The "Geo-Information System Coast Mecklenburg-Vorpommern"

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Abstract

The Division Coast of the State Office for Environment and Nature Rostock has been working on the research project "Coastal Zone Management of Mecklenburg-Vorpommern" since 1997. With the help of Geo-Information Systems (GIS), all available data sources should be pre-processed, recorded and analysed for a comprehensive evaluation of the coastal area. All results are part of the complex "GIS Coast Mecklenburg-Vorpommern", which is based on the ArcView® software.

1. Introduction

Due to the occurrence of broad-focused activities, in particular ocean and harbour trade, shipbuilding, fisheries, tourism and, of course, nature and coastal protection, integrated management is required for the sensible, ecologically and economically justifiable use of the coastal zone.

With the help of Geographical Information Systems (GIS) as well as CAD work places, all available analogue and digital, historical and current data sources should be pre-processed, recorded and analysed.

This should enable the scientists and state officials to produce a comprehensive evaluation of the coastal area as well as to develop a prognosis for possible changes based on the documented actual situation.

2. The Division Coast

The "Geo-Information System Coast Mecklenburg-Vorpommern" is one of the outcomes of a Coastal Zone Management project which has been established within the Division "Coast" of the State Office for Environment and Nature

Rostock since 1997. This project, whose exact title is „Coastal Zone Management – Morphogenesis of Mecklenburg-Vorpommern's Outer Coast", is 100 % (€ 800,000) financed by the Federal Ministry of Education, Science, Research and Technology.

Mecklenburg-Vorpommern is a German federal state located on the southern part of the Baltic Sea coast. Its outer coastal region is approximately 350 km long, 70 % of which is in a state of being eroded and 30 % of which is being accumulated. The Division "Coast" currently employs 15 people in three departments, who are responsible for coastal and flood protection in the entire state of Mecklenburg-Vorpommern. The area of jurisdiction as well as that for investigation ranges from 10 m and, in some cases, 15 m below sea level to the last inland coastal protection constructions, usually the dike or coastal protection forests about 1 km away from the shoreline:

- Department K00: general affairs and coastal science:
  evaluation of coastal conditions and dynamics, including endangerment analyses; derivation of guidelines for coastal and flood protection constructions
- Department K00: technical pre-planning:
  creation of concepts, project planning as well as subject-related consultation for protection measures
- Department K00: technical inspection:
  technical authority for approval procedures on the coast of M-V

The three departments mentioned above work closely together to co-ordinate, plan, evaluate, approve as well as inspect quasi-natural, effective coastal protection and an integrated Coastal Zone Management.

The first major step of the project was the analysis of the various data sources, the digital processing of the data and the presentation of the results in a common projection system within the GIS. Some examples of the overall planning foundation in the State Office for Environment and Nature Rostock are:

- planning maps
  - network of markers of coast (CD)
  - arial view plans (vector and raster, scale of 1 : 10,000)
  - general plan of the coast
- coastal protection measures
  - complete analogue recording
  - groin cadastre
  - sand dune cadastre
  - monitoring *Teredo navalis*
  - securing evidence
  - identification of coastal protection areas
- special information
  - sand deposits
  - coastal dynamics
  - morphologic steep shore cadastre

geologic steep shore cadastre
surf zone mapping
surveying database
- other information
  internal network for measurement
  function of groins (Research project 1993–1997)

3. Hardware, Software, Data

These different data sources (Point 2) had to be put in the GIS with the help of a software combination, which had the following characteristics. It should

- be a well-known common and internationally accessible standard software package,
- have a large distribution and the acceptance of the administrative bodies in Mecklenburg-Vorpommern,
- be able to process raster and vector data,
- be relatively easy to use.

The following software proved to be successful in satisfying these demands and in dealing with the heterogeneous data sources mentioned above:

- Raster GIS – Erdas Imagine
- Vector GIS – ArcInfo
- CAD Input/Output – AutoCAD
- GIS Presentation (print) – Erdas Imagine
- "GIS Coast M-V" – ArcView
- graphic Images – CorelDraw
- data bases and reports – Microsoft Excel, Access, Word, PowerPoint

The users and, of course, the regional authorities who wanted to use the project results and the GIS only needed one standard-equipped work place containing ArcView®.

After the bases for data, hardware, software and structure had been determined, it was particularly important to figure out which results, according to these conditions, were to be expected for direct processing and for pending tasks within the office.

The first part of the Coastal Zone Management project focuses, for the time being, on two issues:

- morphology
  current height (seaward and inland)
  investigation of long-term coastal dynamics since 1692
  sediment transport balance
  cartographic mapping of the sand dunes and cliffs

coastal protection constructions
- sediment dynamics
  geology of the shore, subdivided in classes
  sediment distribution
  mapping of the surf zone
  development of the surf zone (identification of erosion and accretion areas)

The goals can be described as follows: in order to exactly verify the natural, quasi-natural and anthropogenically influenced coastal processes, the construction of a so-called "shore-line management plan" was first realised. Not only the planners in the division, but also those in the licensing/authorisation department are able to use these results; the sound statements concerning coastal dynamics are used to make concrete management decisions regarding further aspects of coastal zone management. For example, some issues are: coastal and flood protection, nature conservation, tourism, harbour construction, fisheries, infrastructure etc. This supports the practical approach of the Federal Ministry of Education, Science, Research and Technology. By giving the authority over the research project to the decision-makers of the various departments instead of to a university or a research institution, the state officials enabled the results to be incorporated quickly and directly into the administrative body's daily tasks.

The general goals are:

- to establish a complete picture of the morphogenesis of the outer coastal region, in particular of changes in the surf zone and shore;
- to establish a complete picture of the sediment dynamics of M-V's outer coast, showing the dependencies of the various factors, their causes and consequences;
- to establish a sustainable coastal protection concept for M-V as an important part of and basis for ICZM

4. Results

The results of the research project are part of the "Geo-Information System Coast Mecklenburg-Vorpommern":

- topographical maps (scale 1:25,000, raster);
- topographical maps (scale 1:10,000, vector) with photos of the coastal region;
- aerial photographs (1998, digital, 6 CDs, bottom resolution 2 m);
- biotope mappings (generalised, vector);
- administrative structures (borders, places, streets, waters etc.);
- coastal main points (official measurement, distance approximately 3 km);
- Coastal help points (distance 250 m, raster- and vector-based, co-ordinates);
- dune cadastre (profile surveying in 1993 and after the storm flood in 1995);
- geological and morphological survey of the cliff area;

- historical and recent shore and cliff lines (1692, 1835, 1885, 1937, 1988 etc.);
- coastal dynamics (absolute value and speed (meters/year) of coastal changes);
- sediment distribution maps (to 10 m and, in some cases, to 15 m below sea level);
- survey of the ridges (position, perimeter, bottom, transport direction etc.);
- contour lines of different periods (1931, 1953, 1983, 1998);
- description of erosion/accumulation areas in the surf zone since 1953;
- morphological survey (historical, topical) of interesting divisions;
- high-tide level determination (based on storm flood in 1872);
- documentation of overflowed areas (places, forest, waters, other ...);
- artificial coastal structures (position, perimeter, project, photos ...);

Additional important aspects are the outcome of passing on first results immediately, without having planned the structure in detail first. Some of these so-called "spin-off effects" are the following:

1. Since the results are used directly by other colleagues, the Division "Coast" receives immediate feedback concerning the condition of the data, their complexity and drawbacks as well as demands for further processing or a specific content.
2. Colleagues developed a need for new data, which, on the one hand, have guaranteed their co-operation. On the other hand, spin-off effects for the technical demands on the data arose.
3. In order to enable data access to all, every work place in the "Coast" Division was equipped with a modern computer, connected to others via an NT server (LAN) and provided with periphery devices (€ 40,000).
4. Planning documents and licensing procedures are no longer carried out manually, e.g. by sketching the coastal protection situation onto a copy of a topographic map. Instead, the arrangement and presentation are done with the computer with higher quality.
5. Additional demands on the digital data material led to the decision that all results from projects done by private companies and research organisations be delivered in a digital format which is readable by ArcView. Furthermore, government funds were also allocated to allow new data as well as improved existing data to be added to the Coastal Zone Management project (€ 1 million).
6. The results of our project, the topography, the coastal measurements as well as the coastal dynamics of the past hundred years are only available on individual CDs. Consequently, those administrative bodies, regional decision-makers and private customers who want to work with the data have at least some of their employees equipped with modern GIS and/or CAD work places.

Another important aspect and a result of the project at the State Office for Environment and Nature Rostock are the following supports for a management project:

- standard software (wide distribution, general acceptance, easy use including literature for looking up information, regular updates, good cost-benefit relationship)
- fast and focused provision of data (need for direct recording, focused collection of data, strive for short-term presentation)
- practical relevance (is guaranteed by directly including the decision-makers in the planning and implementation)
- easy use (easy understanding of the processing of digital data and results for the average user, which do not create a purely "specialist system")
- establishment of interrelations (between data provider and user, so that both receive advantages)
- support of spin-off effects (focused intervention in the dissemination due to administrate measures, analysis of demand and demand intervention and possibly some sort of marketing)

5. Conclusions

As a conclusion, some hard copies of the current ArcView project "GIS Coast M-V", or rather screenshots of the tasks that are being processed, are presented.

The topography, the infrastructure and the boundaries are accessible as vector data. We also have a CD with scanned (raster) topographic maps on a scale of 1:25,000 for the entire coastal region. Our state has a well-investigated method for measuring the length of the coast. A network of markers has been set up. The main markers have been permanently positioned exactly 3 km apart and geodetically surveyed. Other fictitious markers are placed every 50 m between the main markers. Their co-ordinates are known and can be calculated or located using GPS navigation. The localisation of many focused investigation areas and coastal protection measures are based on this system.

In the digitally processed sand dune cadastre, profiles of the high-tide protection sand dunes from the shore line to the inland edge of the dune are registered and presented. The height of the profile is approximately 300 m, depending on visible changes. Fortunately, measurements of the sand dunes were taken directly before a strong tidal wave came in November 1995. We were able to compare them to pictures taken directly after. This comparison enables to quantify the influence of extreme conditions on the flood protection.

Also available are further characterisations and condition portrayals for the geological survey of the cliff area, for the biological (floral and faunal) survey of the most important parts of the dunes, for the contour lines on land, for morphogenetic surveys and historically developed structures.

In the sea part, there are also illustrations of the sediment distribution (sand, silt, pebble, cobble, sludge, clay) and of the contour lines below sea level. These contour lines are from three different "offshore" (offshore region: zone of breakers extending seaward from the low-tide line to the depth at which these waves

first feel the bottom) measurements taken in 1953, in 1982 and, only recently, in 1998. This way, underwater accretion and erosion spots in the water over several decades can be determined.

Statements about coastal dynamics also exist for sediment distribution maps. Every 250 m, in some cases every 100 m, there is a marker containing information about the absolute value and speed (meters/year) of coastal changes over the past 100 years. This provides the most important basis for estimating and authorising the locations of buildings near the coast. One can estimate the approximate lifetime of an object and the indirect danger for people and property. Aside from pure measurement values, it is also possible to display the shoreline and cliff edges of each time period in order to create an overview of the situation or to carry out several measurements.

The storm wave mark is the water level which is reached due to extreme events (e.g. tidal waves) and the amount of water our coastal protection and tide/flood protection construction should contain/hold back. The height depends on the region and results from the water level measured during the century tidal waves in November 1872 plus eustatic and isostatic influences of the past 100 years and another 15 cm for the 100 years to come. It spans from approximately 1.65 m to 3.20 m. Using Coastal Zone Management, we can determine those areas which can be flooded when the water exceeds this water level mark. One can show the dependency on the high water mark, the total area flooded, the sub-department in endangered towns, waters, forests and other areas.

The current condition and the location of artificial coastal protection structures is particularly important for the planning. The coastal protection measures are as follows: groins, artificial beach nourishment, flood protection sand dunes, dikes, coastal protection forests. Exceptions are breakwaters, sea walls and other concrete structures to protect the sand dunes (revetments).

In addition to the location of these structures, the ArcView project contains additional information such as type and size, date of construction, condition, costs, dimensions, building plans as well as photographs. It is possible for the user to produce an overview of the entire coastal protection measures for any specific part of Mecklenburg-Vorpommern's Baltic Sea coast and to use it to concentrate on observations and planning.

Since the year 2000, the Division "Coast" has worked on a follow-up project consisting of these parts:

- biology: collection of data of the flora and fauna in the near-shore region as well as in shallow waters down to 10 m below sea level, in some exceptions to 15 m (15 m bathymetric contour)
- sea maps: digitising of additional information, for instance waterways, buoys, cable sites and construction, bridges, bathymetric contours, navigational signals
- sand extraction sites: geological, geomorphologic and biological sample collections of the sand deposits (according to mining laws) for coastal protection constructions, in particular artificial beach nourishment

– development of the 3D/4D modelling of the water level during storm floods, dependency on the high water mark, the total area flooded, the sub-department in endangered towns, waters, forests and other areas