a result of sand accumulation by longshore sediment transport; and the continental coast comprising of different lithological sectors with the predominance of sand (northern part) and till (southern part) deposits.

Natural geomorphological development of Lithuanian coast is very much influenced by human activities: operation of ports, application of hard structures for coast protection in neighbour countries, etc. These factors have a major impact on current state of Lithuanian coasts and result in the intensification of coastal abrasion. Stabilization of the shore with hard hydrotechnical structures in Kaliningrad (Russia) partly blocked the flow of sediments from Sambian peninsula, as a result the amount of sediments reaching Lithuanian coasts significantly decreased. Breakwaters and the deep entrance channel of Klaipeda port also intercept more than half of the longshore sediment drift and as a result, the continental coast suffers an additional deficit of sand (Žaromskis 2007). Climate change also affect shoreline stability and acceleration of sea level rise has been observed on the Lithuanian coast (Jarmalavičius et al. 2007). Between 1970 to 2000, the Baltic Sea level rose by more than 15 cm (Johansson et al. 2001; Dailidienė et al. 2006). Results of long-term investigations of sea level rise in the Lithuanian part of the Baltic Sea, shows an annual increase of 6,5 mm. A rise of sea level up to 60 cm would cause significant problems for inhabitants and infrastructure on land (Žaromskis 2001). Though the current rates of the sea level rise so far do not induce marked land inundations in the Lithuanian coastal zone, their interaction with the wave set-up strengthen the coastal abrasion during storms (wind speed >24 m/s) (Žaromskis and Gulbinskas 2010).

Determination of coastal dynamic trends was based on the data of annual investigations of coastal dynamics (repeated leveling), carried out in 98 specially selected and equipped stationary stations (50 in the Curonian Spit and 48 in the mainland coast) since 1993. Evaluation of the long-term geodynamic coastal trends was based on the geoindicator – the budget of surface littoral alluvium (m3/m): sum of the spatial and temporal changes of washed out or blown out and accumulated coastal material (calculated until the average long-term sea level) (Žilinskas 2008). The assessment of the state of the coast and the influencing factors was also based on the results of the previous investigations: (Kirlys 1990; Žaromskis 1998; Žaromskis & Žilinskas 1996; Žilinskas 1993, 1998, 2005; Žilinskas & Jarmalavičius 1995, 1996, 2007b; Žilinskas et al. 1994, 2000, 2001; Dubra 2006; and others).

Type of coastal usage was evaluated based on the territorial planning documentation (master plans of Neringa, Klaipėda city and district and Palanga city, National Park of Curonian Spit and Regional Coastal Park).

The impact of climate change is evaluated on the ground of material collected during the implementation of the international projects GRaBS and BaltCica.

Analysis of the whole Lithuanian marine coast (90.6 km in length) helped to define most vulnerable coastal sectors for the priority management and develop recommendations for possible coastal protection measures.

4 Results

Most problematic coastal sectors

Analysis of coastal dynamics and coastal usage helped to identify most problematic coastal sectors, regarded as the priority ones in terms of coastal management and protection (Tab. 1).

Identification of priority coastal sectors helped to propose the complex of recommended coastal protection measures. The measures were divided into 2 blocks: I – measures that should be applied urgently in order to stop intensified erosion processes; II – measures to be applied later considering coastal development forecasting and possible impacts of planned economic developments (ports, terminals, fishery bases, etc).

Based on existing coastal management experience following protective measures were suggested:

- further protection and maintenance of foredune, using natural materials (branches, wooden footpaths, etc.)
- beach nourishment (Palanga is the top priority)
- nearshore nourishment (Palanga, Melnrage, possibly Butinge settlement)
- sediment deficit compensation using dredged material from Klaipeda port entrance channel (Melnrage)
- application of hard structures (gabions) (Kopgalis, possibly Melnrage I)
- protection of natural coastal formation processes (Seaside regional park)
- regular complex monitoring of coastal state (all the sectors)

Table 1: Most problematic Lithuanian coastal sectors.

Coastal sector	Coast characteristics			Shore dynamics	Coastal use	Other remarks
	Length (m)	Average beach height (m)	Average beach width (m)			
Latvian border-Butinge settlement	1,935	2,8	42	Stable	Nature conservation & Industry use	Reconstruction of Sventoji port in 2013 will stimulate the intensification of erosion processes in this sector, therefore possible coastal protection measures should be developed already now
Palanga recreational zone: Osupis-Kunigiskiai	2,330	2,5	33	Erosion (2,6 m^3/m per year)	Recreation	Increasing erosion because of the sand deficit

Kunigiskiai-Raze stream	3,800	2,5	55-80	Accumulation (1,7 m^3/m per year)	Recreation	Stability of this sector very much depends on application of coastal protective measures in northern parts of the mainland coast
Raze stream-Palanga pier	700	2-2,5	15-55	Erosion (11,5 m^3/m per year)	Recreation	Erosion in this place intensified after installation of groine near the pier
Palanga pier-Birute cape	1,680	1,9	35	Erosion (15,7 m^3/m per year)	Recreation	Deficit of sand in the nearshore zone stimulates scour of sandy beaches
Birute cape-Auska sector	1,000	2,5	45	Accumulation (0,1 m^3/m per year)	Recreation	Stability of this sector very much depends on application of coastal protective measures in northern parts of the mainland coast
Auska-Seaside regional park	1,400	2,5	42	Stable	Recreation	
Seaside regional park:						
Nemirseta landscape reserve	4,730	3	60	Erosion (5,1 m^3/m per year)	Nature conservation	Preservation and regeneration of natural coastal formation processes are priority measures
Karkle talasologic reserve	2,680	2	25	Erosion (1 m^3/m per year)	Nature conservation	Preservation of natural processes
Karkle ethnocultural reserve	1,550	2,5	30	Erosion (6,4 m^3/m per year)	Nature conservation	Preservation of natural processes
Olando cape natural reserve	3,360	1,2-3	13-28	Erosion (8,6 m^3/m per year)	Nature conservation	Naturally eroded cliff serves as sediment source for adjacent coastal sectors

Melnrage recreational zone:						
Melnrage II recreational area	850	3,5	45-55	Accumulation (4,1 m^3/m per year)	Recreation	Future state of all sectors depends on further development of Klaipeda port
Melnrage II-Melnrage I recreational area	1,300	4	38	Accumulation (6,1 m^3/m per year	Recreation	
Melnrage I recreational area	1,050	5	35-40	Erosion (7,5 m^3/m per year)	Recreation	Huge impact of Klaipeda port brakewaters
Klaipeda port technogenic sector	450	1-3,5	30	Erosion (10,2 m^3/m per year)	Industry use	Huge impact of Klaipeda port brakewaters
Curonian spit coastal sectors:						
Kopgalis	900	2,5	60	Accumulation (11,7 m^3/m per year	Recreation	Despite of general accumulation trends this sectors suffers mostly from extreme storm events
Preila recreational zone	1,620	3	30	Erosion (1,6 m^3/m per year)	Recreation	State of this sector depends on the functioning of the longshore sediment transport

5 Discussion

Coastal protection example programme was developed after the identification of most problematic sectors of Lithuanian coast. Coastal sectors were distinguished based on the detailed analysis of the factors affecting the development of the coasts. Following sectors were distinguished: Latvian border-Butinge settlement, Palanga recreational zone, Seaside regional park, Melnrage recreational zone, Klaipeda port technogenic sector, Curonian spit sectors (Kopgalis, Preila).

Latvian border-Butinge settlement. Although current geodynamic trends show the prevalence of accumulation processes it seems that from the beginning of 2014 erosion will be back. The main reason is reconstruction of Sventoji port, which will require construction of long breakwaters and deepening of the entrance channel, acting as a trap for sediments tracking from the south towards Latvian border up to Kolkss rags. The projected construction will possibly affect the state of adjacent coastal sectors (deficit of sediments in northern part of the port, accumulation in southern part), thus application of elementary measures for foredune protection and maintenance will be not enough. Supposedly, coastal management measures will need to guarantee permanent bypassing of nearshore sediments from south to north. Other problems include increasing recreational load and urbanization.

Palanga recreational zone. Being the most problematic coastal sector with regard to coastal erosion Palanga recreational zone requires permanent investigations and application of measures, helping to supplement sand resources in the nearshore zone and on the beach. Several beach and nearshore nourishment projects were successfully implemented here from the year 2005, however they should be continued in future in order to keep the status of most frequently visited health resort. Yet bearing in mind the deteriorating state of the southern part of the sector and seeking to preserve the unchanged total recreational space of Palanga, it is necessary to preserve the northern part of the sector in the best possible state, i.e. the reduction of recreational space in the southern part of the sector should be compensated by its expansion in the northern part.

Seaside regional park. Appropriate management of this coastal strip is extremely important not only for the purpose of nature protection, but also for the geodynamic state of adjacent coastal sectors (Palanga, Sventoji). Intensively eroded cliff in Olando cape landscape reserve acts as an important sediment supplier. Therefore, regardless of the negative coastal dynamic trends, only those coastal management measures that would neutralize the impacts of anthropogenic activity and would help to regenerate the natural coastal processes should be applied here.

Melnrage recreational zone. Recreational zone of Melnrage is popular destination for tourists during summer season. Although further expansion of recreational space is hardly possible due to existing environmental restrictions and less attractive stony beaches in the northern part (Olandu Cape landscape reserve) as well as presence of technogenic object (Klaipeda port) in southern part of the area number of visitors is constantly increasing. Moreover, planned construction of a deepwater port foreseen for the 2013-2018 period will have an impact on hydrolithodynamic situation in this area and possibly deteriorate state of the coasts. Therefore application of appropriate coastal protection measures in this area is of major importance.

Klaipeda port technogenic sector. This short coastal strip is currently used for the industry needs. Development of deepwater port is foreseen in the nearest future and potential impact zone seems to increase considerably. Detailed morphometric, hydrodynamic and lithodynamic investigations are currently underway and will help to determine the impact of the port on future coastal zone dynamics.

Curonian spit coastal sectors. All coastal sectors of Curonian Spit are used for intensive recreation purposes. Although state of the coasts in Curonian Spit is relatively good regular maintenance works are required in order to neutralize the hazards to the existence of Curonian spit as an integral geomorphological form. Kopgalis and Preila coastal sectors currently require particular attention due to deteriorative character of coastal dynamics, especially after extreme storms. One of the possible solutions to protect Kopgalis from the intensive erosion could be nearshore nourishment, which would help to keep sediments in shallow waters and ensure their supply for the protection of beaches during major storm events.

6 Conclusion

1. Possible impact of port development (Klaipeda port, Sventoji port) on coastal formation processes should be evaluated before the construction in order to plan most appropriate measures for the preservation of natural coastal features and recreational resources (sandy beaches).
2. Reconstruction and construction works should be carried out in parallel with the implementation of relevant coastal protection measures.
3. Possibilities to use boulders for the coast maintenance, dredged from Klaipeda port area during maintenance dredging works, should be evaluated
4. Permanent morphometric, hydrodynamic and lithodynamic investigations of the nearshore should be carried out for the appropriate modeling of coastal zone development tendencies, choosing of coastal protective measures and increasing the efficiency.

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