Risk & Vulnerability Assessment tool applicability to coastal zones of SE Baltic

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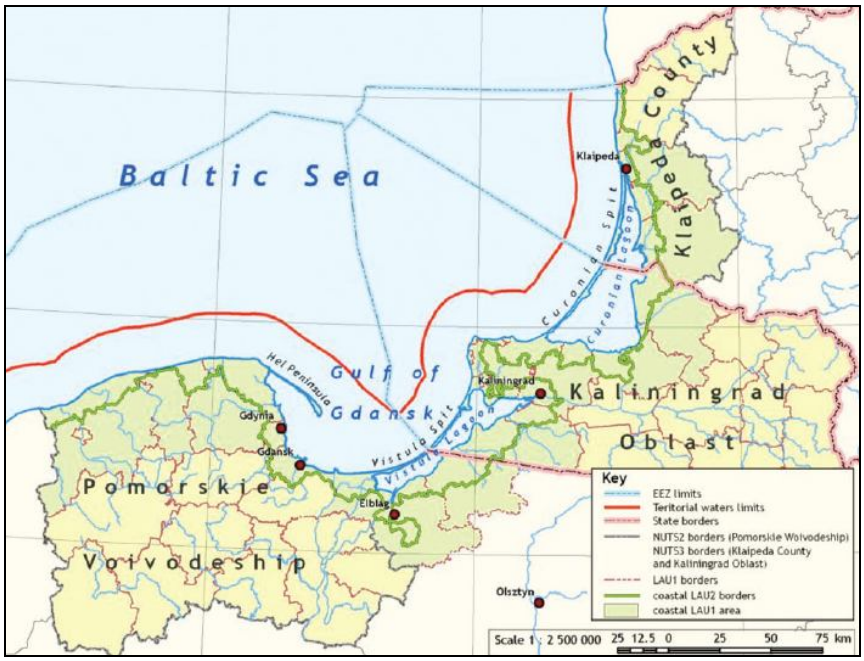
OBJECTIVE:
To test the applicability of developed Risk and Vulnerability Assessment tool in highly sensitive coastal areas of South Eastern Baltic.

INTRODUCTION:
Coastal zones bear large human populations and significant socio-economic activities. They support diverse ecosystems that provide important habitats and sources of food. One third of the EU population is estimated to live within 50 km of the coast, and some 140 000 km^2 of land is currently within 1 m of sea level. Climate change adds to existing pressure on coastal zones and is likely to have significant impacts. According to scientific community and particularly the Intergovernmental Panel on Climate Change (IPCC) most significant and immediate consequences of these climate changes for the world's coasts include sea level rise, coastal erosion, flooding, drought, saltwater intrusion, and ecosystem change. There are also other health, economic and social impacts.
Sandy coasts of South Eastern Baltic (Pomorskie Voivodship in Poland, Kaliningrad Oblast in Russia, Klaipeda County in Lithuania) are particularly sensitive to the changes induced by factors of recent climate changes such us sea level rise, more frequent storm events, seasonal flooding, changed sediment exchange pattern at the nearshore (sand deficit), coastal erosion, etc. These processes are well recognized by scientific community, however still not widely accepted by general public and, by certain means, to urban planners working in the coastal areas. Certain measures should be taken in order to easy up the access to the scientific findings for general public and help to identify appropriate adaptation responses.

- SE Baltic coastal areas



The Vulnerability Assessment Tool was developed by the University of Manchester by applying the principles of an on-line Public Participation GIS. Simplicity of its use and navigation was guaranteed by applying Google Maps and Google Earth API (Application Programming Interface). Although originally the tool was designed to assess vulnerability of urban areas to climate change impacts it also became the good platform for basic knowledge on climate change issues, with proper GIS based visualization and functionality. Apart from the main role of the developed instrument - to increase the adaptive capacity of urban areas to climate change impacts via better informed strategic planning of green and blue spaces, the tool has to be tested in very specific environment – sensitive coastal zone of SE Baltic.
Coastal Research and Planning Institute of Klaipeda University took the responsibility to transform modern GIS software based datasets into the public oriented tool. Testing of the data representation capacity and basic functionalities available on commercial and open source GIS tools was the main objective of the performed exercise.

DEFINITION OF THE COASTAL ZONE

The term ***'coastal zone'*** simply refers to an area either side of where land and sea meet. Its actual size depends on the phenomenon being studied. While talking about physical impact to the coastal zone influenced by the changing climate the most important parts of this zone to be considered are:
'Coast' – the land next to the sea including beach, fore dune or cliff.
'Beach' – extends from the edge of the sea inland to the first change in topography (or land use) such as a fore dune or cliff;
'Shore' – legally, the land between high and low water marks but often used more generally to mean the land along the edge of the sea.
'Coastline' – sea and land contact line.
'Nearshore' – part of the sea adjacent to the coastline extending up to 20 meters in depth.

DATA AND APPROACH:

Coastal zone is a particular area with different natural, economic and social assets that might be or are under the threat. And this should be taken into the consideration very carefully. In order to evaluate the importance of the coastal zone by means of existing developments, leisure potential, cultural heritage and simply living communities, indicators of sustainable development adopted in 2002 by the European Parliament and the EU Council are being used. The State of the Coast Report for the SE Baltic region has been prepared in 2008 in frame of INTERREG IIIA project "Sustainable Development Indicators for ICZM in the South Eastern Baltic (SDI-4-SEB)". Structure of the datasets developed at that time served as a good background when evaluating the risk of the climate change to the social, economic and natural assets in the most integrative manner.
The main steps towards proper risk and vulnerability assessment are:

1. Identification of the direct and indirect social, economic and natural assets exposed to the potential threat.
2. Identification of the main risk factors such as seasonal flooding, coastal erosion, changes in water temperature and salinity, water level rise, extreme storm events, sand deficit.
3. Vulnerability assessment – how different assets are exposed to the potential threats.

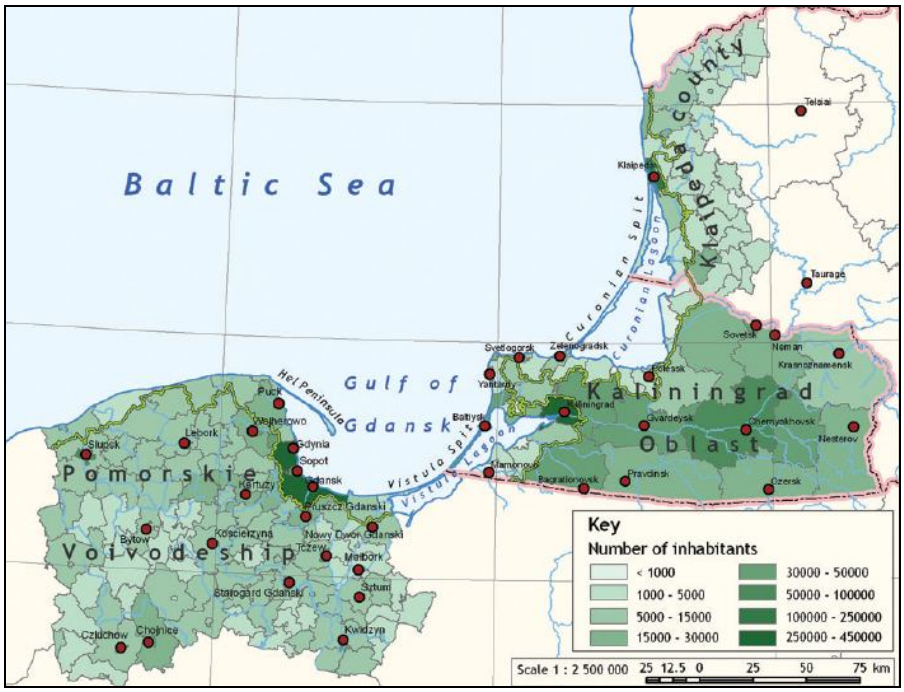
All the tasks mentioned above can be easily completed using traditional commercial and open source GIS tools. However, manipulation of datasets needs professional skills and proper technical base – software, data servers, etc. Developed Risk&Vulnerability

Assessment tool supposed to simplify access to the spatial data and bring available information closer to the end users – decision makers and/or planners.

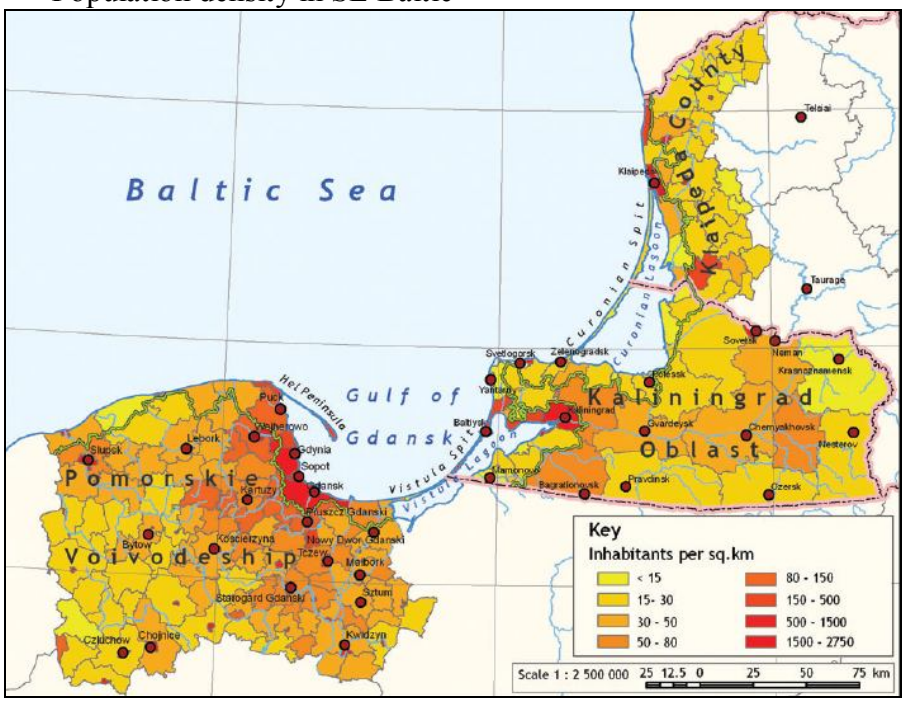
1. Identification of the social, economic and natural assets exposed to the potential threat

Datasets being used for the representation of coastal zone social values:

- Number of inhabitants in SE Baltic

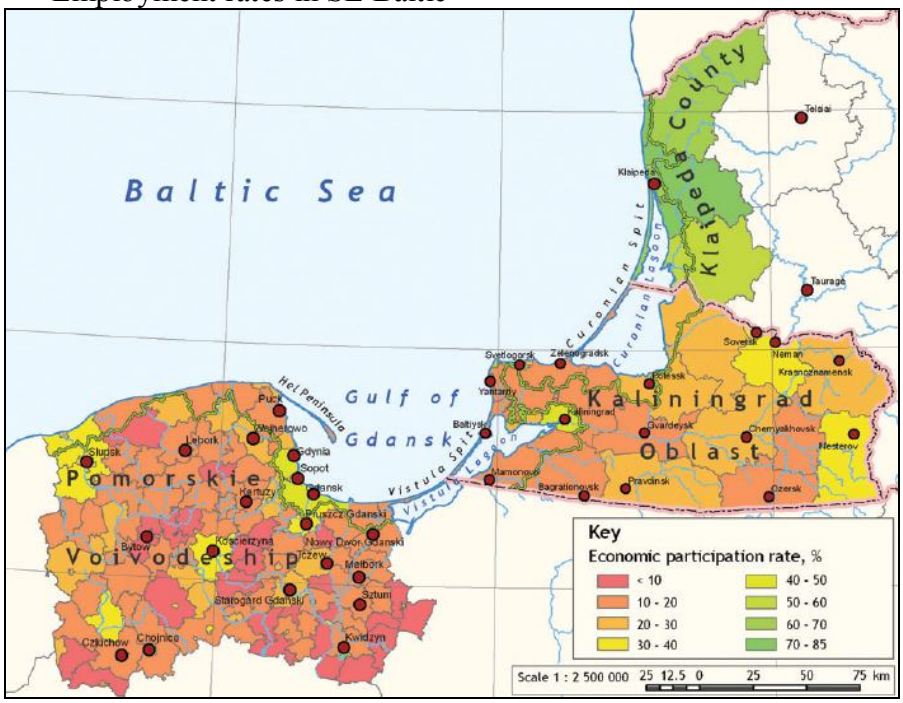


- Population density in SE Baltic



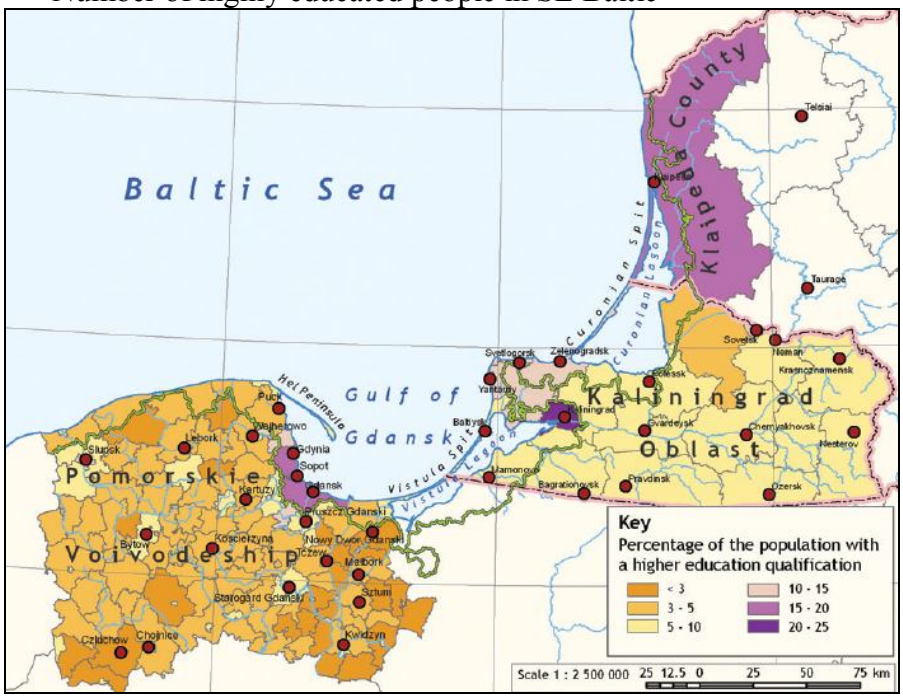
Distribution of the population of a coastal region helps to assess the amount of pressure being exerted on coastal resources by the demand for land, housing, employment, public services, transport, and so on.

- Employment rates in SE Baltic



Such information is necessary when assessing the strengths and weaknesses of the coastal economy and its prospects of generating sustainable employment.

- Number of highly educated people in SE Baltic

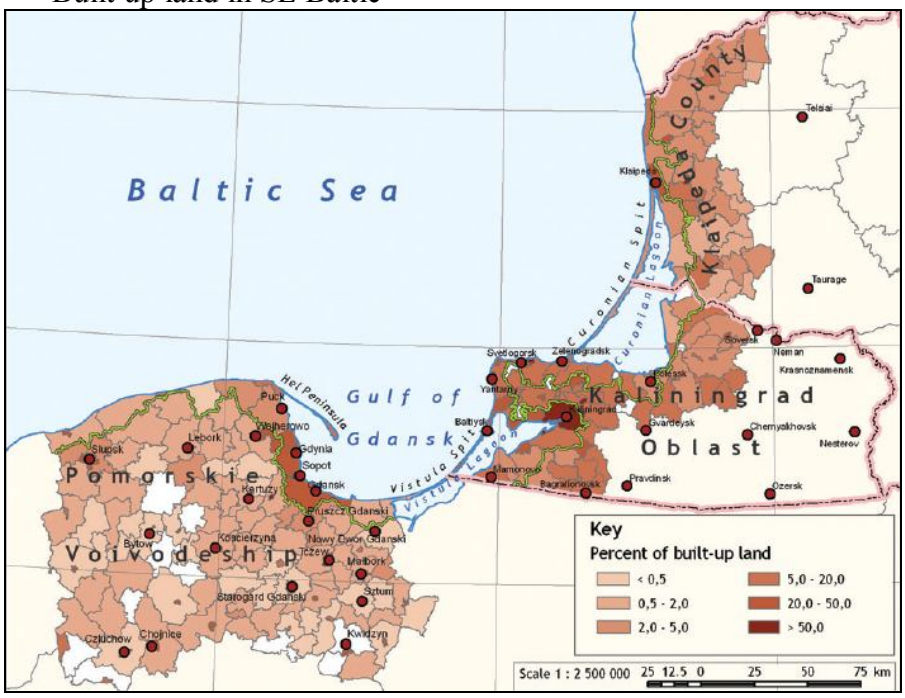


Information about the number of people living at the coast and who have a higher education qualification gives detailed picture of the social and economic structure of the

coastal zone. Educational achievement is often used as a surrogate variable for wealth - the higher the achievement, the greater the prosperity of a community.

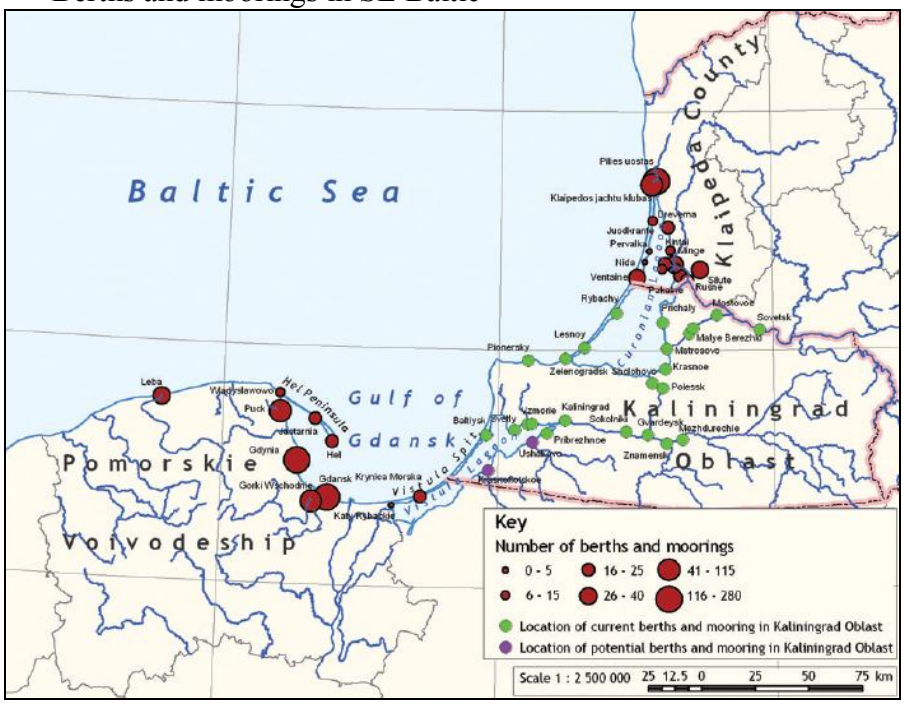
Datasets introducing economical potential of the coastal zone:

- Built up land in SE Baltic



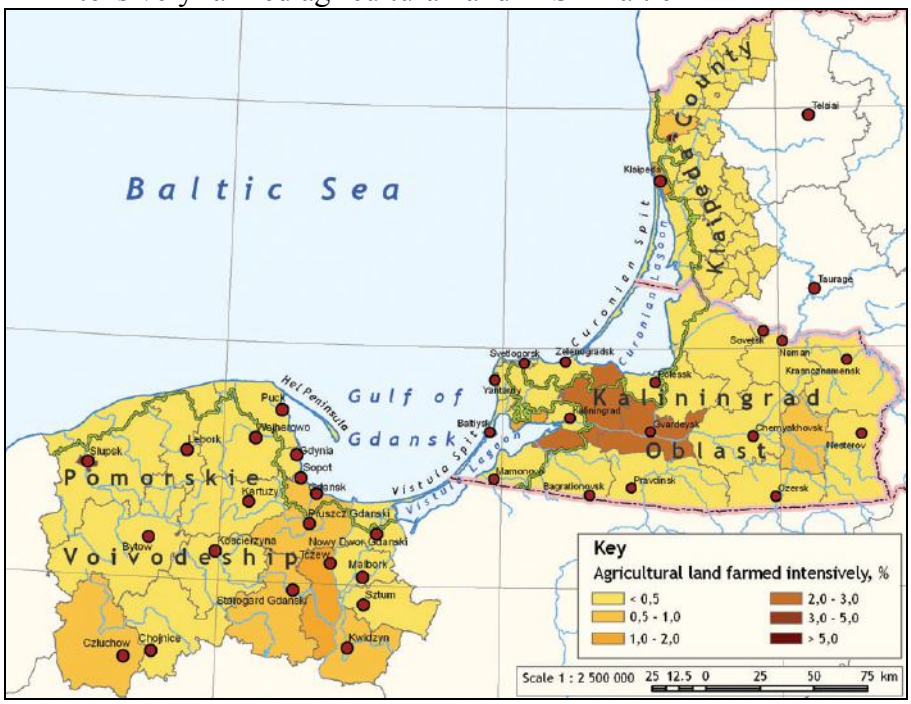
This data allows to identify the extent to which the coast has been built-up over the past years as this will indicate the degree of pressure on the coast and the likelihood of further changes in the future. This also helps to uncover the pattern of development, e.g. has developments concentrate in a relatively narrow coastal strip, or has it spread a considerable way inland.

- Berths and moorings in SE Baltic



This information reveals the pressure exerted by the recreational boats throughout the coast, which is more important in areas close to marinas, harbours with recreational berths and other mooring sites. At the same time it represents the value of the coast by means of created infrastructure and attracted tourism flows.

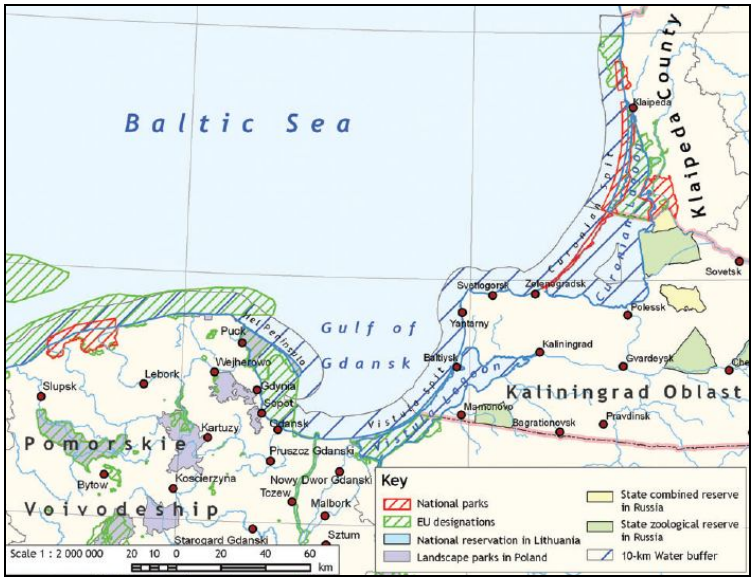
- Intensively farmed agricultural land in SE Baltic



Together with a shift from extensive to intensive agriculture, coastal zones are facing changes in landscape and also established social and economic relationships. This is to be evaluated and there why this is the value to be assessed while considering the potential losses induced by climatic threats.

For expression the natural value of the coastal zone we use integrated indicator – extension of protected areas.

- Protected areas in SE Baltic

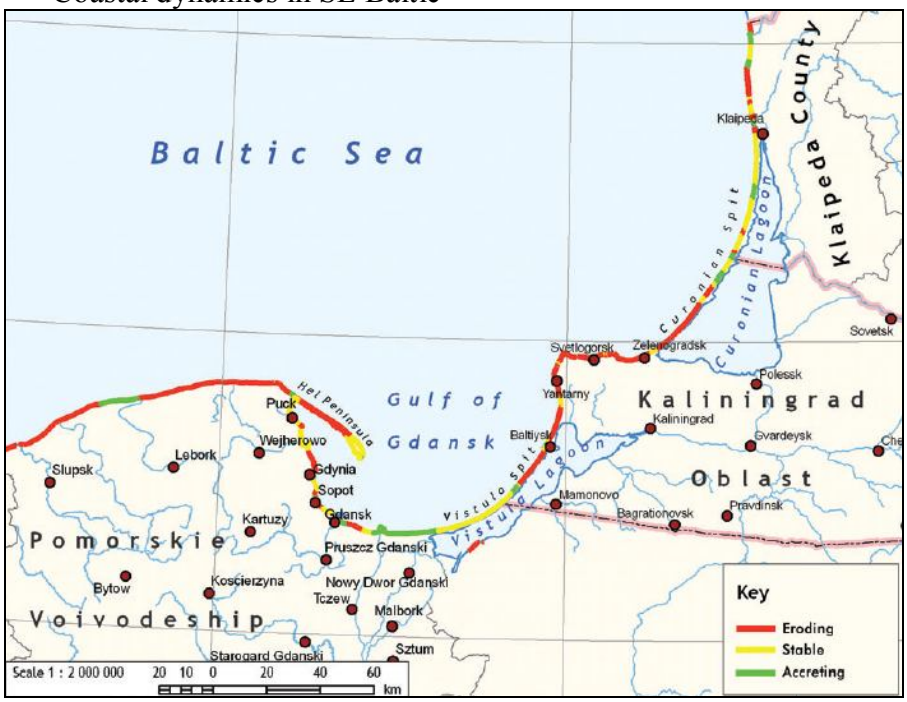


This data expresses the importance of the marine and terrestrial coastal zone with regards to wildlife, conservation of natural areas, special landscapes and landforms; archaeology and cultural 'heritage'. This dataset was used as an example measurement illustrating the natural value of the coastal zone, but we also understand that datasets can be much more widely extended. For example spatial distribution of natural and semi-natural habitats, information of specified habitats and species (e.g. red list species) is very valuable and important information. This is partly covered by the established protected sites and this is the reason why for the assessment tool testing purposes we limit ourselves to this data layer.

2. Identification of the main risk factors

Seasonal flooding, coastal erosion, changes in water temperature and salinity, water level rise, extreme storm events, sand deficit – those are the main risk factors that threatens the natural, economic and, as a consequence, social assets at the coastal zone of SE Baltic region.

- Coastal dynamics in SE Baltic



Coastal erosion is one of the key processes being observed in the whole SE Baltic region affecting the area physically and having further consequences on economy and social wealth of the region. Erosion and accretion are naturally occurring phenomena, existing without human disturbance in a dynamic equilibrium. However, increasing amount of construction works in coastal areas has accelerated the erosion processes in many coastal sectors thus changing the dynamic equilibrium.

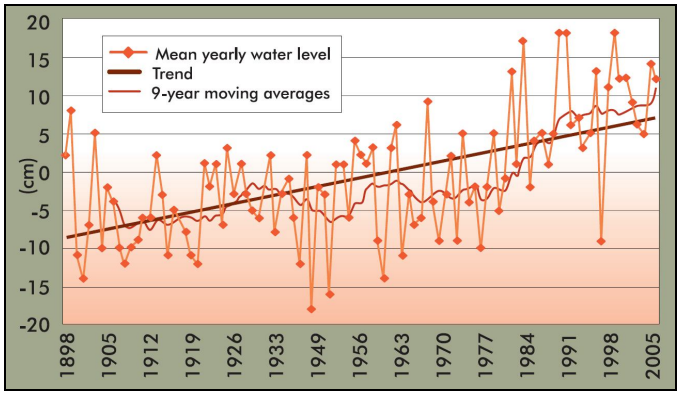
Another important factor, which affects the state of the coast and influences erosion-accretion patterns is coastal protection measures being applied to the most erosive parts of the coast. In this case most relevant is installation of hard structures for the beach and cliffs protection. Those have two functions – positive protective in place where they are installed and negative, fostering the erosion in the adjacent parts of the coast as well as trapping of nearshore sediment drift and as a consequence reducing the overall sediment

balance. Roughly 23% of the South East Baltic coast is protected by hard structures, mostly in harbour areas. The longest continuous stretch of coast protected by hard structures located between Kaliningrad and Baltiysk cities (Russian Federation) on the northern shore of the Vistula Lagoon.

- Hard structures for coastal protection in SE Baltic

It is estimated that ~ 70% of the world's sandy beaches are affected by coastal erosion induced by the sea level rise. Many geomorphological changes in the marine coastal zone are affected by fluctuations in relative sea level. Such changes alter the position and morphology of coastlines, causing coastal flooding, waterlogging of soils and a loss or gain of land. They may also create or destroy coastal wetlands and salt marshes, inundate coastal settlements and induce salt- water intrusion into aquifers, leading to salinization of groundwater. Changing sea level may also have a profound effects on coastal structures and communities. Low-lying coastal areas are particularly vulnerable to sea-level rise.

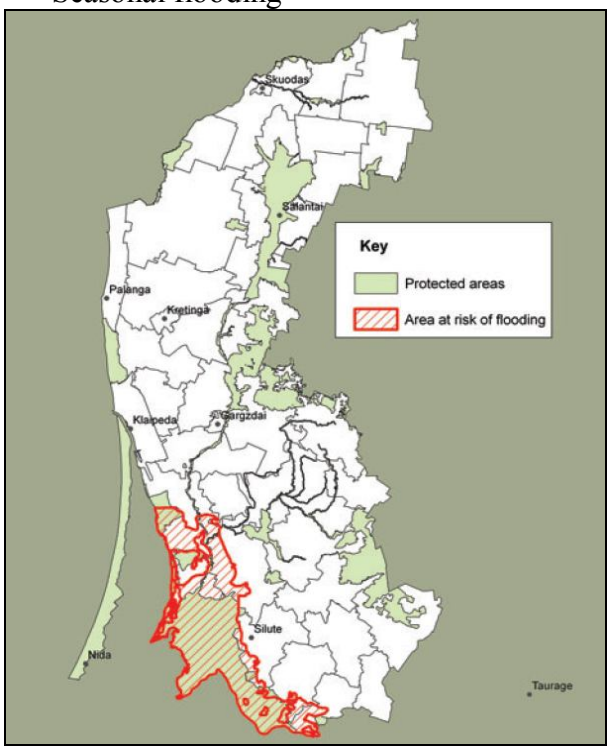
- Sea level rise



Rising sea level and increase in the frequency of stormy weather as a consequence of climate change are exacerbating the risk of flooding along many stretches of coast in the

South East Baltic region. Fluvial flooding is a regular feature, especially in spring when melt water from the interior coincides with storm-driven seas.

- Seasonal flooding



3. Vulnerability assessment

The rate of coastal erosion has been increasing steadily along the entire length of the South East Baltic coast for the past two centuries, but the pace of change has quickened over the last three or four decades. The rate of retreat increases together with the length of eroding coastline, which changed from 18% in 1990 to 27% in 2003. Over three quarters of the Polish coast is retreating, a greater proportion in comparison to any other European country. The greatest rate of erosion can be observed in Kaliningrad Oblast where the length of eroding coast increased by one quarter from 50% in 1995 to 73% in 2005. Those numbers show increasing threat to the recreational potential of the region. Combination of beach area and its capability to host the tourist is the measure that directly illustrates the losses of income in the region. Income is related to number of visitors, number of cars, number of flights, number of hotels, apartments and campsites, number of restaurants, clubs and cafés. The impact can be recognized to be both negative (an increase in CO2 emissions, water consumption, energy use, waste and litter; decline in ecological and cultural diversity) and positive (more jobs, more money, more opportunities, more social inclusion, more stable and prosperous communities).

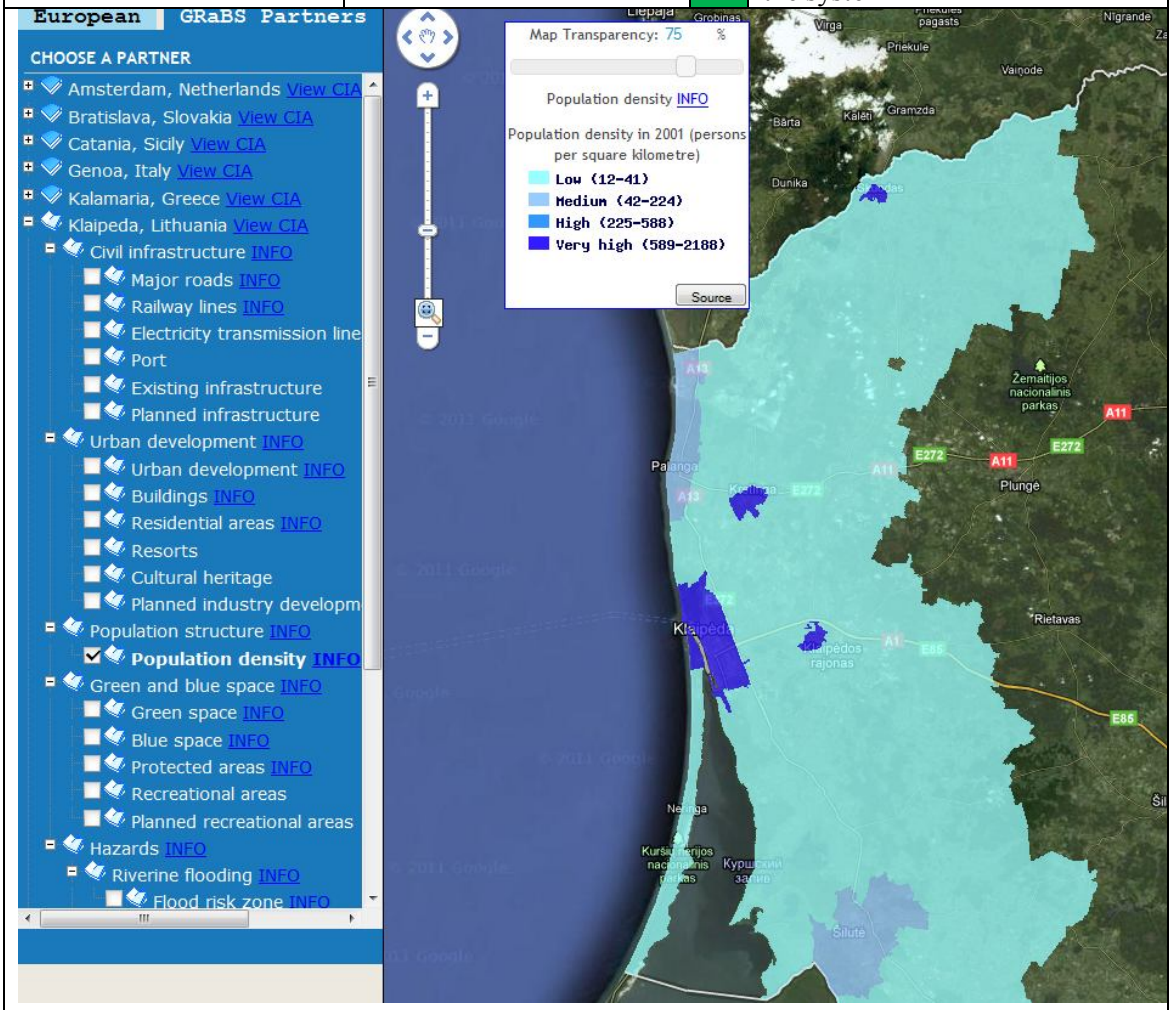
Fluvial flooding is a regular feature of the South East Baltic, especially in spring when melt water from the interior coincides with storm-driven seas. The cost of annual flooding does not appear to be excessive, except in certain localities where properties or infrastructure are under threat. The threat of inundation by the sea would seem to be greatest on the Hel Peninsula in Pomorskie Voivodeship. Whereas in some places, such as the Nemunas Delta in Lithuania, much of the nature conservation interest derives from the annual flood cycle and flooding can not be recognized as a threat but rather basic

conditions for natural assets. Attempts are being made to assess that risk in terms of both the likelihood and the severity of inundation. However, it is also important to identify what damage to natural and human resources will be caused as well as what planning actions are needed to mitigate the impact. In this context planning means striking the right balance between the cost of sea defences and their accruing benefits; preventing further development in areas at risk of flooding; deciding which assets to abandon to the encroaching sea. Hence the number of people living in 'at risk' or vulnerable areas, and the value of threatened natural and economic assets are the proper measurements to be estimated.

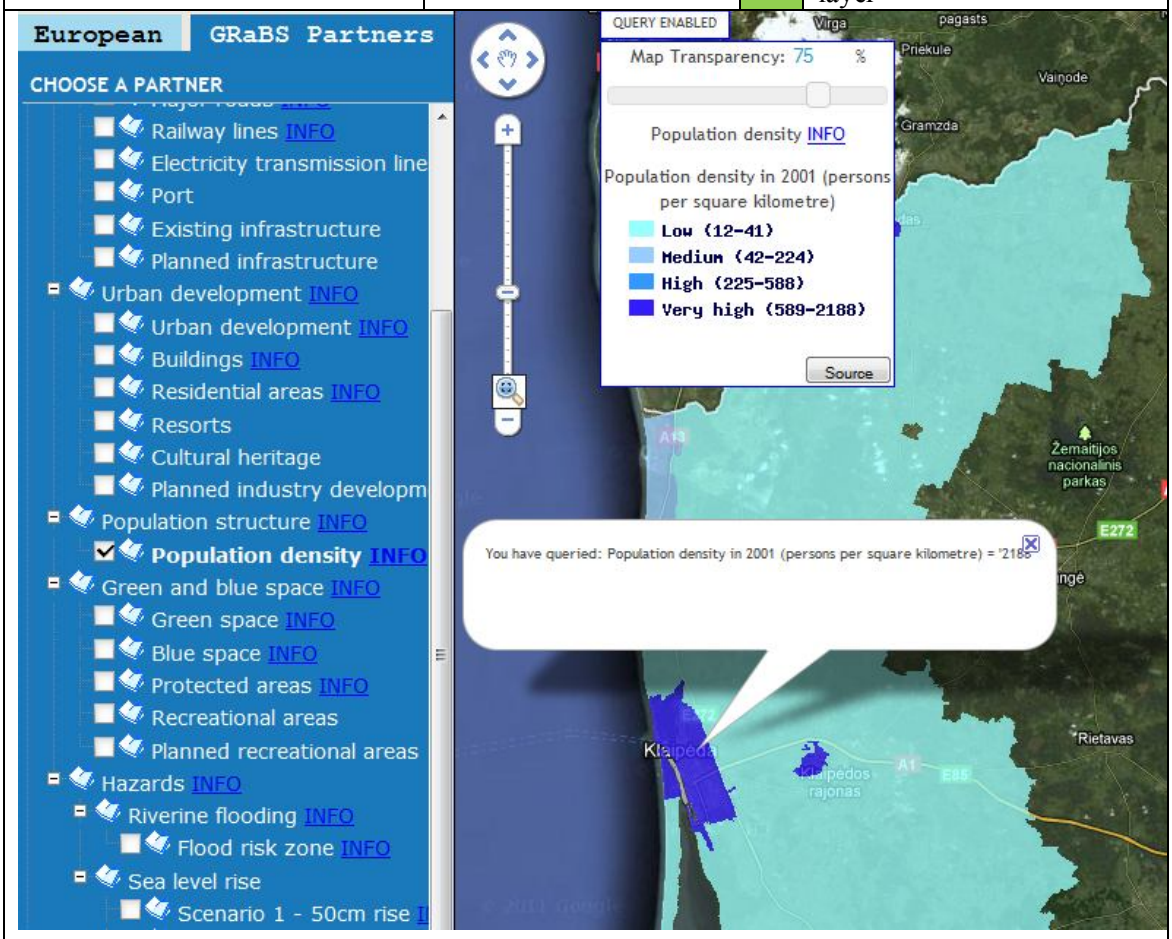
EVALUATION of TECHNICAL CAPABILITIES and FUNCTIONALITY

Introduced approach and datasets that are being used while assessing the vulnerability of the coastal assets to the threats imposed by changing climate conditions had to be transformed to the platform of developed Risk and Vulnerability Assessment tool. In order to do so, certain evaluation of technical capabilities had to be realized.

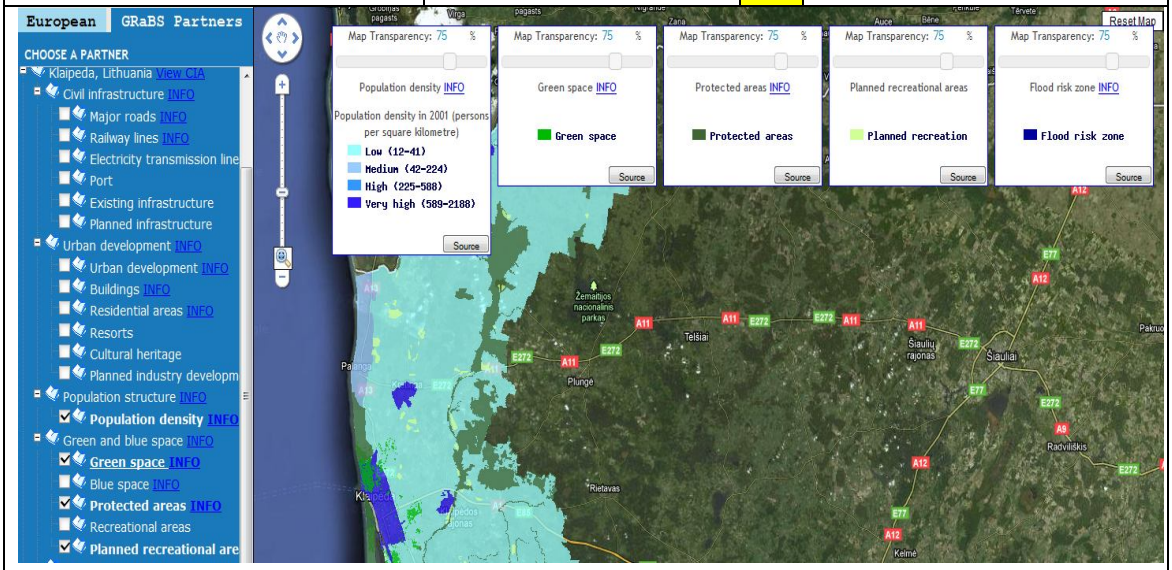
Parameter	Evaluation		Comment
GIS layers import	Very good		Anny layer with geo-referenced information can be uploaded to the system



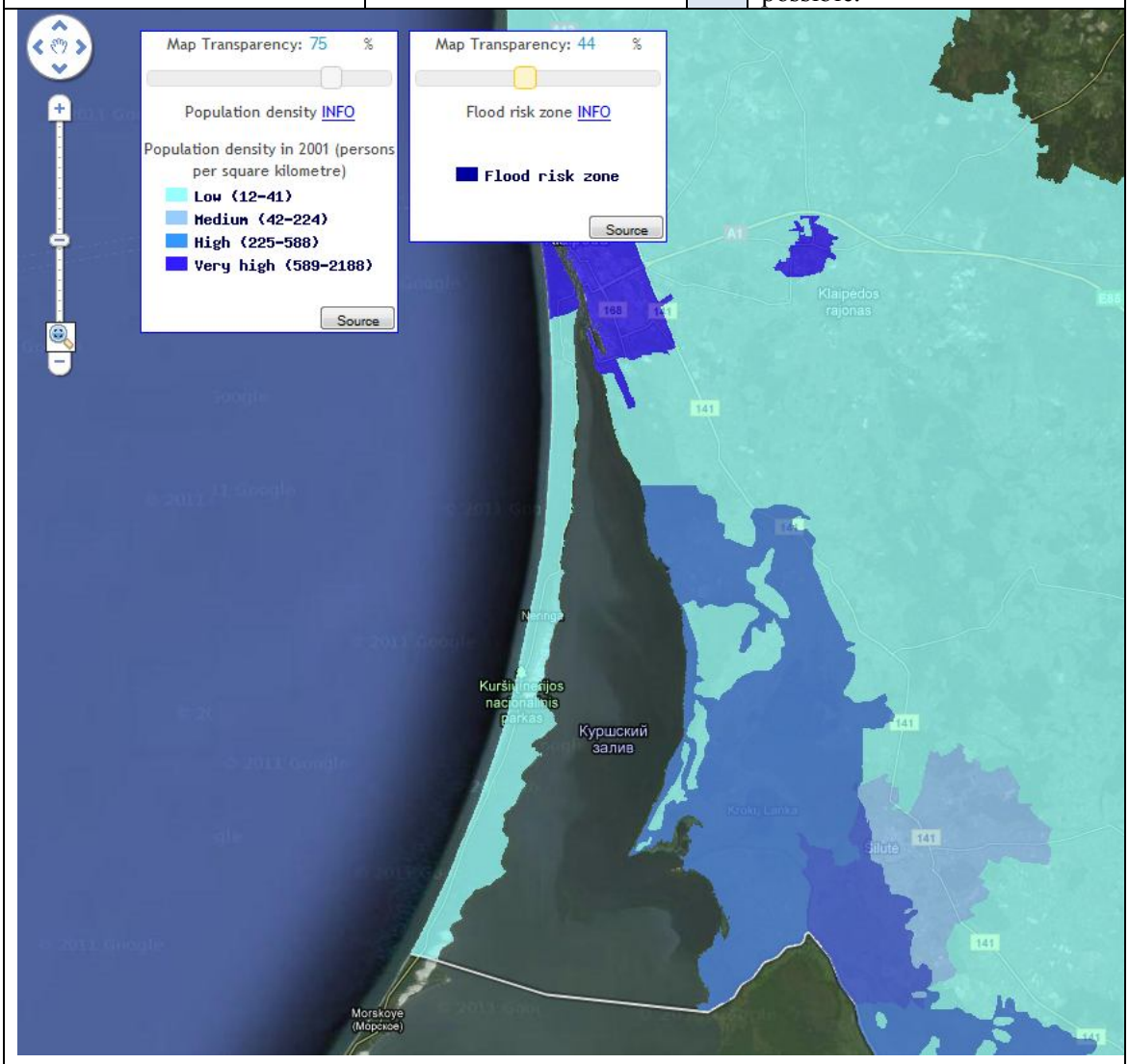
Representation of attribute information	Moderate		Only single layer of information can be attributed to the source layer



Multiple representation of GIS layers	Sufficient		Up to max 5 layers can be loaded at the same time, in general this is sufficient while identifying potential threats to different assets



Parameter	Evaluation		Comment
Overlaying of the layers	Straight forward, not sufficient		Up to 5 layers can be loaded at the same time and their visibility can be managed by means of transparency only. The changing of layer colour/symbol and sequence of displayed layers is not possible.



New layer import	Weak		Adding new layers to the tool is possible only by sending data to tool owners, no possibility to do it interactively. This burdens the update of fast changing information.

Technical possibilities of the tool are important when compiling and managing the data sets needed for assessment of the vulnerability of the coastal assets. On the other hand, functionality of the tool is very important when executing simple exercises with

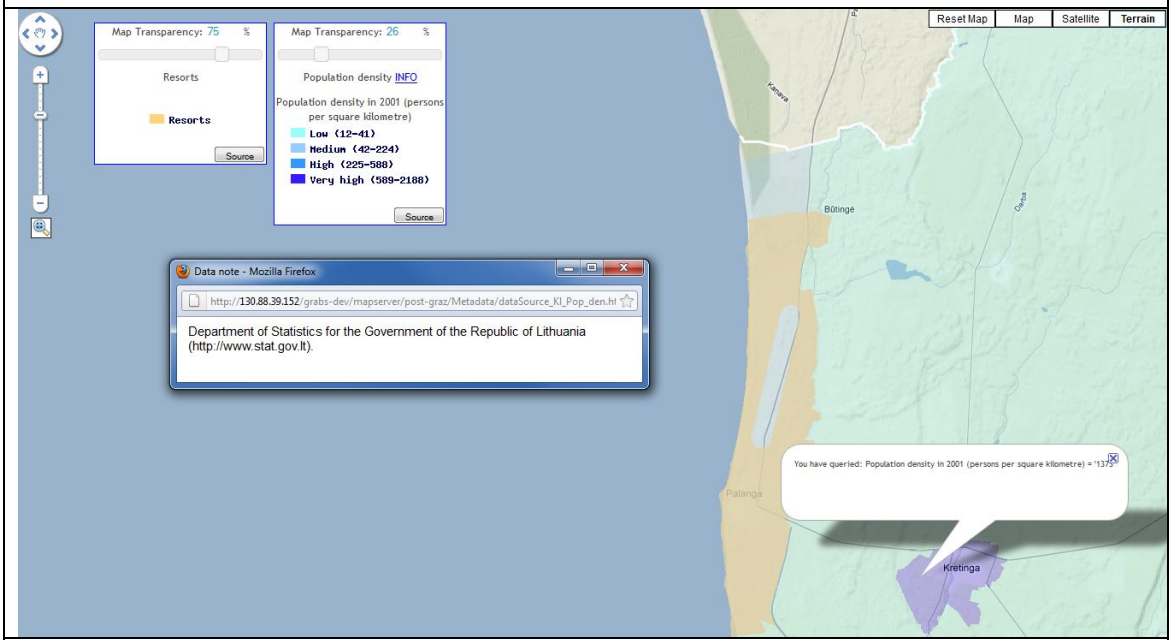
integrated data layers. Therefore, along with technical capabilities, certain analysis of functionality of the tool has been made.

		Easy	OK	Not possible
Map navigation:		X		
Selecting the data to map:		X		
Querying data values in a map:			X	
INFO and data source:		X		
Tracking scale, distance and area				**X**
Changing sequence of the layers				**X**
Updating of the data layers			**X**	
Loading up your own data				**X**

In general technical architecture of the tool is perfect for simplified and straight forward presentation of the data layers and derivative information. Simple functionality, allowing to measure the distance, track the position (coordinates) and identify scale of the map and objects is missing. This makes tool to visually represent the vulnerability of the coastal zone rather than to assess it. Overlaying of the data layers is quite complicated as well. Proposed transparency used in the tool is not sufficient for all cases. Some layers have similar colours with no possibility to change it – as a result overlaying sometimes is not visible.

POTENTIAL AND RECOMMENDATIONS

Potential: developed tool seems to be easy operational and informative platform for the presentation of scientific findings, monitoring of results, hazards and developments of the terrestrial as well as marine areas. Functionality and technical capabilities provide easy access to GIS based data sets, verbal information describing different assets, processes related to the climate change as well as response measures. Apart of the plain text describing different phenomenas relevant to the coastal zone changes, hazards and applied measures, there is a possibility to look deeper into the data layers – accessing the data sources and bit of attribute information.



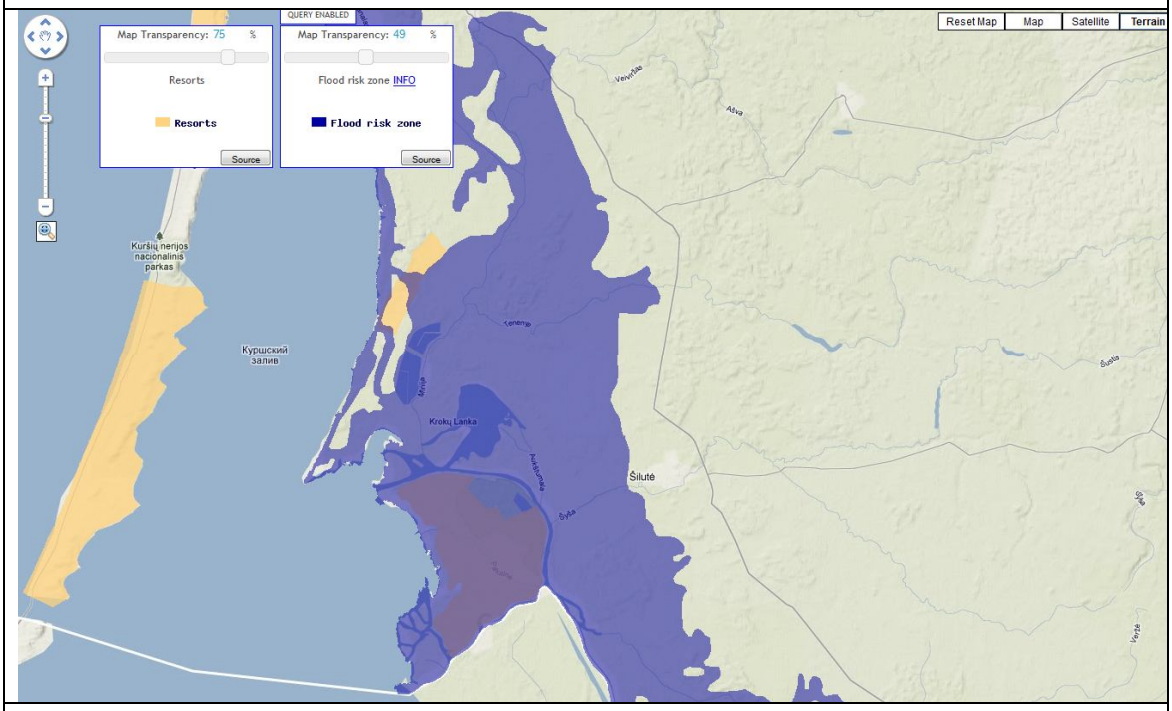
Recommendations: in order to have better visualisation of loaded data sets, possibility to open more than one attribute layer and also more than one information window,

describing the content of visualised information is rather necessary.

Potential: possibility to overlay different GIS layers containing relevant spatial information (such as flooding zone and developments under the threat) is very useful and attractive. The tool itself does not provide a possibility to do simple statistical analysis (e.g. to calculate how many buildings are in the risk zone of flooding), but it allows to upload specific layer containing such information – GIS layer with pre-analysed datasets. Adding up to 5 different data layers enforces decision makers to evaluate the potential threat taking into account different aspects – social, economic and natural value perspective.

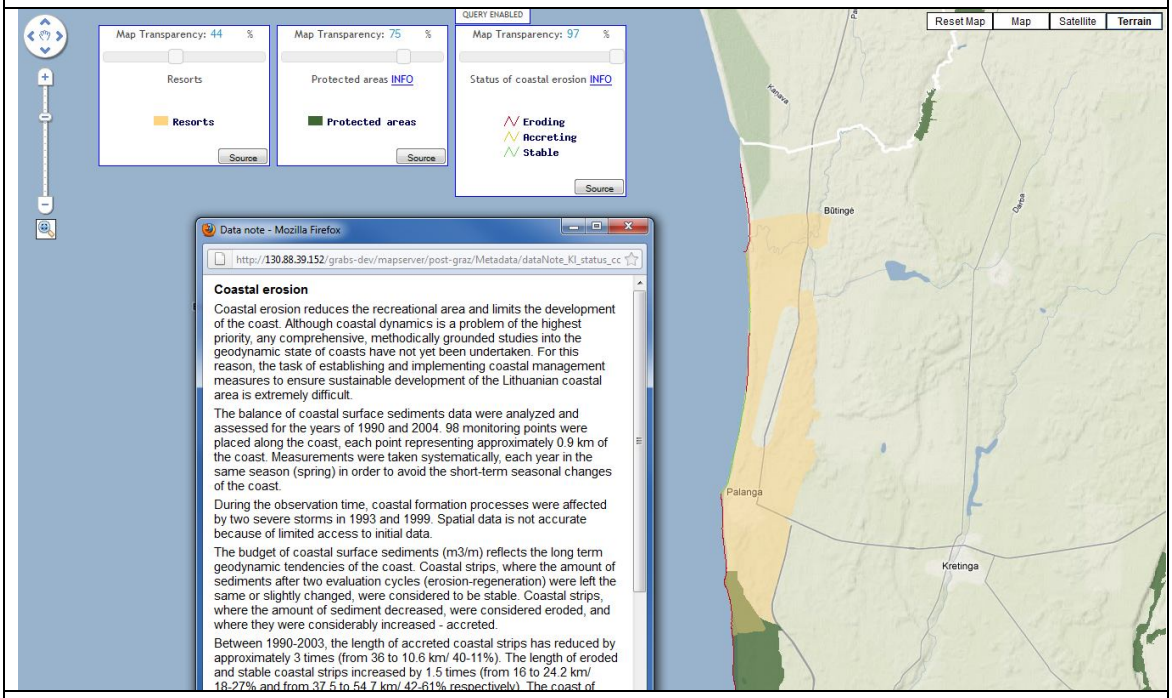
Recommendations: in order to make possible to upload different GIS layers based on certain statistical analysis necessary to supplement the information we intend to present, upload function should be activated. This would allow data providers to be more flexible, and bring the user of the tool much closer to the up to date information and scientific findings. Simple functionalities allowing to make simple measurements of distance, dimensions, position, scale are necessary in order to have reliable GIS based platform.

Potential: provided possibility to select among different basic maps in combination with displayed layers transparency manipulation gives very good opportunity to select most representative layout of the loaded map. This is very important when dealing with coastal environment where relief morphology is one of the key factors while planning the coastal defence and management measures.



Recommendations: even though tool allows to select different layout based on different basic maps, one may require to upload his own basic map that could serve as a main information platform (e.g. general or special plan) helping understand better the level of the threat induced by changing climate conditions. When dealing with coastal erosion, apart of the GIS based data layers, illustration of process using snapshots and photograph pictures could be very helpful and informative. Possibility to upload raster data and straight forward photos would increase the attractiveness of the tool.

Potential: symbols and colours proposed by tool developers are well organized and harmonized with broadly acceptable traditions of representation of datasets of different scope. Pop up windows allow putting more information to specific layers and this gives additional value to the maps and the platform as a whole.



Recommendations: transparency of the layers was already mentioned above, but this is worth to stress that despite of very positive function, maps should be supplemented with possibility to change the colour code as well. It is also important to stress that layers containing non areal information (such as points or lines) also need to have a possibility to change the symbols, e.g. thicken the lines, make points bigger or smaller, depending on the scale selected.

In general we assume that created tool is very well organized platform able to provide comprehensive, graphically well-presented and illustrated information that is difficult to have in one system using other means of information dissemination tools. The open source maps, plain text windows, additional information blocks available, references to data sources and other relevant facilities available provides perfect solution for decision makers, planners and general public, allowing to understand and simply see the hazards induced by changing climate.

ACKNOWLEDGMENTS

We appreciate efforts made by the University of Manchester in order to adopt the developed Risk & Vulnerability Assessment tool to specific areas of sensitive coastal zones of South Eastern Baltic. We are grateful to Maritime Institute in Gdansk and Atlantic Branch, Institute of Oceanology Russian Academy of Sciences for permission of using GIS datasets needed to compile the maps of SE Baltic region.

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