WATERSKETCH: TOWARDS SUSTAINABLE RIVER BASIN MANAGEMENT IN THE BALTIC SEA REGION
BALTIJAS JŪRAS REĢIONA UPJU BASEINA ILGTSPĒJĪGAS VADĪBAS NODROŠINĀŠANA

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Abstract. *River basin planning in the Baltic Sea Region (BSR) has always been a complex, yet important topic, which has gained a new momentum with the approval of EU Water Framework Directive (WFD) in December 2000. The ultimate goal of WFD is to achieve a good ecological status/potential of all water bodies before 2015. Together with the implementation of WFD also principles of Integrated Coastal Zone Management (ICZM) are to be applied and national expansions of Natura 2000 networks are in progress.*

There are many elements which are important in river basin planning systems. In the Baltic Sea region for example, the pressures posed by economic activities including increasing tourism and port activities have to be considered in land and river basin planning. These matters are dealt with in the context of the Watersketch project, a scheme supported by the Interreg IIIB programme of the European Union. The project aims at producing an extensive planning system and a working scheme that accounts for the various, complex and opposing tasks currently subjected to water usage. The main goal is to produce and describe processes, that aid planning and decision making also in areas with limited resources to meet the diverse requirements concerning water. In addition, the project intends to:

1) *analyse and synthesize the different directives and conventions focused on use of water courses.*
2) *demonstrate the major alternatives of river basin planning with a wide set of case studies ranging from southern tip of Baltic Sea (Poland) to northernmost corner of it (Norway).*
3) *provide a Water Planning Decision Support System for spatial planners, which takes into account all main components needed for economically, socially and ecologically sustainable use of water courses.*

Raise capacity to promote the sustainable development in river basins by means of an information exchange platform, training workshops and the dissemination of the information needed for sustainable use of river basins by means of a handbook.

By a combined approach where planning is complemented by training and information exchange, this project will provide a long-term contribution towards addressing the problem, at the same time that it links itself with other similar projects, achieving synergy and avoiding duplications.

Keywords: *sustainable development – river basin management – network- capacity building.*

Introduction – General Information about the River Elbe

The River Elbe is one of the largest rivers in Central Europe, being in the third place after the river Danube and the river Rhine in terms of length as well as the size of its catchment. Drainage basin area of River Elbe comprises 148,268 km^2 (1,2) and is shared between Germany, Czech Republic, Austria and Poland. However, Austria and Poland count less than 1 % of the catchment area while 2/3 is located in Germany and 1/3 in Czech Republic. The River Elbe arises in the Krkonoše (Riesengebirge), flows through Czech Republic, northern and central part of Germany and discharges in the North Sea near Cuxhaven. The River Elbe covers a distance of 1091 km (727 km in Germany, 364 km in Czech Republic) (2) and along its way, the catchment drains some of the major citys in the area like Prague, Dresden, Berlin and Hamburg (Fig 1.)

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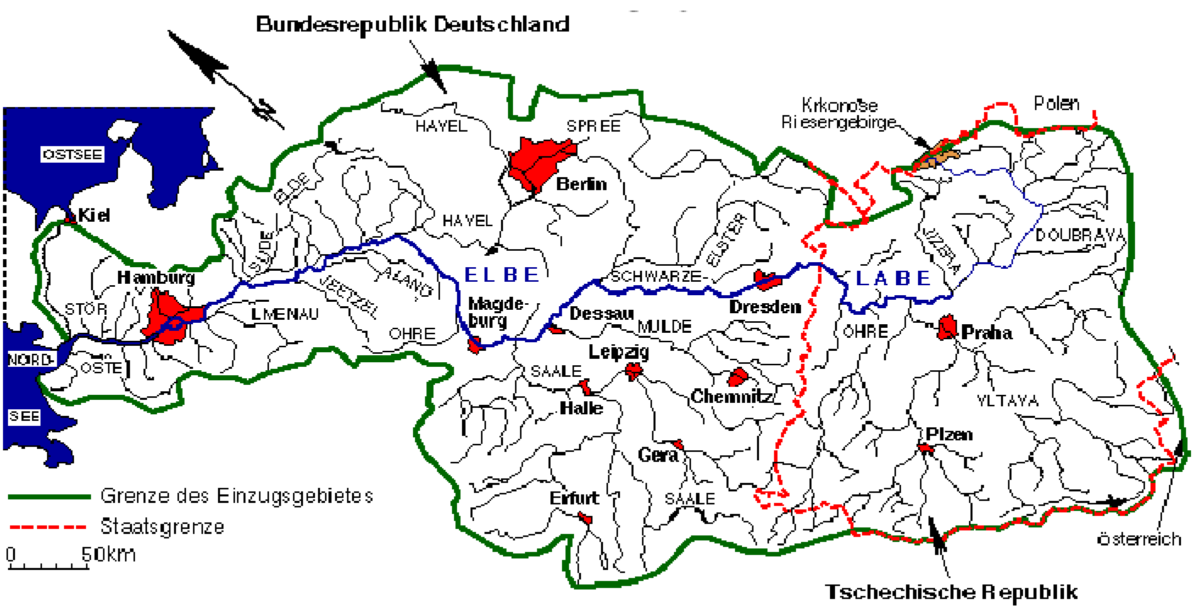

Fig. 1. **Drainage area of the River Elbe (Source: AGRE ELBE, 2001)**

The catchments area covers three main natural regions – the mountain area, the loess region and the Pleistocene lowland. The hydrogeology of the catchments area changes from bedrock aquifers in the southwest mountains to porous sediment aquifers in the lowland. The lower part of the river Elbe is characterised by its estuary and the coastally influenced landscape dominated mainly by the Hanseatic City of Hamburg, especially by its harbour. Tidal fluctuations, which lead to very special forms of wetland habitat and biodiversity, influence also the population and industry located in this region by frequent coastally in-blown storms.

The average annual discharge into the North Sea is about 877 m^3/s (3). The major tributaries are the Moldau/Vltava, Havel and Saale, each comprising a catchment area of roughly 25 000 km^2. The total population living in the drainage basin is around 25 million in total, 18 millon of which in Germany (31% of the total population) and 7 million in the Czech Republic (58% of the total population) (2).

The land area of the catchment area of the Elbe River consists of 29 % forested land, 7% urban areas, 61% agricultural areas and 1,5% water surface (4, 5). The water of the River Elbe is used for several purposes: To a certain extent, it is used to produce drinking water via bank filtration, which makes a comprehensive treatment necessary (6). More than half of the land in the basin is used for agricultural purposes. Main industries include chemical and pharmaceutical industry, paper and pulp industry, metal industry, mining, glass and ceramics and leather and textile industry. A great portion of the basin, around 86% of the German part and 22% of the Czech part, are classified as protected areas of nature reserves (3).

The Free and Hanseatic City of Hamburg

The Free and Hanseatic City of Hamburg is the second largest city in Germany with 1.7 million inhabitants. Like Bremen and Berlin it is a city-state. Hamburg is the cultural and commercial centre of Northern Germany, and its metropolitan region consists of approximately 3 million people. The municipal area is equal to 755,3 km^2 whereas the metropolitan region covers total surface of ca. 19 000 km^2 and embraces 14 districts around the City of Hamburg. With 30 m^2 living space per person, Hamburg enjoys the largest average personal living space of all big cities in the world. In fact, 12% of the city is made up of green and recreation areas whereas ca. 36% of the land use belongs to buildings and open space, 27% to the arable land, 12% to the road area and 8% to the water area (7). Some facts and figures are listed in Table 1.

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Table 1.

Some facts and figures about Hamburg
(Source: Statistisches Amt für Hamburg and Schleswig-Holstein, 2004)

	Hamburg		Germany		In % of Germany
Inhabitants	1.729.000		82.537.000		2,1
Total Area	75.532	ha	35.703.099	Ha	0,2
Built-up Area and Open Space	26.878	ha	2.308.079	Ha	1,2
Recreation Area	5.702	ha	265.853	Ha	2,1
Road Area	8.860	ha	1.711.764	Ha	0,5
Arable Land	21.000	ha	19.102.791	Ha	0,1
Forested Area	3.432	ha	10.531.415	Ha	0,0
Water Area	6.115	ha	808.462	Ha	0,8
Share of Gross Domestic Product	77.08	Mrd.	2.129.20	Mrd.	3,6
Gross Value Added	70.02	Mrd.	1.963.580	Mrd.	3,6
of which:					
Agriculture, Forestry, Fishing	0,12	Mrd.	21.95	Mrd.	0,5
Manufacturing industry	13.2	Mrd.	475.30	Mrd.	2,8
Trade, Transport,	18.31	Mrd.	365.00	Mrd.	5.0
Financial, renting and business service activities	25.67	Mrd.	589.97	Mrd.	4.4
Construction	1.84	Mrd	87.21	Mrd	2.1
Other service activities	13.11	Mrd	424.15	Mrd	3.1
Unemployment Rate in % (yearly average 2004)	11.0		12.5		
Gross Earnings /Year in Euro	29.319				

The geographic and geologic conditions of Hamburg are closely related to the housing development, population growth and economic structure of the City. Hamburg is thus not only "the city built on the water" - as it is called due to the multiplicity of small rivers and canals besides the Elbe and Alster Lake - but it is also "living from the water" (8). Due to the access to the North Sea and to the Baltic Sea (via the Kiel Canal) and the efficient land and water connections to the hinterland, Hamburg Port plays an important role making Hamburg the most important international trade and logistics centre of Germany and a hub to the whole Baltic Sea Region and Central Europe. The international trade volumes account approximately for one third of the Europe's export. The port and shipping sectors are employing around 75,000 people in Hamburg. More than 145,000 jobs in a vast range of industrial and service sectors are indirectly dependent on the port. Besides the level of the regional employment the seaport activities of Hamburg exploit also a relevant role on the regional economic growth. In fact, the GDP the seaport related activities generate is proportionally higher than the quote of the GDP related to the other economic sectors of the Hamburg city-region.[1]

Due to its location Hamburg is also very attractive for industries and businesses to settle here. Following Ruhr area and Berlin it is in the third biggest industrial area in Germany. 70% of all industry related businesses in Hamburg concentrate on one of the six branches: Aircraft-, ship- building and automotive industry; electro technology, fine mechanics and optic industry;

[1] Information taken from: [1], [2], [7], [8]

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mechanical engineering; chemistry; mineral oil processing; or metal production. The importance of Hamburg can be seen also from the fact that not only big industries form their headquarters here but there are also more than 80 000 middle-sized businesses present.[2]

The River Elbe in Hamburg

According to the Water Framework Directive, surface waters are classified on the basis of river basin district. Following that, the sub-river basin of Elbe/Harbour lies on the surface of 156.4 km^2 within the borders of Free and Hanseatic City of Hamburg and incorporates the Entering Hamburg at the river-km of 620 the length of the river Elbe through the city is approximately 77 km long. The landscape of the river basin district can be characterised as a marsh area with its sandy soils mixed with gravel and clay. The deeper subsoil of Hamburg consists of layers shifting from clay to brown coal consisting sands. The flow in the Elbe remains between 1 and 1.5 m/s (the discharge rate varies from 300 m^3/s to 3000 m^3/s) depending on the tides. The river is divided in two branches (*Norderelbe* and *Süderelbe*) near the City of Hamburg forming an estuary with a width of 1.5 km downstream of Hamburg and 18 km near Cuxhaven. However, within Hamburg the river has an average width of 200 m and the depth of 2 to 5.5 m upstream and 15.30 m downstream of *Elbbrücken*. Because of lacking gradient and tidal influence the direction of water drift changes every six hours. For this reason, given water body has to pass the same river section several times needing 4 to 70 days (compared to 1 to 2.5 days upstream of Geesthacht) unless it reaches the open waters of the North Sea resulting in the much greater residence time of polluted water than the upper reaches of Elbe (10).

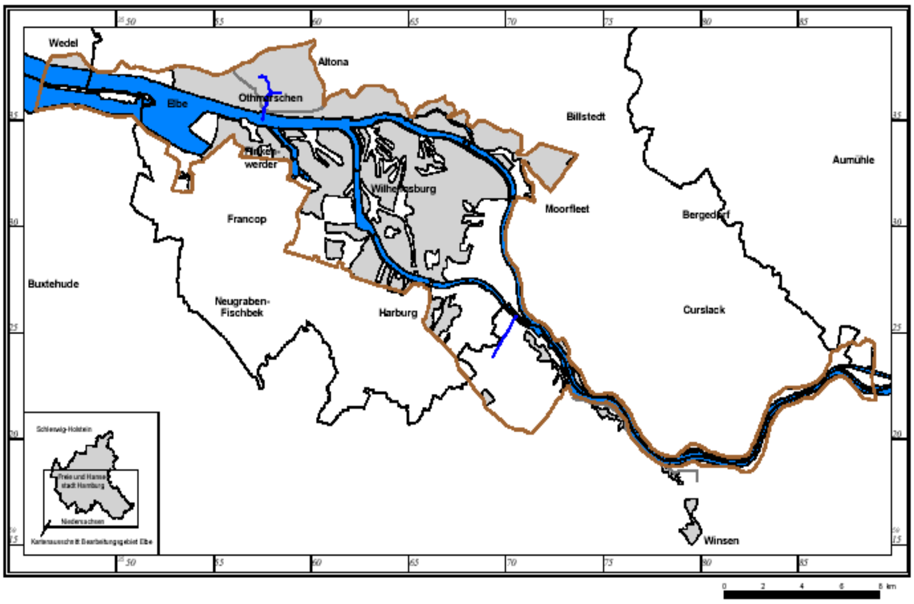

Fig. 2. **Southern and Northern Elbe (9) and the Port of Hamburg**

The water quality, river morphology and other characteristics of Elbe in Hamburg are influenced mainly by the port related and industrial activities, navigation and urbanisation as well as pressures imposed by the activities along the river Elbe upstream of Hamburg. On the other hand the heavy use of Elbe for recreational purposes as well as for attraction of tourists must be stressed.

Current Environmental Problems and related Conflicts of the River Elbe

Table 2.offers a general overview of the various issues surrounding the Elbe in Hamburg, by means of the “Driving force-Pressure-State-Impact-Response” framework. It can be seen in Table 2. that the driving forces resulting in pressures and complemented by the corresponding environmental state, their impacts and responses.

[2] Information taken from: [3], [5], [8], [9]

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Table 2.

The Driving force-Pressure-State-Impact-Response framework

<table>
<tr><th>Driving force</th><th>Pressure</th><th>State of Environment</th><th>Impact</th><th>Response</th></tr>
<tr><td>Port Activities and Navigation</td><td>Dredging

Utilisation of the port area

Shipping accidents</td><td>Change of river morphology and ecological condition of the river

Pollution (oil, chemicals)</td><td rowspan="3">Disappearance of several species in flora and fauna

Contaminant accumulation in sediments and also in fishes

Treatment and disposal of dredged material made difficult due to the heavy contamination of sediments with heavy metals (especially Cadmium)</td><td rowspan="3">National, European and international policies

National and international cooperation agreements and conventions</td></tr>
<tr><td>Flooding</td><td>Flood protection</td><td>Change of river morphology and ecological condition of the river</td></tr>
<tr><td>Households and Industries</td><td>Point and diffused pollution sources</td><td>Pollution of the river water and sediments with nutrients and hazardous substances</td></tr>
</table>

A major problem among the many seen in Hamburg, is the problem of contaminated sediments. In Hamburg, the dredged sediments must undergo pre-treatment following the disposal within the borders of the City to meet the requirements posed by relatively strict environmental laws. Pre-treatment is done in the large scale METHA plant with the annual throughput capacity of 1 million m^3 sediments and consist of separation into sand, silt and smaller amount s of coarse material (11). Due to the contamination of the silt, it is disposed in two specially constructed silt mounds ensuring environmental safety. Another feasible possibility, bearing however relatively high costs, is the utilisation of the silt as a sealing material in the construction of the dredged material disposal sites, for backfilling former harbour basins and as a raw material in brick fabrication (12). The separated sand is nearly contamination free and therefore can be used as construction material or as a raw material or additive in the industry.
However, the criteria of the dredged material for the Elbe river system were developed in the mid 1990s allowing these sediments to be relocated into the river if meeting the requirements. The concept of sustainable relocation is followed to minimise the effects on the environment.
A further key-issue is still the contamination of sediments in the entire river basin resulting from more than 150 years of mining and industrial activities (11). Although there has been a marked reduction in pollution with heavy metals (reduction of Hg: 84 %, of Cd: 22%), compared to 1989, it is generally still high today (mercury, cadmium, zinc) especially concerning the sediments and suspended matter indicating the continuing inputs into the river from upstream. Pollution with copper is heavy, pollution with lead, chromium and nickel is critical (13). According to the existing LAWA2-Classification, in 1998, suspended sediments were assigned to the class “elevated to high contamination” (Class III-IV) with regard to Hg, Cd and Zn and to “moderate to elevated contamination” (class II-III) with regard to Pb (11).
Among other problematic heavy metals cadmium is one of several contaminants that lead to sediment management problems downstream from the sources namely regarding the dredged

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material from the port of Hamburg which does not meet the lower Federal German value for disposal into the North Sea (1, 14).

One of the principal problem substances in the Elbe today as well as in the future is hexachlorobenzene (HCB) due to its high persistency and extensive presence in the sediments (8). The reduction in loads is slow also because of ongoing inputs from Czech Republic. Despite a downward trend in pollution loads in the early nineties, DDT and DDD in particular are still found in the Elbe in substantial concentrations, which sometimes reach extreme peak values. The inputs are suspected to come from the Mulde, as DDT concentrations of up to 2 mg/kg have been measured in the sediments of Mulde (14).

Furthermore, oil spills in marine and coastal waters lead to oil slicks. In 2001 aerial surveillance, which under the Bonn Agreement has to be carried out by the North Sea states as an aid to detecting and combating pollution and to prevent violations of anti-pollution regulations, detected 596 oil slicks in the North Sea. In 2003, the Waterways Police authorities of the German coastal states inspected a total of 6,036 ships and found deficiencies in 1,533 cases. In case of minor infringements, they issued cautions to the ships' masters, chief engineers, and engineers and imposed fines of up to 35,00 € in individual cases. 251 cases were referred to the BSH for further handling. The BSH is the German authority imposing fines for administrative offences that have been committed by shipping in violation of international conventions and national regulations for the protection of the marine environment. Under the German ordinance on violations of MARPOL regulations, those responsible on board a vessel commit an administrative offence if they maintain the Oil, Cargo, or Garbage Record Book improperly or do not comply with MARPOL discharge regulations. The existence of illegal overboard pipes from the sludge tank are considered an administrative offence punishable by a fine.

Due to the contamination of Elbe sediments, the Port of Hamburg is still operating a comprehensive dredged material management system. In 2002, 2.8 tons (30%) out of the 9.5 ton of total Cd load in the river Elbe was removed in Schnackeburg using land disposal. Due to the Elbe flood, the load in 2003 was 60% higher than in previous years (11).

The relocation of dredged material poses a volume problem and has an impact as the human pressures on the North Sea. Two effects on the coastal ecosystem have to be considered in relocation or withdrawal from the marine system: on the one hand the withdrawal of slightly contaminated sediments will reduce inputs of contaminants (positive); on the other hand withdrawal of large amounts of sediments will upset the sediment balance in sedimentation areas (negative) (15, 16, 17). In a modern impact analysis both aspects should be put in a context of questions about sustainable river management and sea level rise, with increasing coastal erosion and impacts on mud flats.

As with regard to conflicts, the present environmental issues of concern like leakage of nutrients, especially nitrate, from agriculture and leakage of harmful substances from mining sites remain also in the future. Methods to treat water with increased concentrations of heavy metals from ore mining over and above the existing research on geochemical engineering as well as strategies to avoid or to decrease heavy metal concentrations in the Elbe catchments area are under development but there is still a long way to go. This shows that the present conflict regarding sediment management has no fast solution and will continue probably in the future. However, it depends strongly on the ability of different stakeholders to co-operate and to move towards the common goal – to establish sustainable sediment management for the whole catchments area of the river Elbe, with suitable guidelines and frameworks that fit in the context of Water Framework Directive –a subject looked at in depth in the project WATERSKETCH- and support therefore also reduction of cost to both the society and the environment.

Future conflicts may rise from the several environmental problems which have to be faced and taken into consideration in managing the river Elbe, namely:

Possible decrease and degradation of the habitats due to the climate change resulting from continuing increase of industrialisation and traffic infrastructure as well as further specialisation of agriculture poses a progressing threat to biodiversity;

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Increases in water temperature and inputs resulting from human activities (e.g. ballast water) may cause sets of problems (e.g. genetic) which may influence populations and the evolution of new species;

Future water quality problems with new hazardous substances like endocrine disruptors may arise. The examples are PCBs and TBT, the production and use of which are being or have been strictly limited or even forbidden;

Due to the development in the shipping sector (e.g. insufficiently trained crews, sub-standard ships, and inadequate salvage capacity) there is a potentially increasing risk of shipping accidents;

Another future threat is a potentially accelerating sea level rise, which may, on the one hand, have an impact on the ecosystem and on the other hand pose an increasing burden on the coastal protection and the safety of the hinterland.

According to the Hamburg´s regional development concept published in the year 2000, the goal is to gain a differentiated regional profile within a trilateral cooperation combining science, labour and surface use politics formed on the basis of guiding projects. Besides harbour operations and settlement of highly specialised industries Elbe has been discovered as a landscape with a high value for urban planning and the improvement of water quality as the ecological basis for life and enhancement of the river's recreational appeal have moved into the centre of debate.

The solution of future conflicts depends on to which extent the barriers to progress in environmental protection and sustainability are to be overcome. This is mainly due to the fact that the nature of problems as well as solutions is complex and international interconnected with different sectors and disciplines. These barriers are underpinned by shortcomings in institutional structures, non-implementation of commitments already made and lack of information on and understanding of possible 'win-win-win' solutions for achieving sustainable outcomes. Protection of natural resources and ecosystems accompanied with social and territorial unity and innovativeness should be considered while finding such solutions.

In the future, harbours are not only important logistics centres and interfaces for the world trade, but they should be used as crystallization points for new industrial "clusters" to minimise the impacts by less use of space, concentration of noise and light pollution and a better control of emissions and pollutants (18, 19). Environmental concerns could lead harbours to an increasing market for green ship wrecking, for vessels such as single-hull tankers, old cargo vessels and naval vessels (9, 11, 14). Some advantages could be provided by recycling expensive raw materials. The EU will issue stringent conditions for ship owners and flags of convenience, which will lead to an increase in the wrecking of older ships.

Conclusions

In order to improve the ecological status of the river, integrated sediment management of the Upper Elbe seems to be an essential measure. This is being considered as case study part of the Interreg IIIB Project Watersketch (http://www.watersketch.net), which looks at the issue of sustainable river basin management in the Baltic Sea region.

By means of sediment management, the unnatural withdrawal of dredged material would be reduced and solid condition of the aquatic system of the Upper Elbe would be supported by the rearrangement of the unladen dredged material. Selective fixed deposition of dredged material as a measure of hydraulic engineering could influence sediment transport in a positive way and at the same time the creation of shallow water zones would be enhanced ecologically.

Contaminated sites in Hamburg as well as in the whole catchment area and the historic contamination emitted from approximately 300 old mining sites in the Elbe catchment area are the main diffused pollution sources causing the contamination of sediment. There has to be analysed to which extent the reduction of dredged material as a contribution to the concept of a

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sustainable clean port and environment can be achieved. The classification system for substances and areas of concern has to be developed as well as the concept for the handling of historic contaminants. The risk of various contaminant sources should be determined following the site prioritisation considering social and economical parameters for better allocation of resources resulting in the maximum risk reduction and protection of socioeconomic use of the river basin.
For the future, the amount of sediments to be dredged could be reduced by means of hydraulic devices like the current deflecting wall. For example, the Koehlfleet Harbour, one of the largest in the Hamburg Harbour complex, has achieved the major benefits in reducing this siltation by constructing a curved wall at the basin entrance. This structure changes the flow pattern to avoid the trapping effect by the eddies. Due to this construction the annual sedimentation of approximately 290 000 m^3/yr was reduced up to 35 % (10). Reductions of cost were even higher, because all the sediment in the harbour can be dredged by the cheaper water injection (16). As it can be seen, such structural measures are proved to be useful to reduce harbour sedimentation, however might differ on an individual basis. It is expected that an optimized wall will lead to further sediment reduction (16).

In managing the trans-boundary water course like Elbe, the issue of new governments with limited sources inheriting the „legacy of the past" is a serious one, and requires most likely a new thinking about resource sharing across borders and entities. Finally, communication between the stakeholders and raising awareness of the public on the sediment issue is becoming increasingly important in order to improve the future river status. The purpose of communication between different regulatory bodies and policies is to include the sediments into the European environmental policy.
Sustainable river management strategy of the river Elbe has to consider integration and implementation of sectoral strategies with regard to policies/activities in the coastal zone and mainland. In other words, it needs integratives approaches (19). As there is still insufficient or lacking cooperation between local, regional, national and EU authorities in the preparation, implementation, enforcement and coordination of the rules and regulations cooperation between responsible authorities is essential. In order to facilitate sustainable management the rules and regulations should be harmonised and simplified.

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