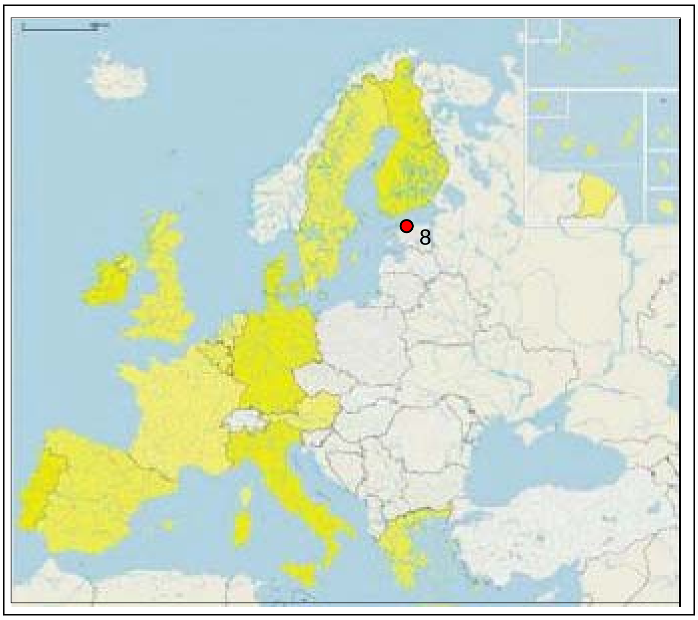
TALLINN
(ESTONIA)



Contact:

Ramunas POVILINSKAS

EUCC Baltic office

Tel: +37 (0)6312739
Fax: +37 (0)6398834

e-mail: ramunas@corpi.ku.lt

1. GENERAL DESCRIPTION OF THE AREA

The length of the Estonian coastline is 3,794 km of which 1,242 km are on the mainland and 2,552 km is divided among the 1,500 islands. The country is bounded to the north by the Gulf of Finland, to the west by the Baltic proper and to the southwest by the Gulf of Riga. Tallinn is the capital of Estonia. It is located in the north of the country on the coast of the Gulf of Finland. The case area covers the marine coast within the Tallinn metropolitan area between Kakumae and Muuga bays (Figure 2). It includes Tallinn urban municipality (linn) and Viimsi suburban municipality (vald) of Harju county (maa).

1.1 Physical process level

1.1.1 Classification

According to the coastal typology adopted for the EUROSION project in the scoping study, the case study area can be described as a combination of:

1b. Hard rock coastal plains
Hard rock sandstone cliffs and limestone steps

2. Soft rock coasts
Moraine coastal bluffs

3b. Wave-dominated sediment. Plains.
Silty, sandy, gravel, pebble and boulder beaches

Fig. 1: Location of the case area.

Within these major coastal types several coastal formations and habitats occur, including bare sandy, gravel and pebble-boulder beaches, vegetated shores and windflats. The waterfront of the Tallinn city mostly presents a developed artificial coastline.

1.1.2 Geology

Recent geological history of the case area since the recession of the continental ice cap (ca. 10 – 12 thousand years B.P.) is largely related to the isostatic uplift of the Earth's crust in the northern part of the Baltic Sea region, which continues till now (ca. 2 mm annually in the study area). Due to the uplift of the Earth's crust, the Estonian coast and beaches are of emergent character. Quarternary glacial drift deposits (till) cover the elevated Palaeozoian sandstones and limestones of the coastal hard rock escarpment (the Glint), which stretches along the Gulf of Finland. The highest point of the Glint in the study area is 47 m above the sea level at Maarjamagi. The eroded hard rock sandstone cliffs and limestone steps occur at Kakumae and Viimsi promontories, while the soft rock bluffs of Quarternary glacial drift deposits occur at Kopli, Paljasaari and Viimsi promontories. During the late Holocene the isostatic uplift of the coast has been enhanced by the decreasing sea level after the highest Littorina transgression. The Littorina coast is currently 20 – 24 m above the modern sea level in north Estonia. At the flat sedimentary coasts the formation of coastal plains and wetlands were the key processes featuring the latest geological and geomorphological coastal development during the Holocene, as the sea bottom gradually emerged from the water.

The northern Estonian coasts outside the urban zones now consist of several different types: till coasts make 8% of the shoreline length, sandy coasts – 33%, silty coasts – 8% and cliffed coasts – 51%. However strictly within the study area this ratio is slightly different in favour of the till coasts. The prevailing sediment type of the beaches within the study area is gravel, pebble and boulders left from the eroded cliffs, but also sand and silt is found there. Sandy beaches are located inside most of the bays. As moraine shores emerge, the finer sand and gravel is washed out, leaving scattered boulders or boulder ridges. Boulders and pebble also prevail on the surface of the foreshore bench.

1.1.3 Morphology

The unevenness of ancient rock outcrops causes irregularities along the coast of the study area (Figure 2). Variations in the nature and thickness of Quarternary glacial drift deposits are reflected in coastal outlines. The coastline of the study area is very indented. The promontories are separated by shallow bays. After the Littorina transgression the Glint and the moraine bluffs became inactive in many places and separated from the sea by vegetated shores of different width or by the erosion terrace (elevated ancient sub-marine bench), and a very flat foreshore of diverse lithology (the windflats).

The coast within the study area can be split into several morphologically different units, from west to east:

Tiskre: A flat coastal wetland is overgrown by bulrush and reeds. Fine sand and silt deposits cover the bare beach, which descends gradually to a very flat sandy foreshore forming a typical windflat. A wide-scale residential development is taking place in the backshore partly reclaiming the wetland.

Kakumae promontory: A steep up to 20 m high sandstone cliff overtopped by a thin layer of moraine till is behind a narrow gravel-boulder beach. Also the foreshore profile is relatively steep. Sandstone bedrock and erratic boulders with pebble form the bench.

Stroomi: Fine sand and silt deposits cover the wide sandy beach, which descends gradually to a very flat sandy foreshore. There are some 2 – 3 m high dunes in the backshore. A large- scale urban development is taking place behind the dunes.

Pohja Tallinn: Urbanized waterfront with harbours, breakwaters and artificially dredged deep foreshore.

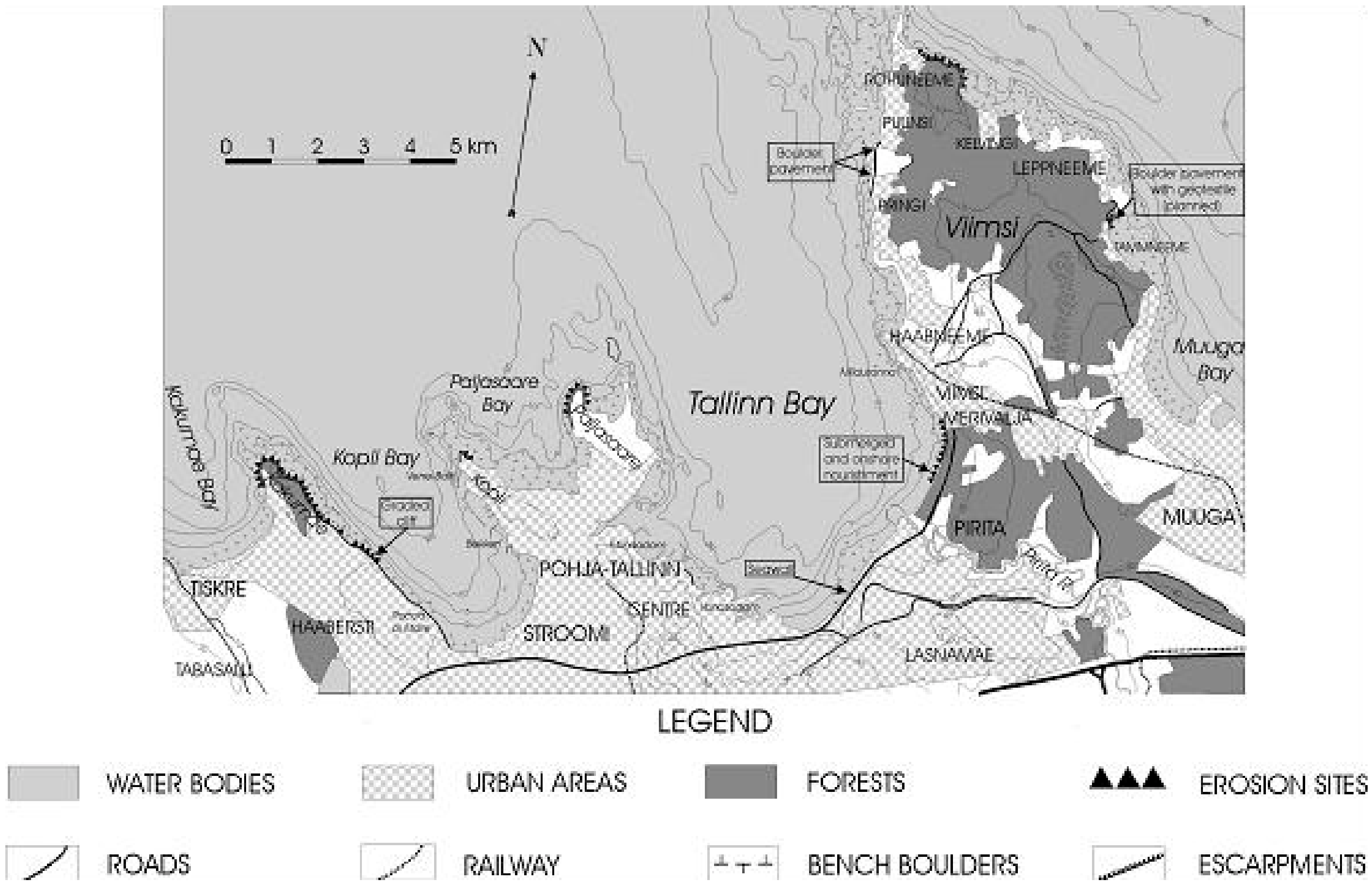


Fig. 2: Map of Tallinn case study area.

Paljasaari promontory: A coastal strip is formed in reworked glacial drift deposits. Eroded moraine bluffs (up to 4 m high), steep narrow beach and boulder-pebble bench frame this small but indented promontory.

Pirita: Wide sandy beaches with urbanized or forested backshore descend gradually to the flat foreshore, which is featured by 2 – 3 longshore ramparts composed by fine sand, Between the ramparts the sandstone bedrock is exposed on the surface of the bench. Two breakwaters and the sailing boat harbour frame the Pirita river mouth.

West-Viimsi: A combination of urbanized backshore at small coastal settlements and low moraine bluffs feature the western coast of this promontory. The foreshore relief is shallow with prevailing boulder-pebble bench.

East-Viimsi: The indented coastal zone of the northern and eastern coast of Viimsi promontory is featured by steep sandstone cliffs, low moraine bluffs and limestone steps, which are interspersed by flat accumulative coastal plains overgrown with grass, bulrush and reeds. In few places at small coastal settlements the backshore is urbanized. The foreshore relief is very fragmented with prevailing boulder-pebble bench.

Muuga: Urbanized waterfront of the harbour with breakwaters and artificially dredged deep foreshore.

1.1.4 Physical processes

Waves and storm surge

Wave activity and the wind-induced surge during storm events are the principal physical erosion agents in the study area. Gulf of Finland is relatively deep and provides good conditions for wave development. The highest waves are 2 – 3 m high. Although a rather limited wave fetch over the gulf limits the wave energy reaching the study area from the northwest, especially inside the bays, but the promontories of the indented shoreline are exposed to strong stormy winds of western directions. Particularly the Viimsi peninsula is open to the longest fetches of the storm wave action. Annually there are about 20 – 30 stormy days (wind velocity above 15 m/s) in the study area. The coasts inside the shallow bays are very susceptible to the storm surge, which might raise the water level up to 2 m at the foreshore. The storm surge even under the limited wave fetch causes erosion of the coast as the sand loss from the beach is not fully replenished after the storm due to wave energy dissipation on the wide and shallow foreshore under the low water conditions.

A succession of severe storms of the kind seen in the northeast Baltic in recent decades resulted in a more permanent recession of the shoreline and a reshaping of onshore and foreshore profiles in the study area. In the last fifty years Estonian coastline has been subjected to at least eleven extremely strong storms (1954, 1967, 1969, 1971, 1975, 1983, 1986, 1990, 1992, 1999 and 2001) of the kind that, according to statistics, should occur only once in a hundred years. As there is little evidence of a rising sea level during that period (see below), the increased erosion appears to be largely due to the increasing storm frequency. Series of subsequent storms enhance the erosion process. With each storm the amount of sand on the beach is decreasing, and after three or four storms the backshore formations are subjected to erosion and bluffing.

Ice

In winter an ice fringe develops on the northern Estonian coast. A steady ice cover puts an end to wave action for the winter period but in spring when the increasing water level raises the ice, the ice-sheet breaks up and is pushed on to the coast by strong winds, where it piles up in 10 – 15 m high hummocks. At the same time blocks of ice scour the sea floor to depths of more than 5 m, as witnessed by divers who have seen deep furrows left by ice. Ice pushed on to the shore loosens scoured foreshore sediments and drives large boulders up from the sea bottom. It may damage natural coastal formations (dunes and bluffs) and artificial constructions on the coast. On the other hand, fast ice protects the coast of the study area from strong winter storms. However during the last two decades the winters have used to be extraordinarily warm, and fast ice has usually formed in sheltered bays only. Therefore its protective impact was negligible.

Decline of sediments

The northern Estonian coast is characterized by a deficit of sand sediments and those present are mainly composed of fine material, which is easily removed by waves and winds. Thence, the decline of sediments on the beach and in the foreshore caused by the increasing storm wave action is a rather important secondary erosion agent.

Eustasy vs. Isostasy

There is little evidence of a rising sea level at the Estonian seashore over the recent decades. As the isostatic uplift of the Earth's crust in the study area prevails, tectonic processes should be considered as playing a positive role in stabilizing the shoreline.

Weathering and underwashing

Both processes play an important role in decreasing the resistance and stability of the exposed seaward cliffs and bluffs thus making them more susceptible to wave action. However the exact assessment of the erosion impact from weathering and underwashing is difficult as this role is closely linked to wave action and no special investigations into the problem have been taken so far.

Tide

Regular tide ranges in the adjacent Baltic Sea foreshore are less than 0.25 m; therefore tidal action plays virtually no role in coastal development in the study area.

Fig. 3: Eroded moraine bluff at Merivalja – Pirita road. Photo: R. Povilanskas, December 2002.

1.1.5 Erosion

Littoral cells in the indented coastal zone of the study area are relatively small in size and in the volume of the material, which is transported along the shore compared to the shore-normal redistribution of sediments. Till deposits left by the glacial drift in Estonia contain little sand. Therefore the main sources of sand sediments feeding the coast in the study area are the Quarternary fluvioglacial sediments deposited within the pre-Quarternary river valleys, which open to the Gulf of Finland at Tiskre, Stroomi and Pirita. These sediments are eroded and washed onshore from the bench and provide the only, although a very limited supply of sediments to the beach.

Structural erosion

The resulting secular retreat rate of the eroded hard rock cliff is estimated to be ca. 0.1 m annually. The moraine coasts are relatively stable in the study area due to residual erosion beach and a very wide bench paved by boulders and pebble, which naturally protect the coast.

Acute erosion

The last two decades witnessed a more active coastal development in Estonia in general, and in the study area in particular. The activation of coastal processes has been observed on the formerly inactive areas of the ancient coastal cliffs and bluffs. Thus during an extremely strong storm of 1983 in the Tallinn bay, big trees, standing at the edge of the formerly inactive moraine bluff fell into the water as the result of the renewed coastal erosion at Merivalja settlement (Figure 3). In Muuga bay the extremely strong storm of 2001 has washed the hitherto stable coast between Leppneeme and Tammneeme settlements. Such increase in coastal erosion is triggered by the increasing frequency of the extremely strong and disastrous storms of the western fetches. The same trend might continue and even increase in the next few decades, as E. Bird predicts.

1.2 Socio-economic aspects

1.2.1 Population rate

The total number of people living in Tallinn metropolitan area is ca. 450 thousand. The number of inhabitants per square kilometre of the coastal area (including Viimsi and Kakumae) is ca. 400 – 600. Population density in urban coastal districts of Tallinn is given in Table 1.

Table 1: Population density in urban coastal districts of Tallinn (within 3 km coastal zone).

District	Population (01.01.01)	Density (inhab./ km^2)
Haabersti	34753	1868
Kesklinn (Centre)	40720	1454
Lasnamae	107566	3586
Pirita	7941	425
Pohja Tallinn	51938	3002

1.2.2 Major functions of the coastal zone

- **Urbanisation (protection of life and value):** The study area is the biggest urban agglomeration in Estonia with most of urban development taking place within the 5 km coastal zone area. Approximately half of the population lives within the 2 km coastal zone. An extensive residential development of high standard is currently taking place at the coast in the suburban zone (Tiskre, Kakumae, Pirita, Viimsi) within the study area.

- **Industry, transport and energy**: The two biggest ports of Estonia are located within the study area – Tallinn passenger harbour and Muuga cargo port, which together make the 2nd largest seaport in Eastern Baltic. The total turnover of the Tallinn metropolitan harbours was 34,3 million tons of cargo and 6 million of passengers in 2000. Distribution of cargo and passenger share among the particular harbours is given in Table 2. Tallinn municipal wastewater treatment plant is located on Paljassaare penninsula. It serves the needs of the entire metropolitan area (ca. 53.3 million cub. m of wastewater treated annually). One of the major industrial enterprises at the Tallinn waterfront is Baltic Ship Repair Yard, which is among the biggest of that kind in Eastern Baltic. Miinisadam harbour in the centre of Tallinn serves as the main Estonian navy base.

Table 2: Cargo and passenger turnover in different harbours of Tallinn metropolitan area.

Harbour	Turnover (in thousand units) in 2000	
	Cargo in metric tons	Passengers
Vanasadam (Old Port)	4248	5989
Muuga	22037	11
Vene-Balti Oil harbour	3535	
Miiduranna	2158	
Paljasaare	1840	
Bekkeri	445	
TOTAL	34263	6000

- **Tourism and recreation**: Tallinn metropolitan area is very important both for daily recreation of urban residents and for national and international tourism as well. Over 900 thousand foreign tourists have stayed overnight in Tallinn in 2000. Pirita seaside resort (from Pirita river to Merivalja) is the most important seaside recreational area of metropolitan Tallinn with sandy beaches and clean foreshore water suitable for bathing (Figure 4). The Olympic Yachting Centre is the most important sailing boat harbour of Estonia (4 – 5 thousand boats visiting annually). Second most important beach area is Stroomi, which is located westward from Tallinn (in Kopli bay). Estonian open-air ethnographic museum is located at “Rocca al Mare”.

Fig. 4: Recreation facilities on the Pirita beach. Photo: K. Orviku, February 2002.

- **Nature conservation**: There are several landscape reserves next to the study area: Tabasalu, Aegna island and Pirita river valley. Nearly all forests of the study area enjoy protection within the general nature conservation framework, being the integral part of the coastal protective belt.

- **Fisheries and aquaculture**: Leppneeme and Miiduranna (Haabneeme) are the most important fishing harbours in the study area providing port faciliities for the small-scale fisheries (mainly for Baltic herring). There is no aquaculture in the study area.

- **Agriculture and forestry**: No agriculture and forestry of an industrial scale is in this predominantly urban area. Agricultural activities are mostly cultivated in small-scale gardening colonies while forests mainly serve for recreational and conservation purposes.

1.2.3 Land use

The land use in the case area is shown in Figure 2. The case area is predominantly an urban area (about 70 %). In the remaining areas some forestry and agricultural land use is present.

1.2.4 Assessment of capital at risk

Within the study area the increasing erosion currently threatens only the recreational functions of the Pirita beach and the existence of few earlier built houses, which are located too close to the edge of the escarpment (Figure 5). The total capital at risk is ca. 0.4 – 0.6 M. EUR.

Fig. 5: House threatened by cliff erosion in Kakumae. Photo: R. Povilanskas, December 2002.

However if the coastal erosion increases during the next few decades according to the pattern predicted by E. Bird, then quite a substantial capital might be exposed to risk from the erosion, flooding and ice pile-up. Particularly these eventual threats apply to several newly built low-lying residential areas (Tiskre and Kelvingi), seaside roads (Tallinn – Merivalja, Haabneeme - Leppneeme and Leppneeme – Tammneeme) and the railroad leading to Vene-Balti oil harbour at Kopli. In that case the potential capital at risk might reach the range of 20 – 40 M. EUR.

2. PROBLEM DESCRIPTION

2.1 Eroding sites

The eroding sites are described from west to east (see Figure 2):

- **Kakumae**

Waves erode the sandstone cliff (Picture 4). If the storm wave and surge action increases, the coming decades might witness a more intensive retreat of the shoreline and the cliff edge.

- **Kopli and Paljasaari**

Moraine bluffs of the promontories are eroded during extremely severe storm surge events.

- **Pirita**

The volume of sand is decreasing with every storm event on the nourished beach next to the Olympic Centre.

- **Merivalja**

The formerly inactive low moraine bluff is eroded during extremely severe storm events (Picture 1).

- **Rohuneeme –Tammneeme**

Formerly stable sandstone cliffs and moraine bluffs were eroded during the latest extremely severe storm events.

Fig. 6: Eroded sandstone cliff in Kakumae. Photo: R. Povilanskas, December 2002.

2.2 Impacts

The impacts of erosion on the socio-economic situation are described from west to east (see Figure 2):

- **Kakumae**

The new residential area is located next to the escarpment and might be eventually threatened if erosion increases.

- **Pirita**

The beach in the most important metropolitan recreational area is losing its value due to erosion.

- **Merivalja**

A road goes along the coastal bluff and might be eventually threatened if erosion continues.

- **Rohuneeme**

Several residential houses (including the one of the former President of the Republic) might be eventually threatened if erosion continues.

- **Tammneeme**

The coastal road became threatened after the extremely severe storm event of November 2001.

3. SOLUTIONS/MEASURES

3.1 Policy options

In Estonian law there is no definitive setback line policy. The most opted coastal protection policy in this country in general and in the study area in particular is limited intervention. In Tallinn and Muuga seaports the principal policy is to hold the line in order to protect the port entrance and facilities. New quays and piers are moving the coastline seawards in cases when port facilities are expanded.

3.2 Strategy

3.2.1 Approach related to the problem

The Act on the Protection of Marine and Freshwater Coasts, Shores and Banks (1995) regulates the extent of coast, shore and bank areas under protection, and management of their ecosystems. According to this Act, the main approach to prevent damage caused by erosion is to restrict construction in the coastal zone to 50 m from the mean water level in urban areas and to 100 m elsewhere on the Estonian mainland coast. This restriction provides a fairly effective preventive policy measure against the coastal erosion, but not against flooding or ice pile-up in the case of low-lying flat coastal areas.
Also, Estonia has a rather strict control of forestry in the coastal zone for landscape protection and in order to fight erosion. The Forest Department of the Ministry of Environment is responsible for the development and implementation of national forest policy and accounting of the forest resources.

3.2.2 Issues concerning threat to life and property

No concrete evacuation plans for a flooding/erosion period exist since coastal erosion is not considered as a serious problem by the public authorities in the Tallinn metropolitan area. Estonian Rescue Board is in charge for the evacuation of people in the case of emergency events, including an eventual flooding, erosion or landslide disaster.

Most of the expensive houses in the coastal area of metropolitan Tallinn are insured against damage. In the case of a very big eventual flooding, erosion or landslide disaster the Government is supposed to provide a limited subsidy for those who would suffer the most.

3.3 Technical measures

3.3.1 Type

Foredune and forestry maintenance

As was already mentioned above, the main type of technical measures aimed to prevent coastal erosion and mitigate the effects of erosion is revegetation forestry.

Nourishment

At the head of the Tallinn bay between Tallinn and Pirita the shallow foreshore was artificially filled in the 1970s. At the same time the beach at Pirita in the immediate vicinity to the Olympic Centre was nourished for recreational and coastal protection purposes using quarried and dredged river sand. As a result, the beach was made 0.5 m higher and substantially wider.

Seawall / slope protection

Between Tallinn and Pirita a seawall was constructed in late 1970s (Figure 7). The coast along the Pringi-Puunsi road was paved with boulders in 1998 – 2000. Also, there exist plans to introduce geotextile combined with application of boulders in order to defend the threatened coastal road at Tammneeme. At Kakumae near new residence district the strip of sandstone cliff was graded in 2000 for coastal defence purposes (Figure 8).

In Figure 2, all these measures are shown for the case area.

3.3.2 Technical details

Foredune and forestry maintenance

Forest plantations of Western taiga type cover approximately 80% of the study area outside the urbanized waterfront. They are managed through cleaning, selective cutting and replanting.

Nourishment

The amount of sand applied for beach nourishment in Pirita in 1970s was 30.000 m^3. Approximately 30.000 m^3 of sand is needed again to renourish the Pirita beach in order to maintain its stability during next decades.

Seawall / slope protection

The length of Tallinn-Pirita seawall is approximately 2,5 km. The length of coastal strips paved with boulders along the Pringi-Puunsi road and the length of the graded sandstone cliff at Kakumae total 1.5 km each.

Fig. 7: Coastal seawall along the Tallinn – Pirita road. Photo: R. Povilanskas, December 2002.

3.3.3 Costs

Waterfront development costs of the Soviet period are incomparable with modern market-related costs of material, labour and technologies. Therefore costs for the earlier taken measures (seawall, nourishments) are not available.

Foredune and forestry maintenance

Annual maintenance cost for coastal forests is 2,5 thousand EUR per hectare.

Seawall / slope protection

The cost of paving the coastal strip with boulders along the Pringi-Puunsi road totals 70 thousand EUR. The grading of sandstone cliff at Kakumae was done by a private real estate company. The costs of works, which have violated routine planning and public endorsement procedures haven't been revealed.

4. EFFECTS AND LESSONS LEARNT

4.1 Effects related to erosion

At the beach nourishment site in Pirita the coastal erosion continues and slightly increases due to increasing storm wave and surge activity and to increasing deficit of sediments. The beach nourishment efforts at Pirita have been relatively effective in the conditions of limited erosion agents. Till the exceptionally strong storm of November 2001 the beach was relatively stable there. Now the renourishment is needed again, as the beach wasn't naturally replenished afterwards. The strengthening of the coast with boulders is relatively effective in the case of an indented and sheltered study area, however latest investigations show, that it should be even more effective if applied in combination with geotextile. The effectiveness of the cliff cutting at Kakumae is still to be examined. So far it had shown resistance to the wave action during the storm of November 2001 although few places at the beach have been washed off.

Fig. 8: Graded sandstone cliff at Kakumae. Photo: K. Orviku, November 2001.

4.2 Effects related to socio-economic aspects

The chosen strategy has indeed worked to maintain the key socio-economic functions of the coast, since the applied measures have served integrated purposes (revegetated forests and replenished beaches – for coastal defence and for recreation, breakwaters and seawalls – for coastal defence and for transport infrastructure development, etc.).

4.3 Effects in neighbouring regions

The effects in neighbouring regions are insignificant since the sediment drift along the coast of the study area is negligible.

4.4 Relation with ICZM

According to Estonian legislation, all coastal management issues, including coastal defense, development and/or coastal conservation are integrated into the general physical planning and management framework. The new Planning Act of Estonia (2002) establishes a planning system on four levels: national planning, county planning, local comprehensive planning and detailed planning. The municipalities prepare comprehensive and detailed plans, secure their implementation and participate in county plan production. A comprehensive plan is prepared for the territory of a rural municipality or a town. Comprehensive planning establishes more specific land use requirements and obligations and defines the primary purpose of certain areas within a local community, town, or particular property. It also determines parts of rural areas where detailed planning is mandatory. There is a comprehensive spatial development plan prepared for the Tallinn municipality.

An international ICZM project for the Baltic States and Poland (1998 – 2000) also covered the study area. This satellite-image and GIS (Geographic Information System) based project was aimed to give Estonia, Latvia, Lithuania and Poland the opportunity to better manage their coastal resources in an environmental and sustainable way.

4.5 Conclusions

Effectiveness

The beach nourishment efforts at Pirita have been relatively effective in the conditions of limited erosion agents. Till the exceptionally strong storm of November 2001 the beach was relatively stable there. Now the renourishment is needed again, as the beach wasn't naturally replenished afterwards. The strengthening of the coast with boulders is relatively effective in the case of an indented and sheltered study area, however latest investigations show, that it should be even more effective if applied in combination with geotextile. The effectiveness of the cliff cutting at Kakumae is still to be examined. So far it had shown resistance to the wave action during the storm of November 2001 although few places at the beach have been washed off.

Overall the coastal protection scheme has been reasonably effective; apparently hard measures are effective in this area where the long shore transport is negligible. The main erosion problems are caused by cross-shore transport.

Possible undesirable side effects

No undesirable side effects have been identified so far at these relatively low-energy coasts. However in the conditions of sediment deficit and the increasing storm activity any future interventions into the coastal zone should be considered cautiously within the study area.

Gaps in information

The coast of the study area is very diverse both regarding geological structure, coastal dynamics and user functions. Therefore a very individualized case-to-case approach is necessary in order to understand and to predict the dynamism of the coastal zone in various places. Longer-term observations about the eventual impacts of the increasing storm-damage on different coastal strips are needed.

5. REFERENCES

Bird, E. (1989). *The effects of a sea level rise on the Estonian coastline*. Proc. Estonian Acad. Sci. Geol., vol. 38, 4, p. 141-149.

Ehrlich, U.; Krusberg, P.; Habicht, K. (2001). *Estonian Coast: Structure of Land Cover and Level of Protection.* In: E. Ozhan (ed.) Proceedings of the Fifth International Conference on the Mediterranean Coastal Environment. Ankara.

Martin, G.; Palo, A.; Moeller, K. (1998). *Introduction to the marine and coastal environment of Estonia*. In: Red List of marine and coastal biotopes and biotope complexes of the Baltic Sea, Belt Sea and Kattegat (compiled by H. von Nordheim & D. Boedeker). Baltic Sea Environment Proceedings, No. 75, Helsinki Commission.

Orviku, K. (1975). *The seacoasts of Estonia* (in Russian). Tallinn.

Orviku, K. (1992). *Main tendencies of the shoreline migration in the northern Baltic Sea area during the past 100 years*. In: Orviku, K. (ed.) Main regularities and tendencies of the Baltic Sea shoreline migration during the past 100 years (in Russian). Tallinn.

Orviku, K. (1992). *Characterization and evolution of Estonian seashores*. Summary of the Doctoral Thesis at Tartu University, Tartu.

Orviku, K.; Grano, O. (1992). *Contemporary coasts*. In: A. Raukas & H. Hyvarinen (eds.) Geology of the Gulf of Finland (in Russian). Tallinn.

Orviku, K. (1995). *Extensive storm damage on the Estonian seashore – sharpening conflict between man and nature?* In: V. Gudelis & al. (eds.) Coastal conservation and management in the Baltic region. Proceedings of the EUCC-WWF conference, Klaipeda.

Orviku, K.; Bird, E.; Schwartz, M. (1995). *The Provenance of Beaches on the Estonian islands of Hiiumaa, Saaremaa and Muhu*. J. Coast. Res., vol. 11, 1, p. 96–106.
Tallinn in figures (2001). http://www.tallinn.ee

Wormgoor, J.; Duyvestein, F.; Pickaver, A. (2002). *Coastal Management in Estonia:* http://www.coastalguide.org/icm/baltic/index.html

Tallinn case area study was compiled by **Dr. Ramunas Povilanskas**, Associate Professor, Klaipeda University, in consultation with: **Mr. Ullas Ehrlich**, Senior Researcher, Estonian Institute of Economics at Tallinn Technical University; **Mr. Juri Lass**, Director General, Spatial Planning Department, Estonian Ministry of Environment, **Dr. Kaarel Orviku**, Project Leader, Merin Consultants, Tallinn, Estonia.

December, 2002