MEASUREMENT METHODOLOGY OF LOSSES DUE TO EROSION OF COASTAL AREA IN LATVIA

Liga Brunina

Faculty of Economics, Latvia University of Agriculture

The aim of this paper is to elaborate a methodology for the measurement of structure of coastal area which is threatened by erosion and to develop a methodology for appraisal of losses due to coastal erosion based on the coastal erosion forecasts for the next 50 years. The goal of valuation is to provide a value for all assets within a coastal area: how much a square metre of a protected area or a beach costs. The following tasks were carried out to achieve the aim: analysis of literature of worldwide recognised coastal researchers; derivation of appropriate figures and methodology for Latvia’s situation; assessment of economic sectors related to coastal area in Latvia as well as calculation of the losses due to coastal erosion for particular location within the area of wastewater treatment plant in Liepaja city. Latvia’s coastline is characterised by erosion patterns, alternated with areas subject to accretion through sediment deposition. According to the data acquired from the coastal monitoring stations, erosion has increased more than 4 times in the past 15 years compared with the 20th century, and approximately 33% of the coastline is currently subjected to erosion. Worldwide, governments and private organisations regularly have a need for estimates of the economic value of natural resource services for cost-benefit analysis, natural resource damage assessments, or facilitation of natural resource policy and management decisions in general. Latvia still lacks a state policy regarding coastal erosion prevention as well as adapted method for calculation of damages caused by coastal erosion and its consequences. Therefore, the author of this paper basing on the results of scientific studies has adapted a technology for the elaboration of methodology for calculation of losses caused by coastal erosion in Latvia. The analysis is derived from the estimates on the economic effects of the sea level rise elaborated by coastal economic scientists of the USA, Germany, and the Netherlands. The research serves as a framework for definition of fields related to Latvian coastline and determines related values of land and capital with per-unit costs of coastal quantities, and costs of dry land and wetland lost to the sea level rise. The author has elaborated and presented in this paper the formula of measurement methodology for Latvian coastline based on the results of Latvian scientific programme “KALME” as well as the analysis of Latvian coastline and its structure and features. For instance, the elaborated methodology was used for estimation of losses due to erosion in coastal area of the wastewater treatment plant in Liepaja city. The problem of coastal erosion for wastewater treatment plant in Liepaja city is extremely significant. Therefore, the design of coastal defence was elaborated in 2009 based on the research study of coastal erosion. Due to discrepancies in legislation and absence of measurement methodology of coastal economics, the author of this paper estimated that the coastal defence alternative, which was chosen within Liepaja coastal protection project - mole would be more expensive instead of the refused alternative – coastal nourishment.

Key words: coastal economics, coastal erosion, environmental value transfer.

JEL classification: Q54, Q57

Introduction

The coastal zone is aesthetically desirable and economically important. The contribution of the coastal areas to economic activity is disproportionately high relative to the land area. Likewise, in Latvia one of the principal geographical features of the country is its strategic Baltic Sea coastline with the population of one million inhabitants residing within 5-10 km of coastal area, subjected to anthropogenic influences and characterised by a multiplicity of beaches and coastal environments.

Of the many impacts of climate change, the sea-level rise is often seen as one of the most threatening. The impacts of sea level rise are straightforward – more coastal erosion and sea floods, unless costly adaptation is undertaken – and unambiguously negative.

Worldwide, coastal zones experience increased rates of erosion due to the sea-level rise, increased storm surge frequencies, reduced sediment deliver to the coast as well as anthropogenic factor degradation and transformation of natural coastal areas (Eberhards, 2003). According to Leatherman, “while many factors contribute to shoreline recession, the sea level rise is considered the underlying factor accounting for the ubiquitous coastal retreat” (Leatherman, 2001, p. 183). He has highlighted concerns in coastal areas, such as pressure on water resources, energy and transport infrastructure;
land degradation; pollution; ecosystem destruction; and population growth. Furthermore, Wascher (2001, p. 129) has observed that many natural landscapes have become cultural landscapes and consequences have led to the environmental degradation.

The European coast is under a rising threat from erosion. A fifth of the enlarged EU coastline is already severely affected, with coastlines retreating by between 0.5 and 2 m per year and by 15 m in a few dramatic cases (Europa 2007a), such as in Latvia (Eberhards et al. 2009). Latvian coastline is characterised by erosion patterns, alternated with the areas subjected to accretion through sediment deposition. According to the data acquired from the coastal monitoring stations, erosion has increased more than 4 times in the past 15 years compared with the 20th century, and approximately 33% of the coastline is currently subjected to erosion (Brunina L., Rivza P., 2010). Therefore, the aim of this paper is to elaborate a methodology for the measurement of structure of coastal area, which is threatened by erosion, and to develop a methodology for appraisal of losses due to coastal erosion based on the coastal erosion forecasts for the next 50 years. The goal of valuation is to provide a value for all assets inside a coastal area: how much a square metre of a protected area or a beach costs. The following tasks were carried out to achieve this aim: analysis of literature of worldwide recognised coastal researchers; derivation of appropriate figures and methodology for Latvia’s situation; assessment of economic sectors related to the coastal area in Latvia as well as calculation of the losses due to coastal erosion for particular location within the area of wastewater treatment plant in Liepaja city.

**Coastal economics and analysis**

Worldwide, governments and private organisations regularly have a need for estimates of the economic value of natural resource services for cost-benefit analysis, natural resource damage assessments, or facilitation of natural resource policy and management decisions in general. In many cases, it may not be realistic for an organisation to collect primary data on which to base economic value estimates. The agency or organisation in such cases may revolve to benefits transfer techniques to acquire the necessary economic value estimates.

Sea level rise could have very considerable impacts on river deltas, and may wipe out the entire islands and island nations (McLean et al. 2001) as well as threatened by coastal flooding lay-down areas near the rivers mouths (Eberhards et al. 2009). Therefore, sea level rise significantly figures in assessments of the impacts of climate change, and the costs of sea level rise equally significantly figures in estimates of the costs of climate change. The mainstreams of estimates of the economic damages of global warming rely on the methodology of direct costs, i.e. damage equals price times quantity. The direct cost method ignores that the quantity change – the amount of land lost to sea level rise – may well affect the price of coastal land. Furthermore, this method ignores the fact that changes in one market have implications on all other markets.

Scientists of economics from the USA, Germany, and the Netherlands have estimated the Economic Effects of Sea Level Rise by combining values of land and capital with per-unit costs of coastal quantities and costs of dry land and wetland lost to sea level rise. They used two models – the Climate Framework for Uncertainty, Negotiation and Distribution (FUND) and the Future Agricultural Resources Model (FARM) (Darwin et al. 2001, pp. 114-125). The assumed values for the European Community wetlands were 5.21 USD 10^4 ha⁻¹ (FUND model) and 0.038 USD 10^4 ha⁻¹ as well as for the USA the ratio was 5.9 and 0.013 USD 10^4 ha⁻¹ in 2001 (Darwin, 2001, p. 117). These studies verify the use of costs of environmental value or benefit transfer for estimating the losses of eroded lands as well as the results of benefit transfer are widely used in cost-benefit appraisal of coastal management in the UK, the USA, the Netherlands etc. (Turner, 2007, p. 405; Roebeling, 2011, p. 1417).

Environmental value transfer can be defined practically as the transfer of existing economic values estimated in one context to estimate the economic values in a different context (Bergstrom, 2006; Holmes, 2004). Goods and services have a socio-economic value; while processes and components represent natural environment characteristics.

In environmental economics, various models and techniques have been developed to measure the value people attach to natural resources and the services these resources provide. Environmental values are measured in terms of money through the concept of individuals’ willingness to pay (WTP) or willingness to accept (WTA) compensation in order to make them commensurable with other market values. Of these two, the WTP approach has become the most frequently applied and it has been given peer review endorsement through a variety of studies (Arrow et al., 1993).

WTP is measured directly by asking people to state a WTP amount in a social survey format called contingent valuation (CV), and indirectly by assuming that this value is reflected in the costs incurred to travel to specific sites (travel cost (TC) method) or prices paid to live in specific neighbourhoods (hedonic pricing (HP) method). The latter two approaches measure environmental use values through revealed preferences, while CV is believed to be able also to measure non-use or passive use values through stated preferences (Brander, 2006, pp. 224-228.). Analysis of the research results and the survey derived from the interviews with coastal board experts highlight that the travel cost and hedonic pricing manner are the most appropriate methods for Latvia. It is explained by different focus groups located in coastal area as well as their specific desire and mainly relatively low influence level on the social and politic level.

Environmental value or benefits transfer remains a controversial issue in various policy contexts, not least because of academic and political reservations over the usefulness and technical feasibility of economic valuation.
tools to demonstrate the importance of environmental values in project or programme appraisal.

Environmental value transfer is commonly defined as the transposition of monetary environmental values estimated at one site (study site) through market-based or non-market-based economic valuation techniques to another site (policy site). The most important reason for using the previous research results in new policy contexts is cost-effectiveness. Applying the previous research findings to similar decision situations is a very attractive alternative to expensive and time-consuming original research for quick information on decision-making. Environmental value transfer has been applied extensively in various natural resource policy contexts, ranging from water quality management and associated health risks to waste and forest management (Brouwer, 2000, p. 138).

The author of this paper considers that for environmental value transfer in case of Latvian coastline we shall follow the European experience and adapt their research results, because of the similar climate conditions, common regulations of the European Union, and possibility to adjust local legislation and guidelines to the coastal area management and economics.

Natural habitats values

Still there are several methods how to calculate the losses of eroded territories considering not only market price of lands but also environmental services or environmental value transfer. Woodward and Wui (Woodward, 2001, p. 258.) have revised 39 studies that contained sufficient data to allow inter-study comparisons for meta-analysis. Meta-analysis has proved to be a useful tool for synthesising the results of numerous studies. The method has recently gained interest in economics as a way to appreciate numerous studies that have placed economic values on environmental goods and services (Brouwer, 2000, pp. 141-144). The central advantage of meta-analysis is that it provides a rigorous statistical synthesis of the literature that cannot be achieved using more qualitative analysis.

Wui and Brouwer divided studies – the weak and strong, and the results showed that, on average, the both studies do not yield statistically different values. Excluding the highest value in collected data set, the average of the weak studies is USD 986 per acre versus USD 915 for the strong studies in price of 1990. Predicted values per acre of wetland services in that study were – flood, bird watch and hunting, commercial, and recreational fishing, amenity, habitat storm, and quantity and quality. The different value of USD150 ha\(^{-1}\)yr\(^{-1}\) is drawn from Brander et al. (2006, p. 234) wetland value meta-analysis and is the median value for salt/brackish marsh. Still this value is low compared with the mean value for salt/brackish marsh of about USD 2800 ha\(^{-1}\)yr\(^{-1}\) taken from the same study. As such, the author would expect the value of USD 150 ha\(^{-1}\)yr\(^{-1}\) to represent a lower bound on the range of possible values. Also the research funded by the US Country Studies programme and the Estonian Science Foundation grants showed the average value of wetland in Estonia in 1995 as USD 219 ha\(^{-1}\)yr\(^{-1}\). Even in Portugal, the values of wetlands vary from EUR 11.588-22.714 ha\(^{-1}\)yr\(^{-1}\) (Roebeling, 2011, p. 1417). In 2007, the USA and Mexico institutes of Ecological Economics calculated the Ecosystem Service Product for natural (terrestrial and aquatic separately) and altered coastal ecosystems on the global scale. The results showed values as follows: wetlands – 436, grasslands – 21 and scrublands – 73.12 USD 107 ha\(^{-1}\)yr\(^{-1}\) (Martinez, 2007, p. 257.)

Carbon values

Carbon values – the monetary value of carbon storage are estimated likewise habitat values. Worldwide, monetary estimate on the environmental damage done per tonne of carbon dioxide emitted into the atmosphere – the damage cost avoided by storing rather than releasing a given quantity of carbon dioxide equivalent units. A recent meta analysis undertaken by Tol (2005, p. 2067), using only peer reviewed studies, estimated that the mean marginal damage cost of carbon dioxide emissions was USD 50 tC\(^{-1}\) (in 1995, USD) and a value of USD 230 tC\(^{-1}\) (Tol, 2005, 2070) to represent an upper estimate of the value of carbon storage, and a lower value was found USD 4 tC\(^{-1}\) by Tol. For estimation of carbon values, the author derived price from USD 230 per tC.

Though the carbon values in Latvia are used only for calculation of emission quotas, still Latvian policy makers are not concerned about facility for future. The problem is that environmental values are not taken into account as a whole system because the economic contribution of environmental services is not seriously considered. The author of this paper considers that natural habitats and carbon values shall be taken hold of based on the worldwide tendency, climate changes and increasing density of population especially in coastal area.

Latvian coastline features and related losses due to erosion

Although, in few cases private households, municipal road, part of a cemetery and other properties have actually been eroded by anthropogenic activities, Latvia still lacks the state policy regarding coastal erosion prevention as well as an adapted method for calculation of damages caused by coastal erosion and its consequences. The research programme “KALME” (Eberhards, 2009) defined eroded coastal areas as well as the territories for the application of hard coastal defence structures, soft defence structures, and no-defence zones. However, the results of the programme are not considered by the governmental institutions or included in currently elaborated planning documents. It can be explained by incomprehension of potential damages and their losses. Therefore, the author of this paper basing on results of worldwide scientific studies has adapted a technology for elaboration of the method for calculation of losses caused by coastal erosion in Latvia as a result of which, the following formula is introduced:
where \( T \) - total losses of eroded places (LVL), \( A \) - agricultural losses (LVL) due to erosion, \( F \) - forest losses (LVL), \( P \) - private lands losses (LVL), \( R \) - commercial and manufactory losses, (LVL), \( I \) - infrastructure losses (LVL), \( B \) - beach losses (LVL), \( N \) - natural habitats losses (LVL) and \( H \) - heritage losses (LVL). For each component a segregated formula has been elaborated taking into account their specific characteristics.

Agricultural and forest values are determined in several scientific pieces of research from 107 EUR \( ha^{-1} \) \( yr^{-1} \) for agricultural lands to 350 EUR \( ha^{-1} \) \( yr^{-1} \) for forests (Roebeling, 2011 p. 1417) as well as Estonian researchers estimate agricultural lands 282 USD/ha/yr and forests average 200 USD \( ha^{-1} \) \( yr^{-1} \) in prices of 1995. However, Portuguese scientists were not taking into account the possible yield of lands, still the USA and Estonian researchers identify separately costs for timber, hay etc. (Kont, 2008, p. 427).

Therefore, the author of this paper for the estimation of Latvian losses has assumed only those internationally scientifically grounded methods to define prices, which are outside these research works due to non-appropriate data for Latvia such us the calculation of carbon, wetland, and cultural heritage values.

\[
A = S_A (C_A + A_p \times a_p + A_r \times a_r + C_{taxA} \varphi \times yr + S_{BA} \times (2B_{BR} \times C_{BA} + B_{An} \times C_{BA} + C_{taxBA}) \times 2\%) \times yr
\]

where \( S_A \) - arable land area (m²), \( C_A \) - cadastral value for arable land (LVLm²), \( A_p \) - yield per square metre (kgm⁻²), \( a_p \) - average yield price (LVLkg⁻¹), \( A_r \) - hay per pasture area (kgm⁻²), \( a_r \) - hay price (LVLkg⁻¹), \( C_{taxA} \) - cadastral tax for agricultural lands (LVLm²), \( B_{Br} \) - existing or operating agricultural buildings (if lost, a new one shall be built; therefore, a multiplier is 2 (lump sum), \( S_{BA} \) - cadastral tax for agricultural buildings area (m²), \( C_{taxA} \) - cadastral value for agricultural buildings (LVLm²), \( C_{taxBA} \) - cadastral tax for agricultural buildings, (LVLm²), - percentage of probability of erosion in a certain year, and \( yr \) - number of years.

\[
F = S_F (C_F + F_{tim} \times a_{tim} + V_{tc} \times C_{taxF} \varphi \times yr)
\]

where \( S_F \) - area of woodland (m²), \( C_F \) - cadastral value for woodland (LVLm²), \( F_{tim} \) - timber per square metre (m³m⁻²), \( a_{tim} \) - timber price per m³ (LVLm³), \( C_{taxF} \) - cadastral tax for woodland (LVLm²), \( V_{tc} \) - carbon value estimation is shown in Formula 4 (LVL).

\[
V_{tc} = \frac{12tCO_2}{44tCO_2} \times \frac{1tCO_2}{1m^3} \times LVL / tC
\]

where \( tCO_2 \) - amount of storage per one timber cubic metre and proportion 12/44 is used to find one tonne carbon.

\[
P = S_P (2 \times C_P + C_{taxP} \varphi \times yr + (2(B_P \times C_{BP} \times S_{BP} + B_{PS} \times C_{BPS} \times S_{BPS} + B_{PP} \times C_{BPP} \times S_{BPP}))
+ S_{BP} \times C_{taxBP} + S_{BPS} \times C_{taxBPS} + S_{BPP} \times C_{taxBPP} \times 2\% \times yr
\]

where \( S_P \) - area of private lands, (m²), \( C_P \) - cadastral value for private lands (LVLm²), \( C_{taxP} \) - cadastral tax for private lands (LVLm²). Public buildings are divided according to three main values based on cadastral classification and referable prices in Latvia as follows: \( B_p \) - number of private living houses (lump sum), \( B_{PS} \) - number of private economy houses (lump sum), and \( B_{PP} \) - number of private auxiliary buildings (lump sum). The same categories are used for areas, cadastral values and taxes: \( S_{sp} \) - area of private living houses, (m²), \( S_{SP} \) - area of private economy houses (m²), \( S_{SP} \) - area of private auxiliary building (m²), \( C_{taxP} \) - cadastral value for private houses (LVLm²), \( C_{BPS} \) - cadastral value for private economy houses (LVLm²), \( C_{BPP} \) - cadastral value for private auxiliary buildings (LVLm²), \( C_{taxBPS} \) - cadastral tax for private economy houses (LVLm²), \( C_{taxBPP} \) - cadastral tax for private auxiliary buildings (LVLm²).

\[
R = (2S_{Re} \times C_R + S_{Re} \times C_R + S_B \times C_{taxB} + V_F \times \varphi \times yr + (2B_{Re} \times C_{BR} \times S_{BR} + B_{Ro} \times C_{BR} \times S_{BR})
+ S_{BR} \times C_{taxBR} + V_F \times 2\% \times yr
\]

where \( S_{Re} \) - area of existing factory lands (m²), \( C_R \) - cadastral value for factory lands (LVLm²), \( S_{Re} \) - area of non-operating factory lands (m²), \( S_{F} \) - area of factory and commercial lands (m²), and \( C_{taxB} \) - cadastral tax for factory lands (LVLm²). Since post Soviet societies still exist in the coastal area of Latvia and part of them are left unattended; the author of this paper has split them into two main categories: \( B_{Re} \) - number of existing factory and commercial buildings (lump sum), \( B_{Ro} \) - number of non-operating factory buildings (lump sum), \( C_{BR} \) - cadastral value for factory buildings (LVLm²), \( S_{BR} \) - area of factory and commercial buildings (m²), and \( C_{taxBR} \) - cadastral tax for factory buildings (LVLm²). The author of this paper highlights the losses on possible downtime or idle standing due to erosion or coastal floods. The figure \( V_F \) - economic losses
Economics and Rural Development

(LVL) - is estimated basing on the information obtained within the project co-financed by the European Commission Directorate-General Transport and Energy (Bickel, P. et al. (2006) HEATCO deliverable No. 5 “Proposal for Harmonised Guidelines. EU Project Developing Harmonised European Approaches for Transport Costing and Project Assessment (HEATCO).” Institut für Energiewissenschaft und Rationelle Energieanwendung, Stuttgart). In accordance with the report, the human lifesaving costs as a factor are considered in cost-benefit analysis; for Latvia (2005), these costs were estimated at EUR 275,000. Assuming that these costs are the expenses of the government and should be covered by economic reasons, then EUR 275,000 are divided by the average working time of people, approximately - 45 years and 22 days per month, an average per day rate of one man-day in Latvia is obtained, which was equivalent to EUR 23 or LVL 16 in 2005.

\[ V_F = D \times d \times (P_u + P_{af} + P_{av}) \]  

where \( D \) - downtime, idle standing (LVL 16 per day in 2005), \( d \) - number of working days, \( P_u \) - number of people who are not able to work because of eroded or flooded sections, and \( P_{af} \) - due downtime in this industry – number of affected people – example, electricity or wastewater treatment plant disorders.

\[ I = (I_{rv} \times C_{rv} + I_{gov} \times C_{lgov} + I_{el} \times C_{el} + I_{mt} \times V_{mt} + I_{park} \times C_{park} + I_b \times V_b) \times \phi \times yr \]  

where \( I_{rv} \) - local road area (m²), \( C_{rv} \) - local road cadastral value (LVLm⁻²), \( I_{gov} \) - governmental significance of a road (m²), \( C_{lgov} \) - cadastral value of gov. roads (LVLm⁻²), \( I_{el} \) - overhead line length/power line length (m), \( C_{el} \) - value of powerline (LVLm⁻¹), \( I_{mt} \) - mobile connection tower (lump sum), \( V_{mt} \) - value of mobile connection t (LVL), \( I_{park} \) - parking space (m²), \( C_{park} \) - cadastral value of parking spaces (LVLm⁻²), \( I_b \) - settled area (m²), and \( V_b \) - value of settlements (LVLm⁻²).

\[ B = S_B \times (C_P + \phi \times (V_{Bsm} + V_{Bgr} + V_{Boli})) \times \phi \times yr \]  

where \( S_B \) - beach area (m²), \( C_P \) - cadastral value of beach estimated from cadastral value for private lands (LVLm²), \( V_{Bsm} \) - value of minerals in market prices for sand (LVLm⁻³), \( V_{Bgr} \) - value of minerals for gravel (LVLm⁻³), \( V_{Boli} \) - value of minerals for shingle (LVLm⁻³), and \( \phi \) - beach coefficient for minerals amount lost per square metre (m³m⁻²). This figure is different for each place because of geological structure.

\[ N = S_N \times (V_N + C_N) \times \phi \times yr \]  

where \( S_N \) - area of natural habitats, wetlands (m²), and \( V_N \) - scientific approved wetlands or natural habitats value per square metre (LVLm⁻²).

\[ H = (H_p \times S_H \times C_p + c_i + P \times P_e) \times \phi \times yr \]  

where \( H_p \) - lost area of heritage, manor house, nature pathway etc. (lump sum), \( S_H \) - lost area of heritage, manor house, nature pathway (m²), and \( C_p \) - cadastral value of heritage area estimated on the background cadastral value for private lands (LVLm²). This assumption likewise beach cadastral value is based on the possible use of hedonic method for estimation of heritage value. In addition, travel costs method could be used to estimate the value. Therefore, Formula 11 appraise the \( P \) - annual number of visitors and \( P_e \) is an average travel cost per trip (LVL).

After estimation of losses, it will be possible to apply cost benefit analysis for realignment of costs to compare and assess the financial-economic viability of concrete coastal defence. Thus, the net present value – NPV for each actual territory will be calculated, including building and maintenance costs of coastal defence structures.

Basing on the information mentioned above, the author of this paper has elaborated a model of calculation, which is provided for specialists of coastal municipalities and spatial planers. Filling in the appropriate, municipality specific data they will obtain financial projections of losses due to coastal erosion for the next 50 years. For the verification of the calculation, the author of this paper estimated losses caused by coastal erosion in the area of wastewater treatment plant in Liepaja city.

Example of coastal erosion measurements in Liepaja city

The author of this paper recommends using the elaborated methodology for each municipality in spatial planning to estimate the economic losses due to coastal erosion and flooding.

The author of this paper has estimated losses due to erosion in coastal area of wastewater treatment plant in Liepaja city.
basing on the elaborated methodology. The problems of coastal erosion for wastewater treatment plant in Liepaja city are very significant and the design of coastal defence was elaborated in 2009 (Bethers, 2007; Bethers, 2009; Brunina, 2010).

In Liepaja city, wastewater treatment plants were built in the downwind area of Liepaja harbour in the beginning of the 1960s approximately 400 m within the coastline. At present, they are situated less than 50 m from the coastline. Due to the erosion “Liepajas udens” has started to protect their area approximately 20 years ago via building two tire walls on basement of wood pales and wiry of steel. The storms in January of 1999 and 2005 washed away the most part of coastal protection as well as the fore-dune was destroyed. The Chlorinate building of Liepaja city wastewater treatment plants now is located less than 30 m from the waterline. The seriousness of situation and the severe consequences that could arouse if no action is taken compelled “Liepajas udens” to start a new multi-complex approach research project with “Consultant services for coastal protection against erosion” which was financed by the EU Cohesion Fund and “Liepaja udens” private investments. Within the research project, vast dimension of data was collected during a period of two years. A whole year was dedicated for a complex analysis of this data as well as mathematic modelling and situation forecasting in order to choose a better and most suitable design for the desired coastal protection. Within the project, a feasibility study was carried out in order to find the best as well as the most economically and technically justified solution where technical, maintenance, environmental protection, and economic aspects were taken into account. The technical aspects evaluated building possibilities and material availability due to local individualities, the aspects of maintenance covered institutional capacity, local shoreline management strategy as well as possibility to change dredging methods of Liepaja city port. The environmental impact assessment included the analysis of aspects of tourism, fishing and biodiversity, especially on fish resources, and considering the nearest shoreline territories in terms of cultural and nature monuments. The most important factor was Jewish memorial (cemetery) located less than half kilometre from the wastewater treatment plants of Liepaja city. It was concluded that the bones from Memorial had already been eroded in the previous storms. Therefore, the project team decided to broaden protecting area of coastline due to threats to increase erosion towards the territory of Jewish Memorial. During phases of institutional and environmental analysis, it was found out that coastal protection policy against erosion in Latvia is non-committal. During the phase of comparison of potential alternatives, several problematic aspects came into sight; therefore, bringing some new issues for consideration. The relevant governmental institutions that needed to be involved were identified while assessing related aspects to the alternatives (shoreline nourishment and mole building). Amongst them, there were Latvian Fishing Agency, Environmental Impact Bureau, Liepaja Municipality, Liepaja City Port, the Ministry of Finance etc. The cause of the problematic aspects was mainly related to contradictory interests and complications in cooperation within institutions intersect. The situation shows that the shoreline belongs to the Ministry of Finance, while building activities in coastal area are under the “Law on Environmental Impact Assessment”. The sand dredged out from port navigation area could be used for feeding of wastewater treatment plant’s shoreline but it compels to the authorities of Liepaja port and municipality to undertake new actions and change the existing solutions. Considering these circumstances, it was finally decided, that the building of mole is more appropriate. This alternative caused the elaboration of new rules of the Cabinet of Ministers (Brunina, 2010).

Evaluation of results and conclusions

Basing on the project results, the author of this paper considers that the environmental losses of the chosen coastal defence – mole will be impressive because of governmental organisations, which due to discrepancies in legislation accept a more inconvenient solution without economic calculations. The calculation method is elaborated by comparing 3 alternatives – “zero alternative” – do nothing; Alternative 1 – mole construction and Alternative 2 – beach nourishment. The results show that within zero alternative the land losses will achieve 55 ha in the next 50 years and the wastewater treatment plant will be washed away completely; Alternative 1 will produce coastal defence for the wastewater treatment plant increasing approximately 12-13 ha in protected area, yet erosion beyond the area will be more critical as results of which the area of 85 ha will be lost, resulting in a final balance of minus 74 ha in total. With shoreline nourishment, both the existing erosion will be stopped and additional accumulation of shoreline area will reach 37 ha, totally obtaining circa 82 ha.

Based on the previous studies, the forecasts of amount of washed sand from beach area (in Liepaja average 2m³ per m of coastline) were estimated by using an average market price (2 LVLm⁻³). The forest area was derived from the data of contiguous coastal territories – in Liepaja city, Tosmare restricted area and Medze nature territory (60 m wide belt) as well as the restricted territories of Grey Dune was assumed as wetland territories (100-150 m wide belt). Using the Carbon value 222 LVLtC⁻¹ and timber price 25 LVLm⁻³, the results of calculation show that purely environmental losses will compose as minimum as LVL 0.8 million for Alternative 1. Although due to the research restrictions, this estimation did not include the costs of heritage, private lands, commercial lands, and infrastructure. The restrictions are clarified by the necessity in another research – estimation of visitors of Jewish Memorial and nature territories (travel cost method) as well hedonic method used for estimations respective to areas of private housing. Although the costs of factory lands for Liepaja wastewater treatment plant are not considered in this paper due to emergency situation after surge storm; in
this case the losses for related fields – factory, environmental protection and human health will run circa LVL 40 million or even because of necessity to build new wastewater treatment plants.

The author of this paper highlights that the necessity for sustainable development and growth of regional economics is possible within evaluation of all sectors situated in coastal area. Clear criteria and reasons shall be defined for prioritising either of the sectors. The methodology for calculation of losses is provided above; therefore, the final decision - to protect coastal area or not - as well as choosing the most appropriate defence structure shall be based on economic results or other clearly defined criteria. The author of this paper considers that the following steps should be taken by responsible authorities, particularly the most important of which is the development of cooperation between related institutions, the establishment of common strategy on the national level, which would estimate the impacts on the national level, elaboration of the guidelines for regional level management as well as the further research is more than essential. The specialists of municipalities and regional planners shall estimate economic losses based on the calculation of damages of coastal erosion. After that, the amount of necessity for consequent budget line will be made clear. The alternative criteria for economically based solutions should be defined for a long-term period. Therefore, principles of sustainable development require using of economically based solutions and criteria, which shall be established on the national level.

Bibliography