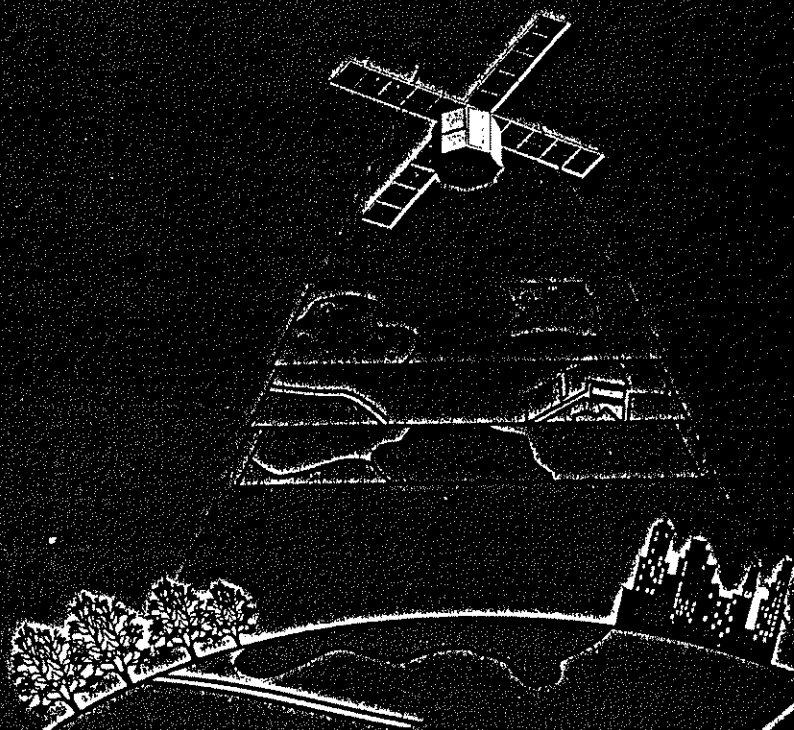


**GIS I TELEDETEKCJA W BADANIACH
STRUKTURY I FUNKCJONOWANIA
KRAJOBRAZU**

**GIS AND REMOTE SENSING IN STUDIES
OF LANDSCAPE STRUCTURE AND
FUNCTIONING**

**POD REDAKCJĄ
ANDRZEJA NIENARTOWICZA I MIECZYŚLAWA KUŃZA**

**EDITED BY
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**GIS AS THE TOOL OF ACTIVITY PLANNING ON
ENVIRONMENTAL MANAGEMENT AND PROTECTION IN
CATCHMENT AREA OF JASIEŃ LAKE
(BYTÓW DISTRICT, POMERANIA)**

**GIS jako narzędzie projektowania działań z zakresu kształtowania i ochrony
środowiska przyrodniczego w zlewni jeziora Jasiień
(powiat bytowski, Pomorze)**

The goal of this work is to demonstrate the possibility of GIS application to inventories and protection of natural objects. Those possibilities were described as well in general as with the example of a chosen area with many environmental problems connected with man's economy. The research area was Jasiień lake catchment in north-eastern part of Bytów district, on the border of physical-geographical mesoregions in Polanowska uplands and Kaszubian Lakeland. The spatial database was created for the researched area in the scale of 1:10 000. The basic data sources for gaining and creating vector layers were topographical maps in 1965 projection, the drawing of spatial arrangement plan of a lake surrounding drawn on a raster layer in the scale of 1:10 000, and forest maps (tree stands, habitats) in the scales of 1:10 000 and 1:25 000. Complementary materials were four aerial photographs from Phare program in the scale of 1:26 000. All analog data were transformed into digital version with the scanning process. The final effect, created by vectorization which took place with MapInfo application, database was made comprising vector layers, concerning three groups of issues:

- environmental sources (water, forests, flora, fauna);
- environmental protection (protected objects, areas and regions);
- anthropogenic elements (infrastructure, farming, cultural objects, environmental degradation).

On basis of created database many analyses can be made, which may be applied in actions concerning natural environment creation and protection. The following activities were presented in this paper:

- overlaying vector layers aided by topographic raster map;
- overlaying vector layers on raster pictures of colour aerial photographs;
- terrain elevation analysis, and creation of 3-dimension elevation model with Vertical Mapper - application to MapInfo program.

1. INTRODUCTION

A geographic information system (GIS) is a computer-based tool for mapping and analysing objects and events (entities) that happen on Earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualisation and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies.

GIS technology can be used for scientific investigations, resource management, and development planning. For example, a GIS might allow emergency planners to easily calculate emergency response times in the event of a natural disaster, or a GIS might be used to find wetlands that need protection from pollution.

Since the early 60's we have been observing continuous development of a GIS throughout all the western countries. In Poland a GIS history starts in mid 70's but the real origin is at the turn of the 80's and 90's decades. It is interesting how the application of a civil GIS technology has been changing for the years. As at the beginning there was only one application i.e. stocktaking. Afterwards, the analysis took its part and finally management was involved. Present percentage application pattern is as follows (Fig.1):

- Stocktaking - about 10%;
- Analysis - about 40%;
- Management - about 50%.

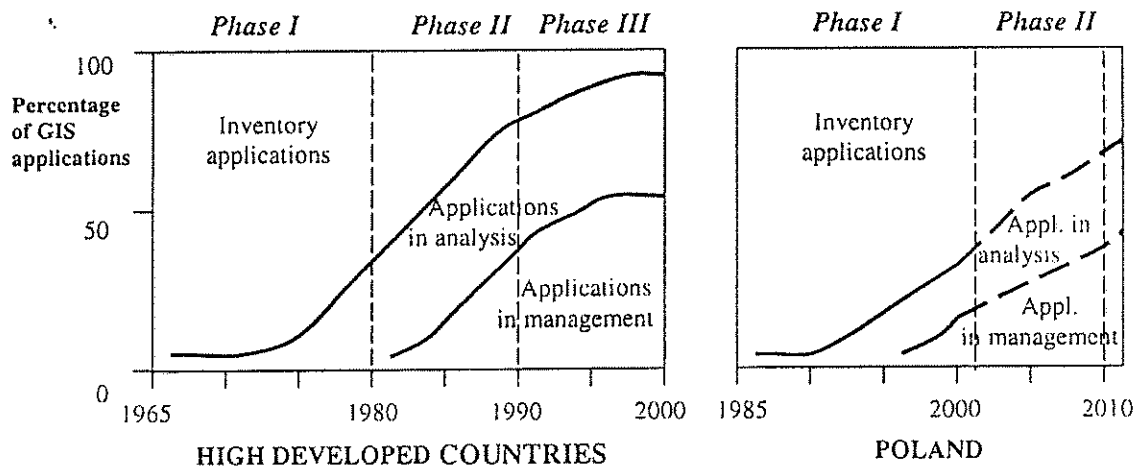


Fig.1. The comparison of GIS applications development in high developed countries and Poland

As well as application changed also usage pattern changed. As first, only governmental institutions dealt with GIS. Now, great many commercials use these systems in their production in tremendous amount of applications.

It's sure that GIS can be useful for many group of people in different applications. There is so many a numeric data allocated on the given area that usually is used by environment protection engineers who are often unable to put them all in order state. Data often change throughout the years at a given point, line or area. There is a need for averages, statistics, curves, tables, etc . As good this tool is we would like to present in next chapters of this paper, generally and on the example of the catchment area of the Jasień lake in Bytów District (Pomeranian Voivodeship).

Mapmaking and geographic analysis are not new, but a GIS performs these tasks better and faster than do the old manual methods. And, before GIS technology, only a few people had the skills necessary to use geographic information to help with decision making and problem solving.

Today, GIS is a multibillion-dollar industry employing thousands of people worldwide. GIS is taught in schools, colleges, and universities throughout the world. Professionals in every field are increasingly aware of the advantages of thinking and working geographically.

1. GIS FOR ENVIRONMENTAL MANAGEMENT

GIS is used every day to help protect the environment. As an environmental professional, you can use GIS to produce maps, inventory species, measure environmental impact, or trace pollutants. Depending on the purpose the system is created for, the GIS allow to perform the following activities connected with environmental management (Fig. 2):

Study and Manage Ecosystems

With a GIS you can analyse entire ecosystems. One can use GIS to study and manage the Analysis Program. Using the GIS you can visualise the ecosystem as a complete unit and display graphics of sensitive areas. Using the GIS you can assess environmental impact, develop planning strategies, and create maps that show the entire system.

Site Characterisation

With a GIS you can organise and refine data to help with site assessments, site inspections, and feasibility studies. Data, such as survey, hydrological, and aerial photos, can be organised and evaluated using the GIS.

Track the Effects of Pollutants

The damaging effects of pollution, such as oil spills, can be assessed using a GIS. With this information, the GIS can model potential contamination for different locations and help develop risk assessment strategies. GIS technology helped the *Exxon Valdez* Oil Spill Council prioritise areas that need protection and to restore damaged species. In addition, the effects of oil spills on coastal tourism were assessed by using the same data to analyse the scenic appeal of different areas.

Waste Management

A GIS enables waste managers to assess current waste facilities or site new ones. In addition, managers can share information in their organisations and co-ordinate with regulatory agencies to improve monitoring, transportation, and tracking of waste products.

Environmental Planning and Management

Using the analysis capabilities of a GIS you can manage relationships among biological and cultural resources, and assess the strategies for response and support efforts during disasters.

Analyse Wildlife Populations

You can use a GIS to display and analyse field data. The integration of both GIS and echo location technologies (connected with GPS) resulted in more detailed information and a more accurate species assessment than obtained from previous methods. After collecting the data, the GIS is used to visualise and analyse the spatial abundance, size, and depth distribution of the given species.

Monitor Protected Areas

One can use GIS to monitor the distribution of vegetation types in a given area. Obtained map can represent the vegetation types in different colours and protected areas in diagonal patterns. With this information one can easily see areas needing protection or currently protected areas that may be threatened.

Monitor Water Quality

GIS can be used to show the distribution and quantity of different water pollutants throughout an area. Usage of soil loss, phosphorus levels, land use, and *Escherichia coli* bacteria levels as components in a water quality model for a given terrain can be evaluated. The water quality model is used to monitor, predict, and manage the overall water quality. The location of each sampling station, landfill, incinerator, pond, and tributary is stored in the GIS. The GIS can plot the features and/or look for spatial relationships between station water quality and potential pollutant sources. With a GIS you can visualise and analyse sampling sites. The evaluated map can show different sampling sites and compares each site by pollutant. In addition, scanned photographs of the sites can be displayed.

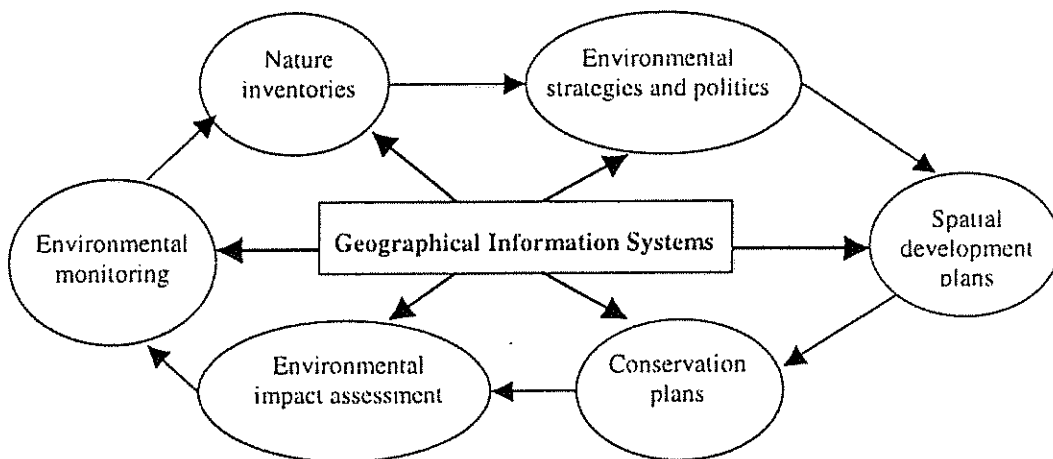


Fig. 2. The general directions of GIS application in environmental management

2. GENERAL ENVIRONMENTAL CHARACTERISTICS OF THE JASIEŃ LAKE DIRECT CATCHMENT AREA

The area taken into consideration is the direct catchment of the Jasiień lake located in the north - eastern part of the Bytów District in the part of mesoregion of West - Pomeranian Lakeland – Polanów High Plain (Fig.3). Choice of the area was dictated by the occurrence of diverse environmentally valuable objects located within and also the area might serve as a base for different environmental analysis related to changes in land use and influence of tourism upon the environmental condition of the Jasiień lake due to application of different systems of space management within last hundred years. The direct catchment of the Jasiień lake is a part of land having the conservation status of "Słupia Valley" Landscape Park.

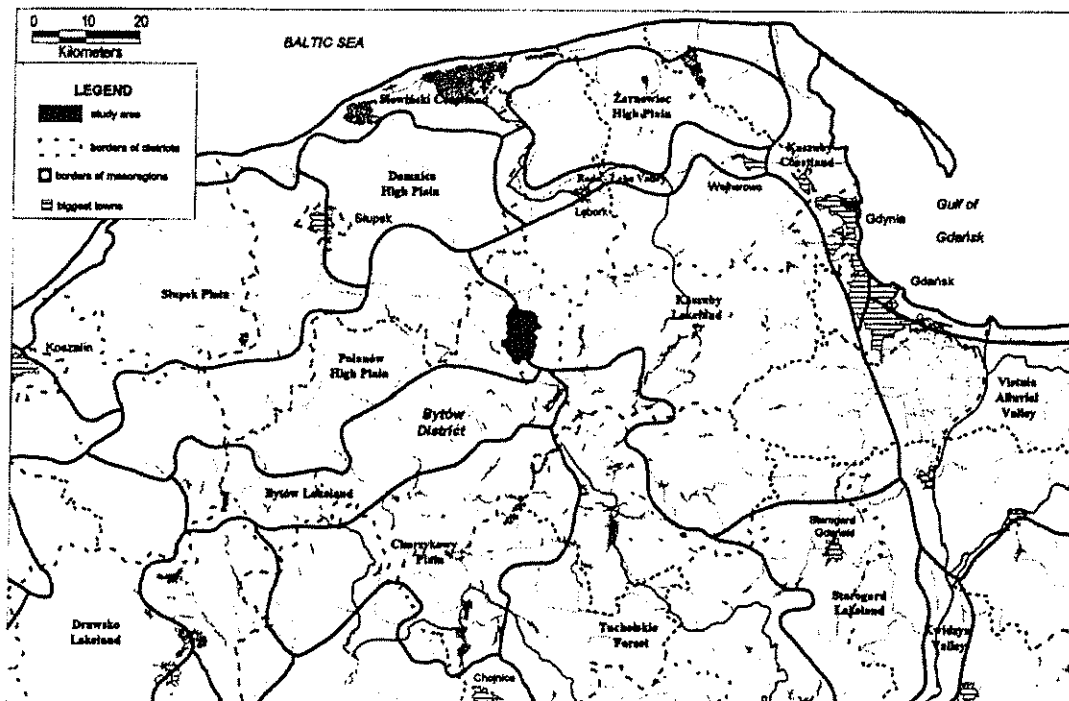


Fig.3. Localisation of the study area

The Jasiień lake consists of two basins - northern and southern of total area 577.2 ha and belongs to the type of post-glacial thread. Its maximal depth is 32 meters. The lake is fed by two tributaries: river Obrówka and the stream without the name that flows through Jasiień and gets to the southern basin of the lake. The direct catchment of Jasiień lake is constituted in about 60% by forests with majority of coniferous trees, and in 17% by arable lands. Łupawa river has its outflow in the northern basin of the lake. Species dominating in the lake are roach, bream, eel and pike. The lake is also an important place in terms of birds' protection. Islands present on the lake are the breeding places for such species as: swan, black cormorant and heron.

Due to the presence of recreation centres at the coast of the lake, especially in the southern part, the lake is threatened with eutrophication. Additionally for several years Jasień lake was used as a sewage tank for the technological wastewater from the near alcohol distillery. Aggregated data describing basic parameters are given in the Table 1.

Table 1. The parameters describing water quality of Jasień lake.

	COD [mgO ₂ /l]		BOD [mgO ₂ /l]		Phosphates [mgP/l]		Total P [mgP/l]		Chlorophyll a [mg/l]		Coli [-]	
	N	S	N	S	N	S	N	S	N	S	N	S
1981	28.5	25.8	-	-	0.123	0.119	0.37	0.57	-	-	1	10
1985	15.6	10.6	-	-	0.112	0.02	0.125	0.326	43	44.5	17	17
1986	15.7	21.07	0.202	5.73	1.207	1.434	0.464	0.488	19.2	39.12	20	4
1987	21.4	10	3.7	3.9	0.355	0.458	0.095	0.496	9.24	10.44	17	17
1988	24.55	17.8	4.75	4.75	0.559	0.444	0.58	0.476	18.75	12.6	2	4
1998	15	15.5	2.2	4.6	0.275	0.654	0.306	0.677	11.2	9.6	20	-

Explanations: N - northern basin of Jasień lake, S - southern basin of Jasień lake

The most recent results, compared to valid standards show that parameters indicate water quality mainly as 2nd class and part of them indicate 2nd/3rd class. Also some parameters are on the level of the first class. Generally the environmental conditions improved due to installation of septic tanks in the recreational centres and abandonment of direct waste discharge to the water and soil after dilution. Although still some of the recreational centres practice such way of wastewater disposal and release part of their wastes to the lake bottom sediments, without the obligatory permissions. The devices for discharge to soil are still observed in the terrain.

3. DATABASE DESCRIPTION

Whole the database was created with the software of MapInfo Corp. - MapInfo Professional 4.0. The platform for MapInfo software was the PC computer served by Windows 95 operational system.

The basis for the database elaboration was the maps of spatial management elaborated in 1993. The basis for the maps were topographic maps in scale of 1:10 000 consisting of three sheets. The maps had been transformed into raster images by scanning and with the control points the digital map was properly oriented geographically in order to be the projection of the real surface on the Earth.

As the source of information we used also two other kinds of maps. One of them was the map of the forest areas in scale of 1:10 000, which due to its detailed description allowed us to create the digital map of the forest units with high

accuracy and additionally assign information concerning the species of trees occurring in the forests. The map was created by the State Forest Survey and it's updated with the information about the state of the borders of forest sections from 1995. The latter map was the map of habitats in scale 1:25 000. The map was also created by the State Forest Survey on the basis of the forest sections map also created in scale 1:25 000.

Another source of data used for analysis are the colour aerial images in the scale close to 1:26 000 from 1997. The possibilities connected with these images are of analytical character. Application of such images for analysis is much easier than in case of satellite images that require

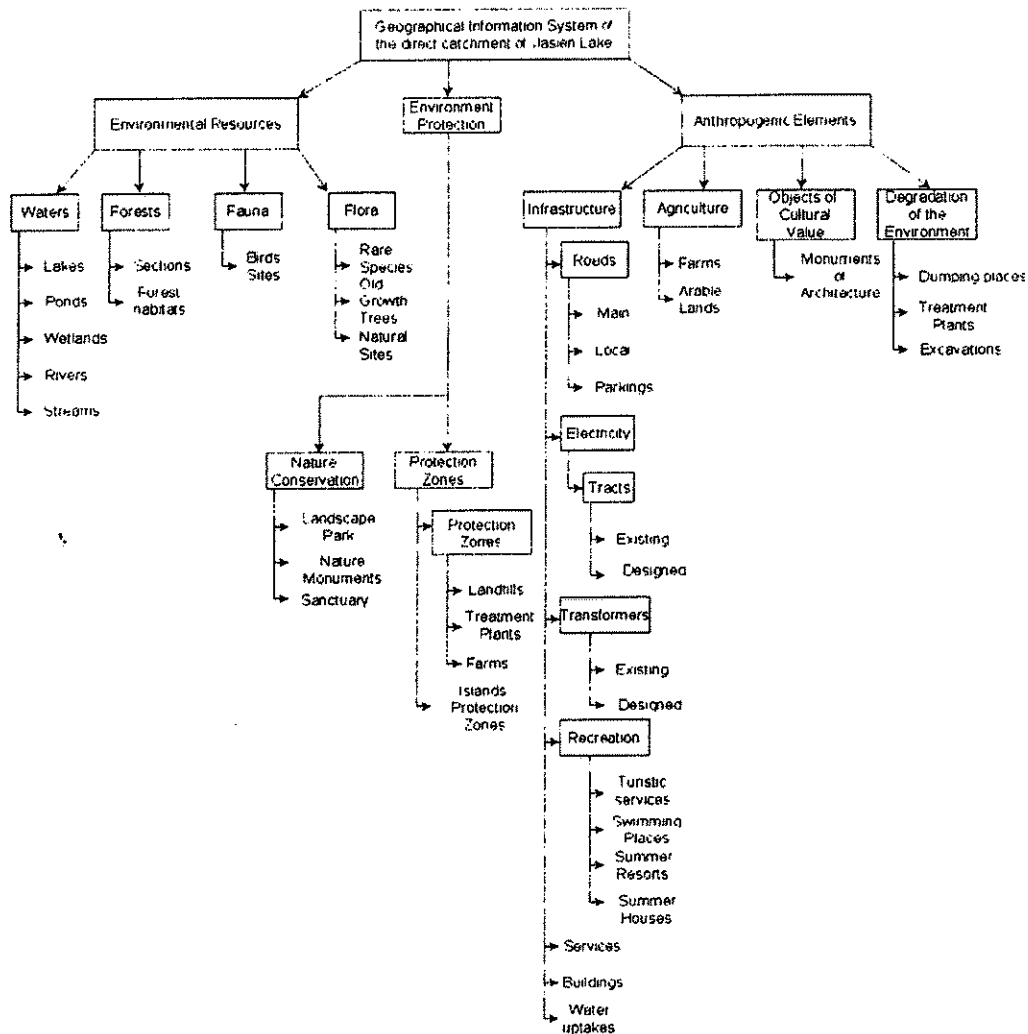


Fig.4. The structure of the digital spatial database

performance of classification procedure which allows to identify different types of land use, vegetation, etc. But performance of classification additionally requires

from the user the knowledge from the field of remote sensing. Such problems do not occur in case of the photos taken from the air mainly due to low altitudes necessary to take the photo in comparison with those at which the satellites operate. It should also be mentioned that the possibilities of automatic classification that makes the classification easier and more exact is not offered in MapInfo software but in the other programs as Arc/Info or ERDAS Imagine which price is of several orders higher than this of MapInfo. Another advantage for usage of such images for simple analysis is the price of one sheet of the image. For the purposes of the thesis we used four sheets covering the area of interest.

In order to describe the area and its environment it was necessary to collect the analytical data, geographical and general descriptions of the surroundings. These were collected mainly from the Voivodeship Inspectorate of Environmental Protection. Some more additional information was also collected from the Voivodeship Council of the former Słupsk Voivodeship. The data concerning tourism at the area of the direct catchment of Jasień lake were collected in the office of "Słupia Valley" Landscape Park. The structure of vector layers in the spatial database is presented on the Fig.4.

The important problem during creation of database, which should be taken into consideration, is the errors of database. Errors having the biggest influence upon the quality of the presented database are the following:

1. The projection of the source map. The map which we used as a source of the majority of information present in the database has a scale of 1:10 000 and it was created basing on 1965 projection created in Poland under communist government. This projection was consciously mistaken in order to make it impossible to identify objects of strategic and military meaning.
2. Another source of errors was the optics of the copying machine. The base map that was copied for the purposes of this elaboration had previously been copied by the institution owning it.
3. Similar type of inaccuracy was introduced while scanning. In addition to inaccuracy caused by the scanner optics, another mistake was done as a result of insufficient qualifications of the person working at the scanner in the specialised company. The raster image that the map was transformed into was rotated in such a way that it couldn't be modified completely by the advanced graphic software (Corel Photo Paint) available for PCs. Neither the capabilities of the image rectification (stretching and rotation of the image registered in the geographic coordinates applied in order to modify the grid of pixels altered in the different process of data transformation i.e. scanning) offered by MapInfo did not allowed to eliminate the inaccuracy.
4. The errors introduced during vectorization as slight simplification of the line shape and inaccuracy of coverage the information from the raster with lines.
5. Errors derived from the lack of uniform criteria of geographical objects identification. This problem had a special meaning in case of the forest maps and the forest sections` borders where for many times the difficulties concerning appropriate identification occurred.

4. APPLICATION OF THE GEOGRAPHICAL INFORMATION SYSTEM OF THE DIRECT CATCHMENT OF JESIEŃ LAKE

The GIS applied in the field of environmental protection, management and study can be divided into several groups (Fig. 5). Classification depends on possibilities of modelling and complexity of application.

1. Inventory systems for data collection and projection in any co-ordinate system and form. These systems allow performing only simple analysis.
2. Cartographic edition systems are related to the inventory systems but oriented towards elaboration of spatial and descriptive data for the purpose of map making as a final product of digital tooling.
3. Evaluation systems are utilised in assessment of the environmental resources performed for different purposes and from different points of view with the data from a single period. So without regarding to the changes within the environment.
4. Retrospective systems - used to compare state of the environment in different periods of time on the basis of data contained in the database. Usually the data from two, three or four periods of time with different time intervals between (a year, decade, or a hundred years) are used for the analysis.
5. Monitoring systems - related to the retrospective systems but assigned to analyse the data gathered from frequent and regular monitoring of the environment (waters, soils, air, and space management). Monitoring should be performed permanently or frequently repeated.
6. Forecasting (predictive) systems utilise the capabilities of evaluation and monitoring systems, used to forecast and simulate changes in the environment in different periods of time: from short (24 hours, week, month) regarding meteorological or hydrological (flooding) phenomena, to long periods (year, several years, i.e. in regard to geomorphologic processes or other aspects of landscape evolution (creation of peatbogs on the lake areas).
7. Experimental systems - created to investigate the technical aspects of GIS application, as testing of simultaneous application of many sources of information about the environment or usefulness of the GIS for the purposes others than those stated primarily.

The content of the database shown on the graph of the database structure (Fig. 4) together with the air images of the area, 3-D views and raster images which can be created with the Vertical Mapper software working in the MapInfo environment enables the user to perform different kinds of simple analysis concerning environment protection and management, spatial management, changes in the land use, assessment of the area in terms of tourism development and agricultural activity. As well the GIS can be used as a source of information about the area in terms of environmental resources, possible environmental threats, existing infrastructure and types of activities located within the direct catchment of JasieŃ lake. Again, the special advantage of the system is the possibility of data visualisation in order that is suitable for the system user. That feature makes the work more comfortable because there is no other unwanted data displayed at the

time. Such thing is impossible while working with analogue maps where the information of our interest is partially covered or crossed by the other information so that the analysis is time consuming and requires higher concentration from the user which engages more energy to perform the analysis and makes whole the work less efficient.

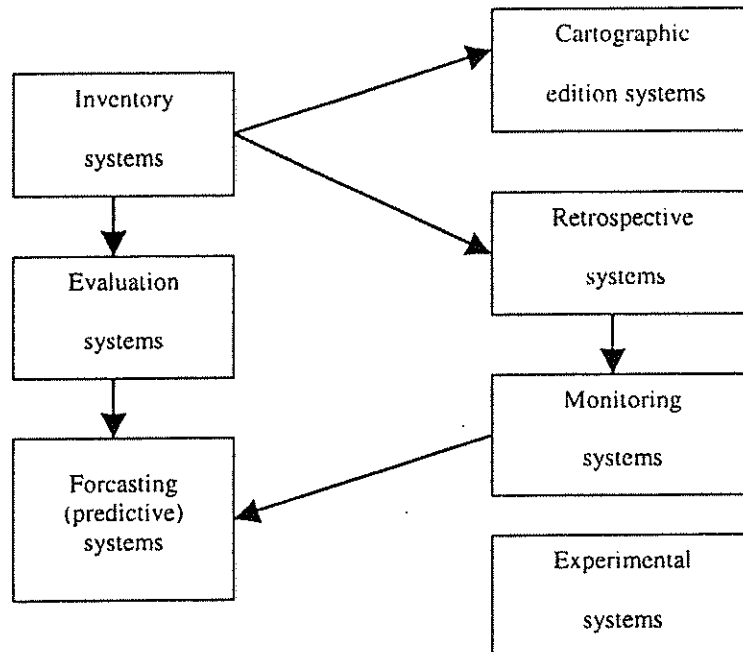


Fig. 5. The types of GIS systems for environmental protection, management and study

Actually we can distinguish between the three kinds of analysis we can perform using the content of the database:

- The analysis performed with the vector objects and base topographic maps.
- The analysis with the use of the data in the form of vector objects and aerial photographs of the area in the form of raster image.
- The analysis performed with the use of vector data, air photographs, 3-Dimensional models of the terrain and other data display possibilities offered by the Vertical Mapper software for MapInfo Professional environment.

Below we will try to briefly introduce the analytical possibilities given by the database but in accordance to the above classification.

The analysis performed with the vector objects and base topographic maps

The information contained within the database was transformed into the digital form from the maps of different scales. As it was mentioned before, the major source of information and simultaneously the base map was the one of spatial management basing on the topographic map in scale 1:10 000. This scale is the one in which all the information gathered in the database is stored. Nevertheless part of the information was introduced to the database from the maps of the scale other than

1:10 000 as in case of forest habitats where the scale was 1:25 000 or the information was introduced partially from the map of the area's spatial management but during vectorisation process it was being corrected in accordance to the more updated map also in the scale of 1:10 000, as in case of the forest sections.

This fact gives us first possibility to perform the analysis of changes in the forest management throughout the period of two years in which the maps were created. Provided that the map of the spatial management had a proper information on the forest sections, displaying the layer of the forest sections we can observe the changes of the borders' shape and possibly the changes of the land use by the possible change of the land classification. Such situation took place on the northern west part of the forests' sections.

Another kind of analysis that can be performed concerns analysis of types of the activities present on the area protected by the status of the "Słupia Valley" Landscape Park. For this purpose the one can display the following layers:

- border of the direct catchment of Jasień lake,
- border of the "Słupia Valley" Landscape Park,
- services,
- tourist activities,
- wastewater discharge devices,
- excavations.

Therefore it's possible to find out the possible threats for the protected fragment of the landscape, by checking whether the types of activities present on the area of the Landscape Park are the ones which are acceptable from the legal point of view (Fig. 6).

Additionally, in order to simplify the work, it's possible to save some layers under one file (extension .WOR) which if chosen displays all the layers linked to it, at once. This kind of file is used in order to quickly open the files necessary for further vectorisation or analysis.

Very useful feature offered by the MapInfo Professional is the complex information about the selected object. The box that appears after double clicking on object of interest displays the periphery co-ordinates of the object, co-ordinates of its centre, and the area. Also it is possible to change the units in which the information is to be displayed. MapInfo offers either the possibilities of the reciprocal cross -secting the objects in order to find out the area of their common part.

The capabilities offered by MapInfo allow clearly identify the threats for the nature, rare species of flora. As an example we can use the layers containing the sites of natural flora and the layers with the local roads. In the southern east part of the catchment we can observe the site of natural species lying next to the road which constitutes the potential threat for these plants.

Using the data collected in the database we can also try to predict future of certain elements of the landscape as swamps and wetlands. Displaying the vector layers with these information and adding information on inhabited areas, roads or farms etc. the one can clearly see the reciprocal spatial relations of the objects. It is obvious that the swamp or a pond located next to the farm or any kind of inhabited area is more threatened with eutrophication or peatbog formation due to feeding with nutrients from waste waters or soil fertilisation.

Very useful tool of MapInfo related to map making is the possibility of printing maps with the information that we're interested in. This possibility gives the command Create the Thematic Map from Map menu that allows to print the objects on the map in different colours and backgrounds or graphs with no necessity of changing the original vector information. Simultaneously the legend is being created automatically but it can be easily edited by the user and adjusted to his/her demands.

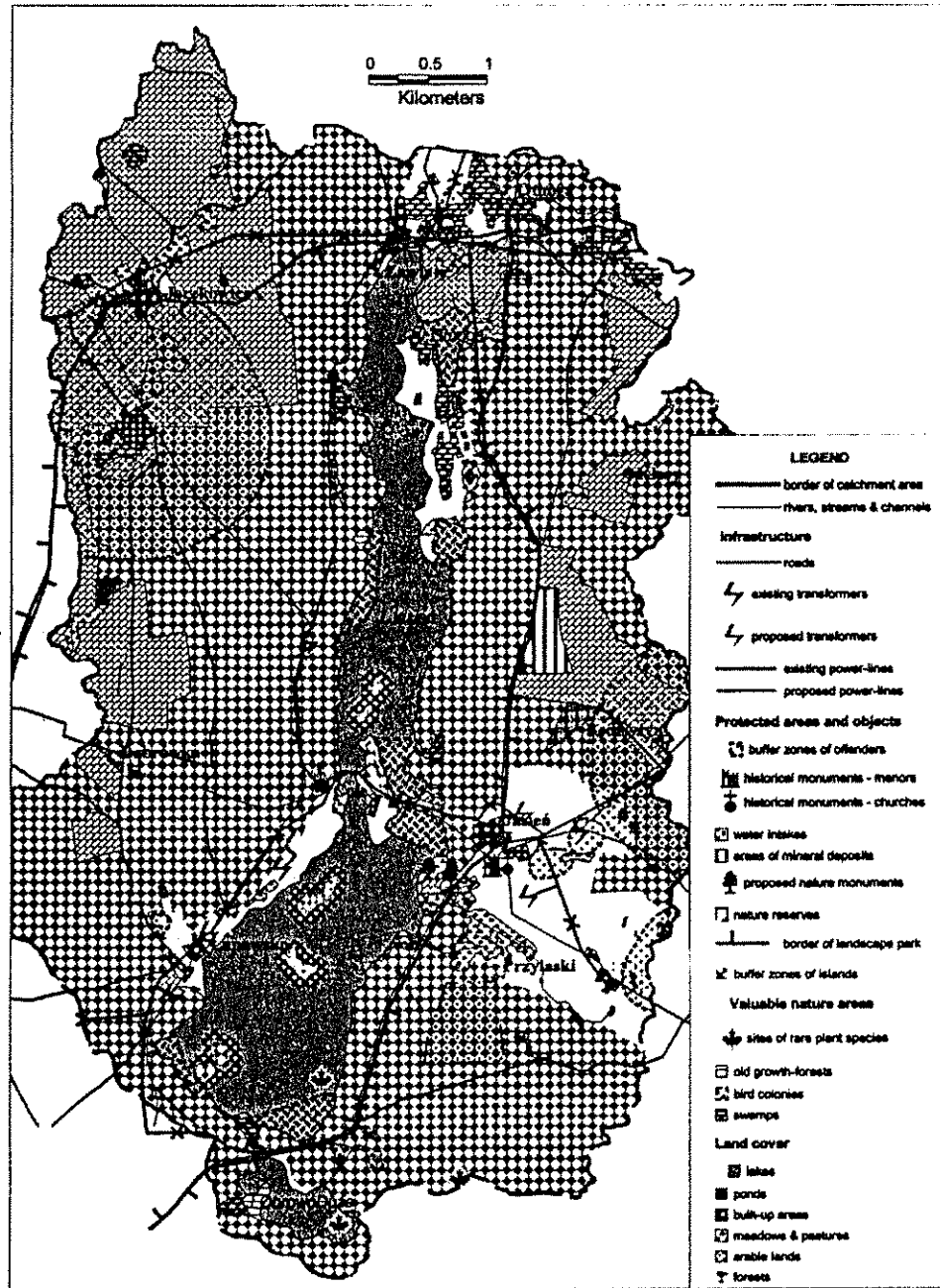


Fig. 6. Presentation of the study area by the database's vector layers

Analysis with the use of aerial photographs in the form of raster images

As it was mentioned in the chapter describing the database, the aerial images used for the purpose of this elaboration (sponsored by Phare Programme of EC) are in scale 1:26 000 and to cover the area of the direct catchment of Jasień lake four photographs have been used.

In order to use them as a raster image in the database, they required registration within the geographical projection (geographical longitude/latitude). After scanning the photographs were displayed on the monitor together with the base map, and registered by searching common points on both the map and the image. The easiest and probably the only possible way to register the image is searching for the same points as crossroads and other characteristic objects. The one has to notice the fact that it is a very difficult task to register the image in an ideal way due to limits imposed by MapInfo software in the field of the image rectification. Another barrier on the way towards proper registration is the resolution or the original quality of the photograph. Sometimes it occurs very difficult to put the control point exactly in the point it's supposed to be, because of insufficient resolution which at higher magnification makes the point looking "molten". While registration of the images we experienced mainly the latter problem.

Thanks to the aerial photographs it's possible to verify the consistency of map's information with the real state. Overlaying the aerial images with data contained within the vector layers makes it possible to update the information i.e. on the land use and different types of activities performed within the area (example on Fig. 7).

The aerial photographs might also be the basis for retrospective analysis. In case of our work we could use either vector layers containing the information at least two years older than the aerial images which were taken in 1997, or the base map which topographic part was created c.a. 25 years ago and the spatial management information in 1993. The subject of analysis might be swamps, ponds and streams. Overlapping the raster with the thematic layers containing the mentioned information it is possible to find out whether these elements of the landscape still exist.

It's possible to perform the same analysis in the other very interesting way. Instead of vector layers the one can use the base map. MapInfo makes it possible to modify the raster map's view setting the colour chosen by the user as transparent. This way is the most effective as the base map is just a black and white image. Then it's enough to set white colour as transparent and the only remaining is the information in black colour which laid on the aerial image makes it possible to perform the retrospective analysis. In case of this work it's more convenient to use vector layers for such analysis due to high density of different types of information contained on the map.

Another argument for using aerial images for such analysis instead of satellite ones is that the scale 1:26 000 allows to perform detailed analysis and there is no need to perform the process of classification which requires knowledge from the field of remote sensing and more advanced and more expensive software.

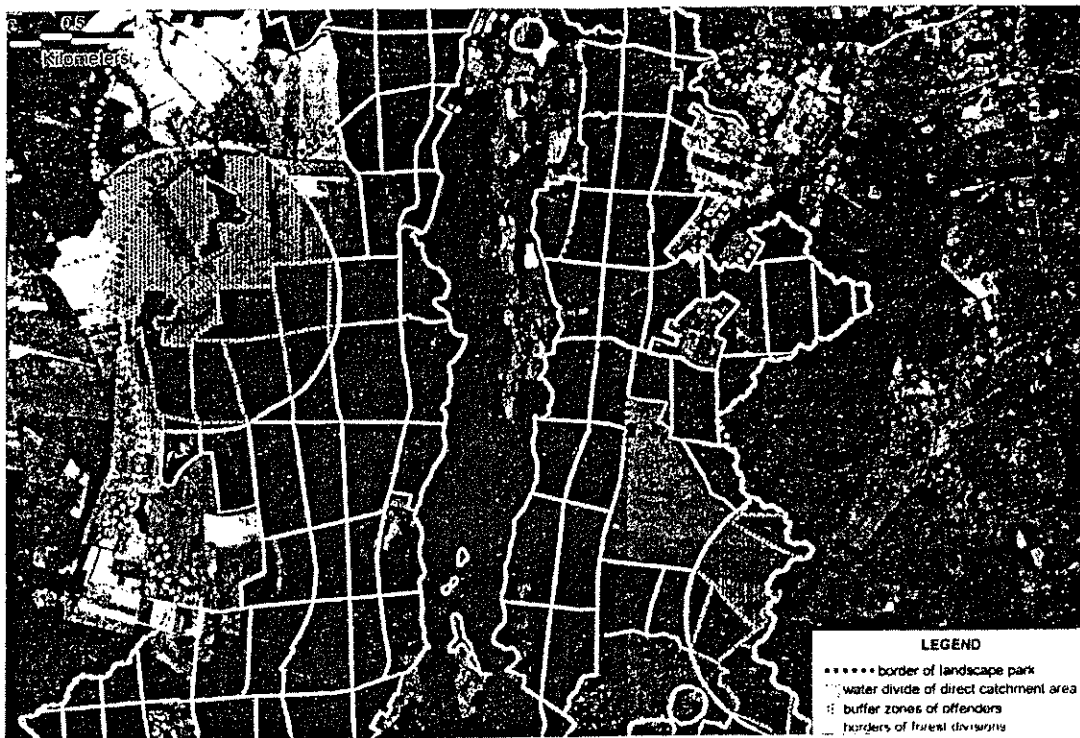


Fig. 7. An example of overlaying of forest division borders and buffer zones on aerial photo

The analytical possibilities offered at work with Vertical Mapper 3-D modelling

The Vertical Mapper ver. 2.0 software operates with the files of other structure than MapInfo. As MapInfo operates on the layers, the Vertical Mapper operates on the grids which actually is a grid of pixels with the assigned information. The grid represents the data that vary throughout the space, in case of this work to create the grid, the layer of elevation points have been used which possessed assigned information on the altitude. The gridding process creates an imaginary network of regularly spaced cells and then estimates, or interpolates, a new value for every cell based on the value of original site contained within the MapInfo tables. For the purpose of a grid creation Vertical Mapper offers four kinds of interpolation techniques. Each of them is suitable for different kind of analysis. The one that we had chosen to create the grid that further served for creation of 3-Dimensional model and other operations was the Natural Neighbourhood.

The Vertical Mapper software is the one that allows to perform more complicated analysis and for the purpose of this elaboration only a few possibilities have been used. Application of all the tools requires higher technical and environmental knowledge. Anyway these few functions that we used allowed us to show other great analytical possibilities offered by the software.

Creation the 3 - Dimensional model of the terrain gives the great possibility to visualise the changes that took place in the landscape or in the land use at certain area. During the process of creation the 3D model the user is able to adjust its exposition, displaying it in accordance to his/her own needs.

As it was mentioned in the chapter concerning the characteristics of the direct catchment of Jasięń lake, changes in the landscape that took place concerned reforestation of the area but there were no changes that might have influenced the shape and exposition of the landscape elements. If such changes happened, possessing the maps documenting the state of the landscape before the changes, it would be possible to create some 3-D models of the terrain in order to visualise and compare the changes that took place and analyse its attractiveness i.e. in terms of tourism or availability and usefulness for different activities.

On the basis of layer with altitude points (Fig. 8a) that we created for the whole area of the catchment we were able to perform some interesting analysis. The tools that occurred very useful for our purposes were the ones allowing for creation the grids of slopes and aspects of the terrain (Fig. 8b-c). It must be added that the created grid might be later given up to the process of contour creation after which the map in form of MapInfo layer with polygons and assigned information is created.

So that the created grid might be undergone different operations. The possibility mentioned above is creation of 3D model but having the possibility of contour creation, the map can be created to be later used with other MapInfo layers. Simultaneously Vertical Mapper enables the creation of legend to the contours and colours adjustment. But the practice shows that it is better to create the legend with MapInfo tools due to the fact that the created legend appears in form of map with geographical attributes that is rather difficult to edit.

In our work we created the grid of slopes and aspects for the study area. This gave us possibility to perform the following analysis:

- searching for areas suitable for agriculture and housing (on the basis of map of slopes and aspects),
- searching for the areas (landscape elements as waters, swamps, wetlands) threatened by eutrophication.

First, meaning of the map of aspects should be explained: the map of aspects shows orientation of the areas toward the directions of the world (rose of winds). Having the map of aspects we overlapped it with the following layers:

- areas of the agricultural activity (arable lands),
- summer housing,
- settlement housing.

Then we can analyse which of the arable lands seem to have a good location for such an activity in accordance to the orientation. It's well known that the sunlight plays an important role for growing plants. So that it's obvious that areas poorly exposed to the sunlight are those of northern orientation and the best are the ones with southern orientation.

The same way might be regarded to housing, especially to summer housing. The places of southern and southern-west orientation are the best for houses which being exposed to the sunlight do not require application of artificial light on very big scale and simultaneously less amounts of energy will be required to heat the houses.

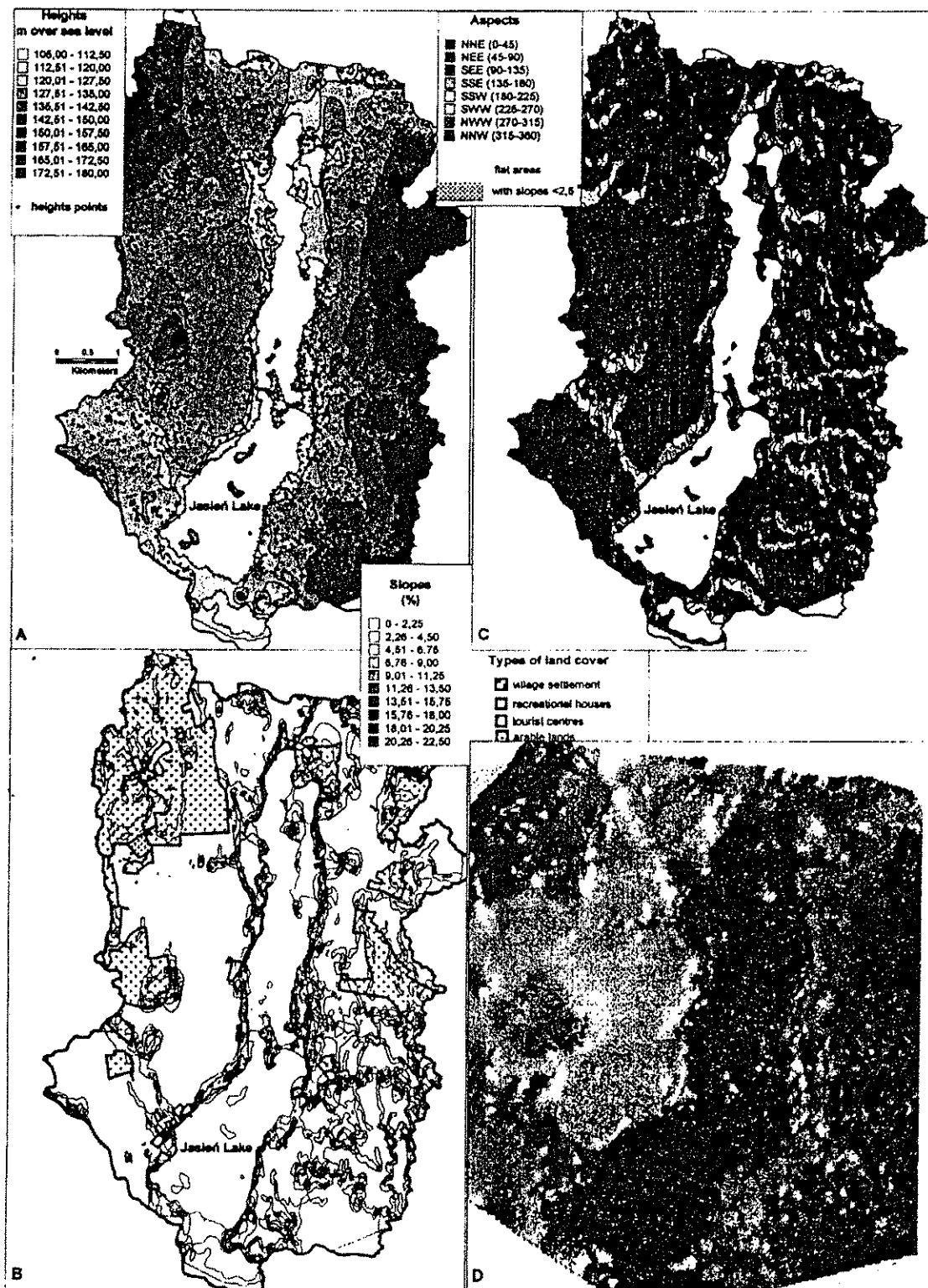


Fig. 8. The different types of presentation of digital elevation model (DEM):
 A-map of heights, B-map of relief slopes, C-map of relief aspects,
 D- draped model of relief (Vertical Mapper)

The second, analysis of places (landscape elements) threatened by eutrophication based on the map of slopes. The layer was overlapped with the following:

- forest areas;
- inhabited areas.

First, the elevated areas of high slope have to be identified. Then we can check the form of the land cover. In case of elevated areas of high slope covered with the forest, the runoff will be much lower than in case of non - forest areas due to lower drainage. It's well known that the trees and plants assimilate high quantities of water.

Looking at the map of slopes we can see that significant part of the inhabited areas (mainly summer resorts) are located on the lake's channel edge that is of course of high slope. So that the lake is exposed to the flow of waste waters in case of any leak from the septic tank, and washing out all the man - made pollution from the areas of the resorts.

Due to unavailability or inaccessibility of certain kinds of data as: the amount of fertilisers applied to the arable lands and the map sketching types of soils present within the area of the direct catchment of Jasień lake we were unable to perform more advanced analysis concerning the amount of runoffs getting to the lake.

Another one of the interesting possibilities offered by Vertical Mapper is creation of so called drape files which make it possible to display any layer (map) from MapInfo on the 3 - Dimensional model (Fig. 8d). So that the drape file is just the MapInfo file displayed on 3D model. This tool is the another feature that makes the visualisation more detailed.

STRESZCZENIE

Celem pracy było zademonstrowanie możliwości zastosowania GIS do inwentaryzacji i ochrony obiektów przyrodniczych. Możliwości te omówiono zarówno w ujęciu ogólnym, jak i na przykładzie wybranego obszaru, na którym występuje wiele problemów środowiskowych związanych z gospodarowaniem człowieka. Terenem badań była bezpośrednia zlewnia jeziora Jasień, położonego w pń.-wsch. części powiatu bytowskiego, na granicy mezoregionów fizycznogeograficznych Wysoczyzny Polanowskiej i Pojezierza Kaszubskiego. Dla badanego obszaru wykonano bazę danych przestrzennych ze szczegółowością odpowiadającą skali 1:10 000. Podstawowymi źródłami danych dla pozyskania i stworzenia warstw wektorowych były mapy topograficzne w układzie 1965, rysunek planu zagospodarowania przestrzennego otoczenia jeziora wrysowany na tych podkładach w skali 1:10 000 oraz mapy leśne (drzewostanowe i siedliskowe) w skalach 1:10 000 i 1:25 000. Uzupełniający materiał stanowiły cztery barwne zdjęcia lotnicze z nalogu Phare w skali 1:26 000. Wszystkie materiały analogowe zostały w wyniku skanowania przetworzone na postać rastrową. W efekcie końcowym, poprzez wektoryzację przeprowadzoną przy zastosowaniu oprogramowania MapInfo 4.0, stworzono bazę danych obejmującą kilkadziesiąt warstw wektorowych, dotyczących trzech grup zagadnień:

- zasobów środowiskowych (wodnych, leśnych, florystycznych i faunistycznych);
- ochrony środowiska (obszarów i obiektów chronionych, stref ochronnych);

- elementów antropogenicznych (infrastruktury, rolnictwa, obiektów kulturowych, degradacji środowiska).

Opierając się na stworzonej bazie danych można prowadzić szereg analiz, które mogą być wykorzystane w działaniach z zakresu kształtowania i ochrony środowiska przyrodniczego.

W niniejszej pracy zademonstrowano następujące działania:

- nakładanie warstw wektorowych wspomaganie rastrową mapą topograficzną;
- nakładanie warstw wektorowych na rastrowe obrazy barwnych zdjęć lotniczych;
- analizy rzeźby terenu i tworzenie 3-wymiarowego modelu rzeźby przy zastosowaniu Vertical Mapper – aplikacji do programu MapInfo.

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