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Visualization of the hydrologic data of Biebrza Valley in Poland

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Visualization of the hydrologic data of Biebrza Valley in Poland

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Abstract

Biebrza Valley (northeastern part of Poland) has the unique water conditions, which were conductive to create valuable marshland, the biggest natural wetlands in central Europe. Climate changes, changes in land use and several hydrological works influenced water conditions. It caused the menace of them in whole Biebrza region. That is why there are founded several projects, which have the aim of finding the best way of farther managing water conditions and at the same of preserving many species characteristic for that kind of ecosystems. Such managing support system needs to be discussed with several partners like farmers, Biebrza National Park, administrative policy makers, sponsors of the project. Cooperation between them nowadays is weak and should be improved. There is a need of showing the data gathered by research institutes during those discussions with partners, in an intelligible way. This thesis was made to show visualization techniques, which can help in communication between scientists and other groups of people during discussions about the environment. This work was focusing of finding the best way of showing the data as the part of the PIN Matra Project "Man and Nature at Biebrza. Integration and dissemination of knowledge for sustainable nature management" (the presentation module). The results of this thesis are prepared exemplary visualization of terrain model with thematic data and report containing the theory as well as evaluation of the presentation.

Study area is situated in northeast part of Poland – in the middle part of Biebrza Valley. For that part there were provided calculations for hydrological module based on different scenarios of water flow.

Key words: visualization, terrain model, Terra Explorer, interface, communication.

TABLE OF CONTENT

Acknowledgments III
Abstract IV
1. INTRODUCTION 1
1.1 VISUALIZATION 1
1.2 STUDY AREA 2
1.3 THESIS OBJECTIVE AND RESEARCH QUESTIONS 7
1.4 METHODOLOGY 8
1.4.1 Outline of the report 9
2. GENERAL ASPECTS OF THE PRESENTATION 11
2.1 PERCEPTION AND UNDERSTANDING OF SPATIAL DATA 11
2.2 CRITERIA OF THE PRESENTATION 15
3. COMPONENTS AND FUNCTION OF THE PRESENATION 17
3.1 INTERFACES – MAIN CONCEPTS 17
3.2 NEEDS FOR THE PRESENTATION INTERFACE 20
4. DESIGNING THE PRESENTATION 22
4.1 CHOOSING THE TOOL FOR VISUALIZATION 22
4.2 SKY LINE VISUALIZATION TOOLS 23
4.3 DESIGNING THE INTERFACE 25
4.4 GRAPHICAL DESIGN OF THE PRESENTATION 30
5. BIEBRZA APPLICATION 34
5.1 GEO-DATA AND ITS PREPERATION 34
5.2 HYDROLOGICAL MODULE DATA 35
5.3 PRESENTATION PRESUMPTIONS 40
5.3.1 Target groups and users 40
5.3.2 Some conclusions 42
5.4 LEVELS OF DETAIL, RESOLUTION AND REFERENCE INFORMATION 43
5.5 PROCEDURE FOR PREPARING THE PRESENTATION 51
5.6 CHARACTERISTICS OF THE HYDROLOGIC THEME 53
6. EVALUATION OF THE APPLICATION 56
7. CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS 61

1. INTRODUCTION

1.1 VISUALIZATION

"**Visualization**" means of "making things visible". Putting data, ideas, way of thinking into a graphical form can help to understand them better. People already noticed that making schemes at the very beginning stage of communication. Particularly when we deal with the space, it is very efficient to use graphic form for showing the localizations, directions or shapes instead of words. It is because on the surface we can code the topological information almost in the same form as it exists in reality. The words building the language are in a different way of coding; use other kind of dimensions, which cannot handle to communicate many details easily visible at the image. That is why the interest of developing visualization methods is growing, especially now, when the computers techniques allow proceeding huge amount of data.

Visualization is a very broad term. It contains scientific visualization of many fields (from medicine to networks) as well as artistic creations. In this report it is taken only the part connected with the Earth data, which is called **geo-visualization**. Geo-visualization has the long history started from very first maps. Along the time it has been built broad knowledge – cartography, which concerns two-dimensional (2D) representations of the world. Nowadays with computer aid, the interests have shifted to the side of multimedial, 2.5D, 3D presentations. They are supposed to be easily understood than traditional maps, so it would be possible to communicate geo-information to much bigger group of receivers.

Geo-visualization has specific characteristics and it is under specific rules, which have the base in cartography. Graphic presentation of reality, has precisely defined relation between topology in the real world and topology in the reality model. This relation allows coding the same features of information, which can be perceived in the real world. Any other kind of presenting the data (texts, tables) cannot maintain topological patterns, spatial relations between phenomenas. Possibility of perceiving spatial characteristics is irreplaceable for analyzing geographical data. "The objective of visual data analysis is to use graphics to assist in data exploration and the development of ideas in scientific investigation" (Unwin et al., 1994). Thus geo-visualization can be treated as the tool for experiencing, the surrounding world. In the geo-presentation there are potentialities of underling certain relations or phenomena, taking advantage of playing with the scale, thematic layers, details of objects, dynamism, colors, lights, movements, etc. When we use such enhanced models of reality, we "have the advantage of representing phenomena we normally can't see" (Wodtke, 2003). This tool is using then to

"explore salient patterns and relationships in geographic data that are otherwise hard to comprehend" (Lo, 1994).

Visualization of geographical data is developing for helping to understand the information hiding in the raw data. It is made for certain purpose, to take a deeper look in the certain part of the data, to find the answers for our particular questions. Visualization is seen as a process of data exploration over a product itself – data presentation (Crampton, 2001). So it is distinguished as an activity.

Visualization can also be perceived as the result of the activity, of the process. Then it has the similar meaning as **map** (as the result of visualization process) and the **presentation** (prepared arrangement of the spatial data for communication with other people). It illustrates the producer's ideas, the final effect of research in the form to share it with others. The computer aid makes possible interaction with the product. It gives the chance of answering user's questions and at the same of more efficient communication.

This thesis project tries using this advantage of geo-visualization in the case of study over Biebrza region in Poland.

1.2 STUDY AREA

The study area is situated in northeastern part of Poland.

It is the region of valuable ecosystems of rare marsh-peat lands, swamps and diversified fauna. Priced and unique value of the nature in Biebrza valley relies on the biggest and most natural complex of peat lands (90 000ha) in middle Europe. To preserve that value of the land in 1993 it was decided to establish Biebrza National Park and in 1995 it was designated a Ramsar site. Little transformation by the men, "lack of heavy industry, the absence of larger urban agglomerations, low population density" (Mioduszewski et al., 2002), low level of agricultural activity are additional conducive facts for preserving so natural character of the region. Due to those facts, this terrain attracts many researchers.

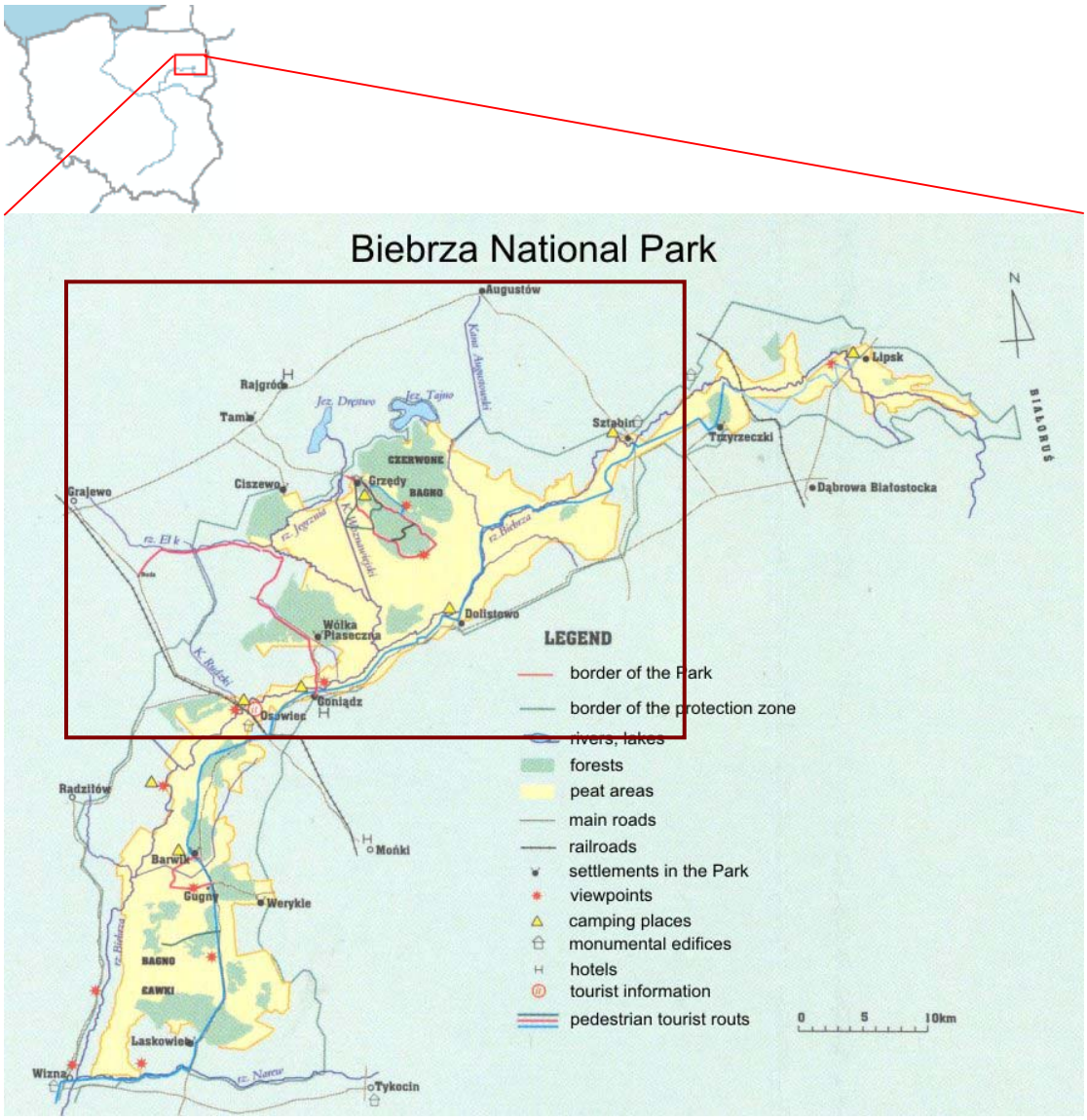


Fig.1. *Study area – Middle Basin of Biebrza Valley (Source: Wiatr, A., Wroblewski, W., 2000)*.

Water is a main factor formed the conditions of that land (over 95% of the Biebrza valley is a wetland (Slesicka, et al. after Banaszuk, 1996)). "The Biebrza valley has the largest retention capacity among river valleys in Poland. The capacity is comparable with that of large retention reservoirs. Such a large retention capacity results from storing water from floods and groundwater in the peat deposits." (Mioduszewski et al., 2002). Characteristic feature of Biebrza River – flooding – appears in the valley (in the southern and the middle part) almost every year. "Waters which inflows into Biebrza valley, is accumulated there due to the small longitudinal slopes of the Middle and Lower Basin as well as due to the fact that syncline like widening of the Valley is closed downstream of the confluence of Biebrza and Narew Rivers by the moraine formation" (Mioduszewski et al., 1996). Water is coming to the valley during snowmelt or after long lasting

rainfall. Additionally to the incoming surface water, groundwater seepage increases the resources of inundation. Ground water is pressured from the bottom of the valley and the water floated down from widespread water stratum of surrounding highland moraines (Web-s. 2). The highest water levels are observed in the spring, usually from February till May. Those natural conditions are essential for sustaining the ecological processes. Ration of peat accumulation and the growth of peat forming plant species are the most valuable processed taking place in that region. They strongly depend on magnitude and frequency of the floods (Mioduszewski, 2000). It is influenced by the water conditions of whole Biebrza catchment. Due to previous hydro-technical work (see appendix) it is noticeable the change of the water distribution. It causes lowering of the summer water tables, which leads to the mineralisation of organic material in the soils and consequently to interruption of peat accumulation processes. Disturbance of hydrological conditions leads to permanent changes in the entire swamp ecosystem. It results not only in changes of soil cover but also consequently in plant communities, and in animal populations. Other factor causing changes was that after Second World War people migrating to towns abandoned the meadows; cattle and horses were stopped grazing freely in the valley and meadows were not mowed anymore. That is why the vegetation started to overgrow swamps taking out reach natural vegetation and animal world. The most meaningful process is encroaching shrubs and trees (semi-natural asosociations) having the negative effect on biodiversity. This process is much faster during dry years (Schmidt, 2000), (Wiatr, et al, 2000). Expansion of the high vegetation, particularly forests, speed up the deterioration of moisture conditions of the wetlands. It has higher capacity for evapotranspiration than e.g. low grass and uses much more ground water.

The effect of lowering of the ground water table is also visible by disappearing of old riverbeds, side streams and short inflows existed in the past (Mioduszewski et al., 2002).

Nowadays it is searched for strategies to halt the loss of the bio-diversity and regenerating previous conditions to maintain valuable wetland ecosystems. There are founded several projects, which can determine the best strategy for managing that part of the land. “This involves creating conditions to maintain, over a longer period of time, high levels of ground and surface water and thus, a high level of moisture on hydrogenise sites. Proper water management in the catchment of the Biebrza River together with renaturalization of the hydrographic system is a key requirement to protect natural values of the valley. It seems that local drainage system damming is the most efficient and only feasible way of increasing the available water resources on the floodplain” (Mioduszewski et al., 2002) (see appendix).

Fig.2. *Rivers in the Middle Basin of Biebrza Valley (based on: Wiatr, A., Wroblewski, W., 2000).*

To maintain the high soil moisture the presence of spring flooding in the valley is substantial. In the past the area was regularly flooded within larger range and for longer period.

Apart from hydrological works, many areas should continue to be managed for agriculture (cultivated grasslands) to tracts of open grassland, which with no management will become overgrown by bushes and trees (Mioduszewski, 2000). Agriculture in some parts of the valley has played and should continue to play a beneficial role in shaping and maintaining the present diversity of plant communities (after Szulczewska, 1993) e.g. restricting the expansion of scrub and woodland. Supporting and promotion of mowing and grazing became the high priority in the region (*Man and nature at Biebrza*). The major challenge is finding a way to reconcile interests of agriculture with those of nature protection, since areas bordering the Rudzki Canal and the old channel of the Jegrznia and the Elk rivers are still used as meadows and pasture" (Mioduszewski, 2000).

Raising the groundwater level and the surface water level will increase the moisture content of peat soil, stop the mineralization processes, and increase the biological diversity. But on the other hand the higher moisture of the soil will have some negative influence on agricultural use of hay meadows. It is concerning mainly the strip along the old Jegrznia bed. The best solution will be either to buy the land from the farmers or negotiate with them special terms of land use. This confrontation will be indispensable because big area is in private hands and acceptance and participation of the owners in regenerating projects is crucial. The range of aspects within projects works seems to be wide. "At the moment, working on the river Biebrza one has to deal also with sectoral approach bound to the territories/borders, for example borders between a

National Park and outside of the Park, borders between communities etc., with little understanding and interest for the consequences on the other side of the "border". There is essential need of cooperation between nature management, agriculture and tourist organisations in land use planning within the present socio-economic context, especially that they represent different interests.

There are provided works within the frame of PIN Matra project "MAN AND NATURE AT BIEBRZA. Integration and dissemination of knowledge for sustainable nature management". The aim of it is "to find a balance between agriculture, recreation and nature management facilitating sustainable co-existence of all three functions" (*Man and nature at Biebrza*) – in more detailed way – to find out the best way for achieving previous hydrology conditions in the Valley.

The aim of the studies is to estimate consequences of hydrological measures for the existing agricultural land and for the natural and semi-natural ecosystems in the park (Mioduszewski, Wassen, 2000). All available and gathered knowledge within previous projects will be combined and serve as the base for a Management Support System (MSS). It will demonstrate the opportunities to optimize water and vegetation management, give recommendation for future monitoring activities, and help to select scenarios, which are economically acceptable for the local stakeholders. The MSS contains a hydrological and an ecological module, consisting of geographical data and models, which are connected in a GIS environment. The hydrological module is already prepared and outputs are available for analyzing different scenarios of water management. The ecological module is now being built using as input the calculations from hydrological part.

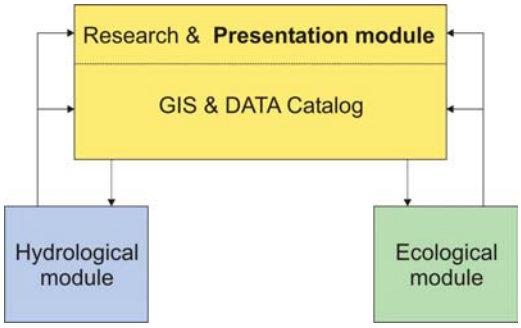


Fig.3. *The Management Support System (Source: Man and nature at Biebrza).*

All changing in hydrological conditions have to be accepted by the local water board and communicate with owners and managers of the land (that is Biebrza National Park, local voivodships (a group of municipalities), farmers and non-governmental organisations focusing on nature and sustainable development). Still this communication is weak. The PIN Matra project

contains the part of presentation module, which can be a helpful tool to facilitate those discussions.

At present situation geographical information and data gathered by research institutes are used on discussions on a form of reports, GIS databases, satellite images, air photos, thematic maps. All those kinds of presenting the data are understandable to scientists but not to farmers and other people not familiar with maps and spatial data presentations. For discussions with them there is a need of using more appealing presentations. Until now there are no prepared generalized and easy to perceive presentations. To fulfill this need there was created the idea of this thesis. Geo-visualization techniques can facilitate creating such presentation.

1.3 THESIS OBJECTIVE AND RESEARCH QUESTIONS

This thesis project is focused on the Middle Basin of Biebrza Valley, where is situated the study area for the hydrological module within MSS. For analyzing the 3 different scenarios (including one of the present situation) of hydrological works there were made output calculations of that module. That data is quite rich and for this thesis there is chosen only the part containing changing surface water depending on the scenario is chosen. Changing water level is the most meaningful problem for that region. Based on that data and available data of the terrain, it will be created the presentation, which can be used within the presentation module of PIN Matra Project for facilitating the communication between scientists and the other groups interested in Biebrza area.

The thesis has the aim of creating understandable, easy to use and informative presentation of the hydrologic data of Biebrza region.

To be able to achieve that goal, it is necessary to answer following research questions:

1. What are necessary components of such presentation?
2. What are functions, which should be available within the presentation?
3. What is the optimal scale of the presentation?
4. What is the role of using the data containing different level of detail?
5. What reference information is needed within the presentation?
6. Does hydrologic data have special characteristics?
7. How it is possible to build the presentation based on available data of Biebrza region?

8. What is the necessary data for preparing the good visualization of changing the water level in Biebrza region?

1.4 METHODOLOGY

The first step for answering research the questions is defining the aim of the presentation, needs and abilities of target groups on their perception of the spatial data. It will be based on widely available information and will be confronted with scientists, who are preparing the data and the coordinator of the project (WWF). Those people already have an experience with working, discussing and communicating information with people having interests in Biebrza region. Also the important step is to formulate the criteria, which give the answer of meaning of the adjectives characterizing the presentation: "understandable", "easy to use", and "informative".

Next step is analyzing available data, which is being prepared by the research institutes.
At present situation the materials for discussions with partners in Biebrza region are used in the form delivered by scientists. They contain all necessary information but the form seems to be difficult for perceiving as mentioned before.

Based on gathered information and literature research I will be able to choose the most suitable tool for creating the presentation paying attention at available components and functions for it. Then I will prepare the presentation within chosen program. During this process I will get the experience of limitations and advantages of the program and also I will get to know what data would be needed for better visualization of Biebrza hydrologic themes.

Preparing the presentation has the aim of improving present forms of visualizations of the data.
My proposition will be confronted with the coordinator of the Project and people from research institutes – it will be known the opinion of the user. This discussion will be put in chapter 6 about evaluation of the presentation.

Question 1 and 2 – discussion about the components and functions of the presentation is in fact discussion about the interface of the presentation. Based on literature and my own experience I will choose the most convenient tool to present the data. It will be confronted with coordinator of the Project. In this way it will be checked the opinion of users about the usability of proposed tool.

Question 3 – the scale of the presentation is depending on the available data and the information, which should be conveyed. The scale also depends on the resolution of the bitmaps, which will be discussed in the text. After analyzing the data and building the presentation it will be possible to answer that question.

Question 4 – in the presentation it will be used the data of different level of detail and it will be shown what information can be conveyed using particular one.

Question 5 – that question is in fact asking about the ability of understanding the geographical terrain model. After building the model, it will be known what is the necessary information helping with orientation and understanding transferred hydrological information. Coordinator of the Project will comment my proposition.

Question 6 – the answer for this question will be the discussion over the hydrologic thematic layer. It will include the conclusions, which I will get after building the presentation.

Question 7 – answering that question will be possible after finishing the visualization process. I will write the description with explaining all steps I will make. It will be also mentioned the limitations and advantages of the program.

Question 8 – the experience of preparing the presentation will allow finding out what would be the 'ideal' data set for building the presentation of hydrologic problem in Biebrza Middle Basin.

1.4.1 Outline of the report

Chapter 2 – gives the overview of the theories of perception and understanding the spatial data, which helps to formulate the criteria for the presentation. It explains also the terms abstraction and realism of the terrain model.

Chapter 3 – gives the overview of the concepts of interfaces, which helps to formulate the needs for suitable tool for visualization the data of Biebrza region.

Chapter 4 – contains the concept of the chosen tool and explains how it is possible to work within that.

Chapter 5 – explains the specificity of Biebrza case. It deals also with characteristic of hydrologic theme and technical issues of the program.

Chapter 6 – contains the comments of the coordinator of the Project and scientists, who were gathering the data, which allows concluding how presentation fulfills the initial criteria. It gives also the comparison with previous visual data.

Chapter 7 – contains conclusions and gives some recommendations about the needed data for visualizations of Biebrza region.

2. GENERAL ASPECTS OF THE PRESENTATION

In this chapter one can read the theory background for making the presentation of spatial data.

2.1 PERCEPTION AND UNDERSTANDING OF SPATIAL DATA

Understanding of the information transferred in graphical form depends basically on the proper coding, graphical aspect (esthetics, composition, complexity) and former users experience. Proper coding of the information is the most important part of designing the content of the reality model.

There are some universal rules, which makes the graphical information better perceived. That fact underlined Bertin (1974), Ratajski (1989), Kraak (1996) and others. The most important aspect seems to be the ordering the information. For example when the information is chaotically diffused on the desktop, it is difficult to find needed element. During the searching process our eyes are getting tired and if we do not succeed after few minutes, we loose our interest. Ordering or organizing the information can shorten the time needed for finding the information and we can check fast if needed detail exists.

Organizing the information rests on structuring data based on its characteristics and grouping similar elements. At once we can perceive and distinguish 6 – 8 variables (colors, positions in graphical menu). It means that this amount of information can be read without almost any effort. Using too many colors, we loose the chance of concentrating on the whole image at the same time (Bauters, 2001). Too much information at the same level of importance does not give us any hint for interpreting it; we spend the time for searching for some regularity because the aim of the presentation would be not readable. Grouping similar elements makes easier the interpretation and also allows transferring additional information. At the first sight we can distinguish the main groups (themes on the map, meaning of the windows, menus) and we know the main structure of the image and later we see details. One can achieve it by giving to the detailed information the characteristic of more general group (like the conductive color, shape or position). Then we already can know to which bigger group it belongs. For example we can see in the map legend that all elements connected with water are blue, and looking at the map itself at the first sight we can see how big area is covered by water.

Generally when we look at the image, it should be light and just nice. Otherwise, when there are too many elements on the surface, it can discourage the reader to pay attention on that. Balance kept on the page or monitor screen is very important. One side overweighting is

continuously disturbing our attention to the whole presentation. Also bad color composition can give this effect. E.g. contradictory colors (red-green, red-blue) put together are seen to quiver in the borderline.

Designers should put attention also on optical illusions. If we need to compare the colors in the different parts of the composition, we should be aware that they are perceived depending on the surrounding. This illusion also influences sizes and directions.

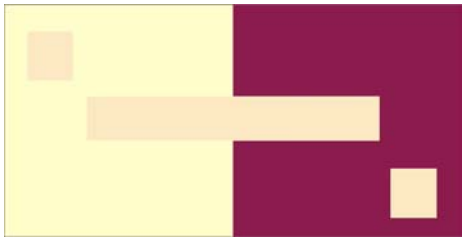


Fig. 4. *The brightness of the inner shapes is the same.*

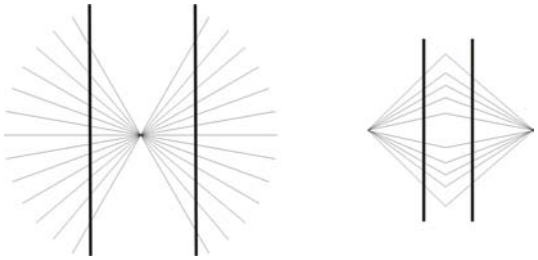


Fig.5. *Lines are parallel.*

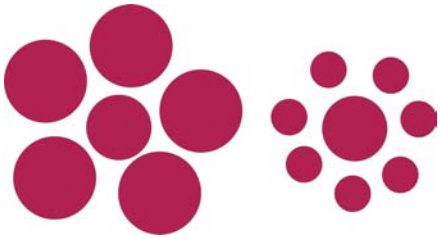


Fig.6. *Size of the inner circles is the same.*

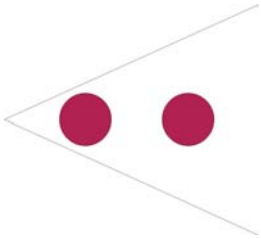


Fig.7. *Those two circles have the same size.*

Being aware of such illusions, designers should lie a bit with colors and sizes to make able to see the 'true' effect.

Good color-coding can facilitate the interpretation of the graphical information. Previous users experience can fasten the interpretation if the designer wisely uses it. There already exist several standards and they should be taken in consideration. E.g. red color is associated with alarm, yellow with warning, green with acceptance, etc. From the observation of the nature also raised some standards. E.g. water we observe as blue, vegetation as green. For coding other information, through the legend we can teach the user our way of coding. And in that coding we should be very logical, and then we can shorten the time for learning it.

All theory concerning the symbolization, abstract way of representing the world, was built for cartography. Maps were the first models of the terrain. By means of the small surface cartographers transmit chosen information about the world. It is impossible to put all details from the real world on the paper or the computer screen, that is why it is necessary to simplify the

reality. Especially that those presentations are made in a scale. It gives the advantages to see at once the big part of the terrain, and at the same it gives the chance of noticing some patterns, which are not visible without reduction of dimensions. Representation in the scale implies that the information should be "squeezed" because there is not enough space to show it in the legible way. It can be done using special symbols, omitting some objects, simplifying shapes, patterns or just objects, or presenting the characteristics of objects instead of objects themselves. That is the way of creating the model of the reality. Interpreting such a model we create the imagination of the real world. This whole process is called Cartographic Communication Process:

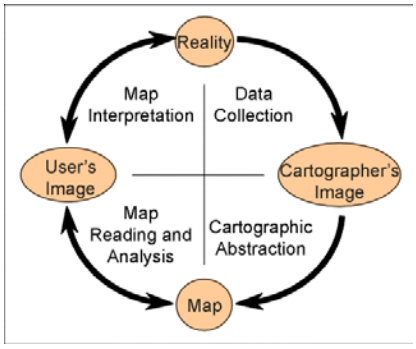


Fig.8. *Cartographic Communication Process* (*source: http://www.fes.uwaterloo.ca/crs/geog165/ccom.htm*)

How close would be our imagination of the real world, built based on the model, to the reality depends on the good coding the information and also on abilities of interpreting it by the users. If cartographer uses sophisticated methods to present the information on the map, this map would have only specific (means small) group of receivers. There are several tries to make easier the interpretation of maps and generally of spatial information. Developing of computer techniques is a big step in that direction. It was said above, that users interpretation of the reality model depends on their former experience. If we want to have wide group of readers, we should think about their experience, which is for sure … the surrounding world. So everything, which is similar to reality, should be easy perceived. Several authors are paying attention on that, e.g. DiBiase (1990), Bishop (1994). To achieve the similarity, there were applied different techniques for showing the height (Fig.10, 11, 12), the perspective views (block diagrams) and after, using the developing computer graphic techniques, it was possible to apply more dimensional data models.

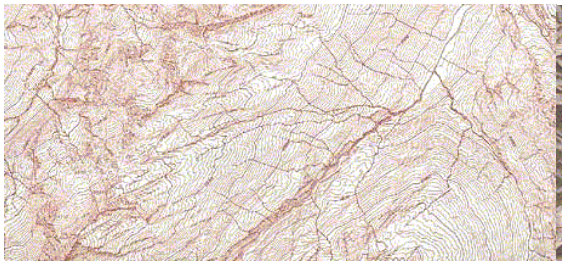


Fig.9. *Isolines showing the height*

Fig.10. *Shaded isolines showing the height*

source: http://www.reliefshading.com/try_it/index.html

Fig.11 *Shading*

source: http://www.maps.ethz.ch/Imhof21engl.html

Fig.12. *Shaded topographic map (giving the impression of seeing the Earth from the height).*

If we deal with realistic model, fewer elements need to be interpreted by the user; they can just be read or seen. In this sense "3D visualization provides an effective way of presenting large amounts of complex information to a wide audience, especially those with no experience of GIS or mapping (Bishop, 1994), as it provides the user with visual cues that are more intuitive than those of a two-dimensional map (Reed, 2000), yet it is often overlooked in environmental assessment (Lange, 1994)" (after Lovett and others, 2002). So the easiest for communication are the most realistic presentations: 3D models photorealistic or simply those, which adapted photographs. Then it takes away the effort of comparison relating models to users experience of the physical environment (Dykes, 2003). An example of implementation using pictures (panoramic) for Wageningen is available at http://www.wageningen.interstad.nl/?http://www.wageningen.interstad.nl/pages/plattegrond-wageningen.html as the virtual walk through the city. The most realistic presentations have limitations due to the scale. Direct comparison to the real world has to be finished when the small-scale presentations start. It is because we just cannot observe e.g. whole Earth at once in our everyday life without going to space. For such presentations there should be chosen the most "natural" ways of presenting geographical data. Searching for those solutions, there were invented methods of interaction with the model. There were raised virtual worlds, virtual reality with user navigation capability. As far as the navigation is based on our experience from the

reality, interaction is intuitive, easy to work with. Essential change is user role, he can also create and design. This gives a lot of new possibilities, which help a lot with analyzing the data. “Fully interaction with spatial information allows user e.g. to create own environment for the making of assumptions and testing of hypotheses, enable the creation of user-defined views and maps” (Fairbairn, 1997) giving sometimes important new point of view.

To use whole similarity to the world it is necessary to apply also the movements. Just after technical difficulties were overcome, animations started to be applied more often. Animations are used in virtual worlds as well as in 2D presentations. By them we can relay new information. Movements can show the e.g. time (temporal dynamics), can imitate real word like changing of the light, movements of the clouds (spatial dynamics) or can code more abstract information like e.g. frequency or quality of changing some phenomena. “Animations not only tell a story or explain a process, they also have the capability to reveal pattern or relations, which would not be evident of one would look at individual maps” (Kraak, 1996). So the role of it is difficult to overestimate.

It is important to still remember that the best way of presenting simple information is the simple tool. Then the accent is put on relaying the information not on the tool itself. And of course the big difficulty is in choosing the best tool to visualize certain information. Esthetics is the subjective term but the efficiency and informativeness of the model can be verified.

2.2 CRITERIA OF THE PRESENTATION

The above theories can be summarized to formulate the criteria of good presentation. The objective of this thesis is to create ‘understandable’, ‘easy to use’ and ‘informative’ presentation.

‘Understandable’ presentation should use easiest way for interpretation and coding of information.

- model of the terrain should show the reality in the most possible realistic way
- if the realistic way of presenting the data is not possible (because of the scale), the explanation of abstract way of coding information should be explained. User should be able to find that explanation without an effort
- colors and symbols should use standards if possible
- the presentation should be as simple as possible

‘Easy to use’ presentation should take advantage of the previous users experience and conventions:

- the way of managing the presentation should be intuitive (easily understood buttons and menus, etc.)
- presentation should adapt the similarity with the world – e.g. way of movements
- the composition should be graphically balanced and light to focus the user on the main topic of the presentation

‘Informative’ presentation should contain grouped and well structured information. It means that:

- user should be able quickly know the structure of presented information
- the aim of the presentation should be easy noticeable
- user should be able to find quickly and easily the needed information which can answer his/her questions within the presented topic

3. COMPONENTS AND FUNCTION OF THE PRESENATION

This chapter explains concepts for interfaces and their role for working with data.

3.1 INTERFACES – MAIN CONCEPTS

Designing presentation should start from the outline – from setting the functionality, which should be available and the form (designed components), in which it can be used. It means, designing should start from the interface.

Human-computer interaction is only possible through interface. It predefines the possible activities on the computer, making them available. At the same time it limits the possible functions, which can be accessible for the user.

The same role plays GIS interfaces by making possible managing of spatial data. "The user interface of GIS determines to a large extent how usable and useful that system is for a given task for a user" (Egenhofer, Kuhn, 1999). The user takes the advantage of good construction of the interface, which influences the easiness of using the system and the wideness of functionality, which influences the possibility of answering his or her research questions connected with certain problem.

In the 1970s and early 1980s, command line style accessible only to expert users dominated GIS-user interfaces. There are several advantages of using complete programming language, but at the same time the command-line interfaces have poor cognitive characteristics. A screen full of text has too high density of information for the user for easy interaction. Also it is difficult to find objects of interest seeing uniform letters on the screen. Much more efficient is using graphical objects instead of error-prone typing, difficulties with determining the appropriate command for a task, with remembering the names of variables were another arguments for replacing typing commands by graphical objects.

In the second half of the 1980s graphical user interfaces (**GUIs**) started to be produced. They used the same syntactic structures as **command-line interfaces**, but hid them behind icons and menus. This change improved the familiarity of the systems by reducing the need to memorize correct syntax of commands. From late 1990s GIS-user interfaces started to be characterized by the use of **windows, icons, menus, and pointing devices**. It is called **WIMP-style** interfaces (Egenhofer, Kuhn, 1999). This kind of interfaces is already widely implemented for graphical programs. For users, who are familiar with working with them and also with Windows operational system, the way of using WIMP-style interfaces is almost intuitive. This is a big

advantage for users, who don't need to spend much time anymore learning the rules of manipulating the datasets. The more way of interacting with the GIS system is similar to human behavior and thinking, the less time one needs to spend on training (which in turn implies the minimum need to modify the user's behavior) (Lo, Yeung, 1994).

In such kind of GIS-users interface the commands (showed by icons) are available in menus. There are basic operations almost always available, like **selection by pointing and clicking**, or **moving by dragging** as well as **querying** a geographical database and presenting the results in maps and tables (Egenhofer, Kuhn, 1999 after Egenhofer, Herring, 1993). Basic **functionality** of GIS-users interfaces includes most often **selection** of data layers; the **identification of objects** by location, name, and elementary spatial relations; and the **modification of graphical output** parameters such as colors and patterns (Egenhofer, Kuhn, 1999). Whole range of achievable functionality is much wider and one can divide it into the following:

- **Basic display** – tools are needed to pan, zoom, scale, transform and rotate
- **Orientation and identification** – explanation of map/presentation is needed. User needs to know where the view is located and what the symbols mean
- **Query data** – user needs to have the access to spatial database and retrieving existing information
- **Multi-scale** – tools are needed to enable combining different data sets
- **Re-expression** – tools are needed to display the data in different mapping methods
- **Multiple dynamically linked views** – tools are needed to enable making a combination of multimedia and brushing technique. User could have the advantage of interacting with several types of data (like sound, video, text) represented related aspects of the main topic viewed in different windows
- **Animation** – tools are needed to represent changes in the data – temporal and non-temporal. User needs to influence the flow of the animation by the so-called dynamic variables (like choosing display time, duration of the animation, order of the data, frequency of changes, rate of changes and synchronization).

(Kraak, Ormeling, 1996)

The above functionality allows exploring and manipulating the spatial data in an interactive way. The level of interactivity determines the amount of operations, with which user can create his own output. Interaction, which the interface makes accessible for the user, can be divided into:

- **Movement** – free path
- **Navigation** – dedicated path
- **orientation –** viewing marks (above interactions are under geometric domain)

- **selection** (of objects in the 3D scene)
- **explanation** (thematic information about selected objects)
- **elaboration** (more background information about objects)
- **manipulation**, which are under thematic domain (of objects)

(Lammeren, 2003).

Movement defines free moving through the terrain model. It can be also predefined by certain routes, along which motion is possible. Then can only be available changes of viewpoints. Free movement (flying over, walking through, crawling through the model) has the advantage of similarity with the real world. Big similarity shortens the time for learning how to move through the terrain model and more – it helps with the **orientation** within the model. When the user learns the link between the model and the reality, he can freely go where he needs. Those movements simplify **navigation** possibilities. User can have directed movements to the certain points, in certain directions, on certain height and with the certain speed. Other (more advanced) possibilities of interaction with the model are based on the possible behavior inside the virtual environment. The **selection** of objects can be done in the model during walking through it or from the position of the interface (like selection from the lists of objects available in the model). When the object has been selected, **explanation** about the meaning of the object will be a next opportunity. More information about the object can be asked for via **elaboration**. Elaboration could be realized by linking the object with related information fields that could be activated by clicking the object-link. The last possibility – **manipulation** – of the selected object can rest on moving it, deleting, copying or creating similar new object or modifying existing one (Lammeren, 2003).

Graphic interfaces with functionalities should enable answering users generic spatial and temporal questions such as:

Where is…?

What is a location…?

What is a spatial relation between…?

What is similar to…?

Where has … occurred?

What has changed since…?

What will change if…?

What spatial pattern(s) exist(s) and where are anomalies? (Egenhofer, Kuhn, 1999 after Rhind, Openshaw, 1998).

Those are questions, which users are the most interested in, when they use GIS programs. There is the tendency of building very complicated programs, where user can find many possibilities, even those not necessary. But if the interface is created for the certain purpose, it should contain only needed functions. Then it can be kept optimally simple and clear. Too many unnecessary information, functions create errors and prolong the time to perform the task (Jansen, 1998). But there is a big problem of prediction the user's behavior, that is why the big part of the designing work is dedicated for testing and analyzing the feedback from users.

3.2 NEEDS FOR THE PRESENTATION INTERFACE

According to the objective of the thesis and the above theories, the interface of the presentation should be manageable intuitively. The functionality of it should make possible answering users questions about hydrology in Biebrza region.

Most probable users are used to windows **style**, so it would be easy for them to work with:

- WIMP style interface, where one can find menus and widely known symbol buttons.

The presentation of geographical data has some specificity not existing anywhere else. And those characteristic functions should use the user's previous experience with computer programs as well as similarity to human behavior.

To present the hydrologic data, the **functionality** should contain tools:

- for zooming, panning, rotating the model, changing the height above the model
- allowing free movement above the model
- enabling to give the information about the distances within the model
- for showing and hiding thematic layers (selecting seems not to be necessary)
- for showing (and hiding when not necessary) the data on the different level of details
- adding new hydrologic data
- querying the data – making possible finding the places or certain hydrologic information
- for accessing additional information – views should be linked together
- for making animations based on the hydrologic data depending on time

The **components** of such interface should contain:

- main window with the terrain model and thematic layers
- windows with the legend and other explaining elements like orientation map, text information, internet links, graphic information (pictures, schemes, etc.)
- window (menu) with the list of available thematic layers and characteristic places linked with the main window

- navigation/interactivity toolbar

The presentation is being made to show the thematic layer for illustrating certain ideas. The functionality of re-expression would not be necessary if already prepared way of visualization of the hydrology themes is conveying the needed information. Also the needs for query the data are not high – limited only to prepared topics.

4. DESIGNING THE PRESENTATION

This chapter contains explanations about decisions and arguments, which were used to develop the presentation. It was decided to design the presentation within already existed tool. It would be also possible to create new interface (viewer) by programming but it would be too long process for this thesis work.

4.1 CHOOSING THE TOOL FOR VISUALIZATION

Several GIS programs were reviewed for their visualization capabilities. Two groups were distinguished: programs (or parts of them) specialized in analysing spatial data in 2D and in 3D and programs specialized in presenting 3D data.

From the first group VirtualGIS (Erdas Imagine), Arc Scene (Arc GIS) and 3DScene (ArcView) are selected. From the second group Terragen, VRML and Terra Explorer Pro (Sky Line) were analysed if they can process gathered data giving the satisfactory visual result.

Terragen was rejected at the beginning because of the weak possibilities of importing existing elevation models. Additionally that program does not contain the functions to manage vector layers.

Digital elevation model converted into VRML had more than 50 MB and it was impossible to move through that model in the reasonable time. That is why it was also rejected.

All GIS programs have big advantages of managing spatial data in the very fast way. Even big files – e.g. satellite images can – be zoomed in/out quickly. The quality of displaying the data is very good, but only in 2D viewers (in Viewer (Erdas Imagine), Arc Map (Arc GIS), Arc View). In 3D extensions the visible resolution gets very poor (compare fig.13 with 14 and 15 with 16).

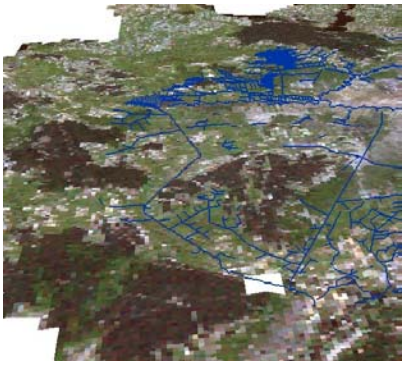


Fig.13 *Arc Scene view*

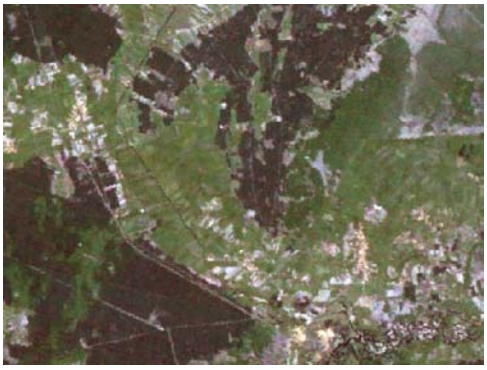


Fig.14 *Arc Map view*

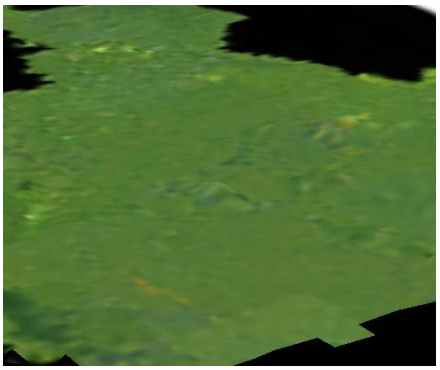


Fig.15 *3D Scene (Arc View)*

Fig.16 *Arc View*

Additionally within 3D extensions of GIS programs it is not possible to show whole thematic layer, when it is combined with DEM. In that situation thematic layer is only visible in the range of DEM. To show whole area covered by the theme layer, height information cannot be used. Apart from that disadvantage, GIS programs have powerful tools for analysing the data. Also they contain tools for showing the data, like those for preparing animations. Created animations concern only moving over the terrain model but not changing vector thematic layers, which would be important to present changing water levels. Presenting the data in satisfactory way is impeded by difficulties with putting referencing markers –text – on the scene. There are no tools for making e.g. names of towns visible. All characteristics of the objects are available only from the table. There is the option of opening many windows at the same time to present the data. It can give the advantage of comparison different viewpoints of the same data set.

The interface of Terra Explorer seemed to be most convenient for preparing the whole presentation. It is possible to import the vector layers in the shape format – so the data can be prepared in GIS programs (using its abilities). Also it is convenient within that program linking additional information about object or generally about the area. The viewer needed to see the presentation is small (1 Mb) and free available, so it no problem to get it for almost each computer. Disadvantage of that program is no possibility of having more than one 3D window opened at the same time. Either it is not possible of making animations with prepared vector layers. Additionally that program has the advantage of fast rendering the data while moving through terrain model. It can be done fast and also available tools make it easy to learn. Despite from those inconveniences that tool gives the impression of most suitable according to the previous criteria.

4.2 SKY LINE VISUALIZATION TOOLS

This sub-chapter contains the description of the structure of the chosen tool.

Sky Line products can be divided into three groups (fig.17):

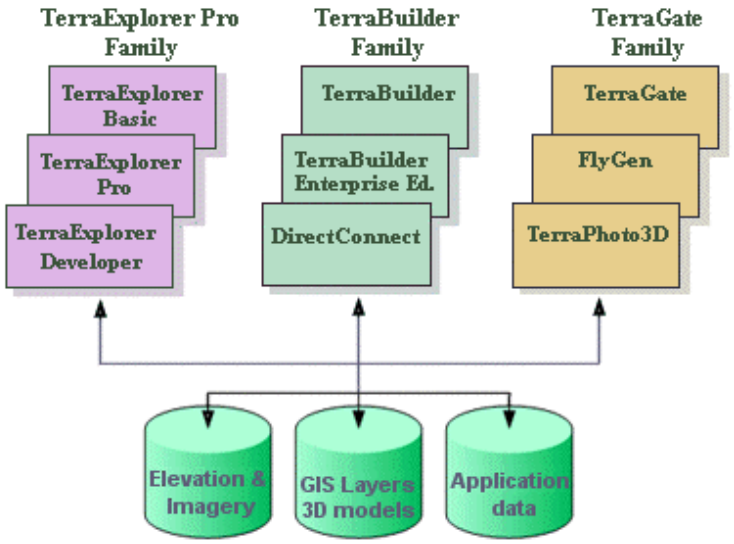


Fig.17 *Concept of Sky Line tools* (source: http://www.skylinesoft.com/corporate/technology/technology_home.asp)

Terra Explorer - allows users to view presentations (projects) developed in Terra Explorer Pro and perform basic operations (that tool is meant to show the presentation to target groups. It is available to download from the Sky Line web-page)

Terra Explorer Pro - allows users to create their own customized 3D visualizations by editing and annotating the 3D database (that tool was chosen to prepare the presentation)

Terra Explorer Developer - allows users to customize the Terra Explorer Pro user interface and integrate it, as ActiveX component, in any application

Terra Builder - allows users to create a photo-realistic, geographically accurate, 3D model of the earth for their geo-referenced applications (in that application it was prepared the terrain model)

Enterprise Edition - improved performances of large data processing, by dividing compression processes between several computers in the enterprise

Direct Connect - extension - dsirect connect to TerraGate provides the ability to stream aerial and elevation data in its native format

Terra Gate - is a network data server designed to stream and managing 3D geographic data in real-time to TerraExplorer clients

Fly Gen - extension- HTML callable server that provides integration between web sites and Skyline's TerraExplorer and TerraPhoto3D viewer

Terra Photo 3D - extension - HTML based client-server solution provides low bandwidth access to Skyline's 3D world from any PC, hand-held or wireless device (Web-s.9)

Terra Explorer Pro was chosen to create the presentation.

4.3 DESIGNING THE INTERFACE

In this sub-chapter designing process, which have been made according to previously formulated criteria (section 3.2) is explained.

Interface determines if the presentation is 'easy to use'.

Interface - components:

Conclusions concerning interfaces (see ch.3.2) were containing the needs for components. They concern creation of needed windows and availability of a tool bar.

The **main window** is needed to show the terrain model with the thematic layers. So it is important to make it relatively big. That window should attract the attention. Then the attention can be focused on the main topic of the presentation.

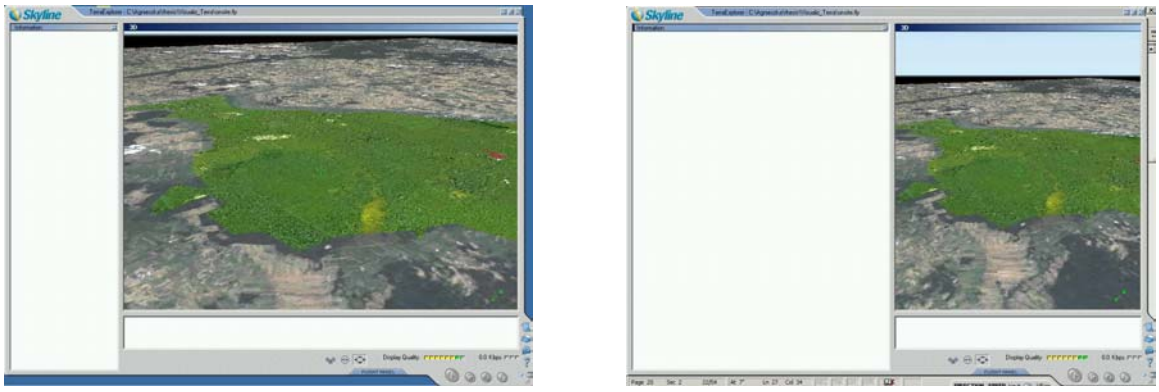
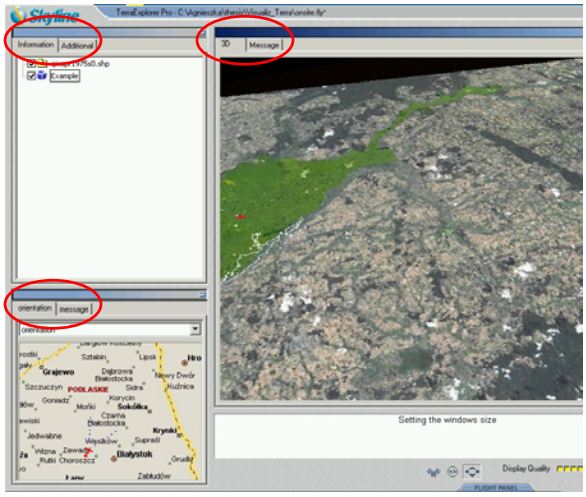


Fig. 18, Fig.19. *Most simple design of the interface proposed by Sky-line*

In Terra Explorer Pro the size of the main window can be changed and one can choose the best proportion of the division of the screen (fig.18). Only the bottom window has the fixed height and it cannot be changed. The size of the main window can be saved and applied with the first view after opening the program. For the presentation this window was set as the biggest to underline that it conveys the most significant information.

Windows containing the legend, orientation map and additional information should also have been created within the presentation. They are necessary to convey the information helping with the orientation, explanation and elaboration. For the presentation there were created only necessary windows to achieve that aim. Presentation should stay as simple as possible (see also chapter 2.2) otherwise the attention of the receiver can be unnecessarily distracted. Within the

program windows containing additional information can be added behind upper and lower left windows and behind main window (fig.20, 21)



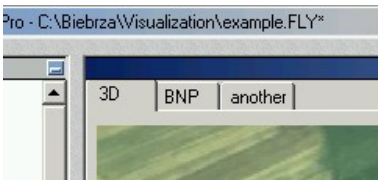
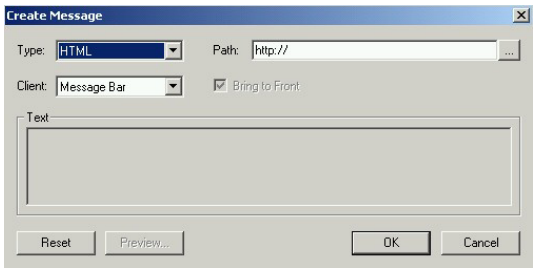


Fig.20, Fig.21. *Adding windows with different type of information*

The size of the orientation window (lower left) is flexible. If there is a need to show bigger area of the orientation map or information, which is in the tab-window below, one can always change the current size of it. As the default size for the presentation that window had set the size, which allows showing the additional information (e.g. pictures and map of the Biebrza National Park) in the readable form. It takes much space from the main window but otherwise the information in the orientation window would be not legible. Changing the size of the left windows can be done when there is a need for that during presenting the data.

The **list window** (upper left) contains the list of the created or imported objects, which are visible in the main window on terrain model. The size is flexible in the same way as the orientation window. Width regulation is common with orientation window. So it is not possible to set wide orientation window without making big the list window. For the presentation first was set the size of orientation window – it contains spatial information and to show it, the area should be big enough. It influenced the size of the list window.

Each element from the list can be **linked with the additional information**. Details of that linkage are set in the message window:



It is possible to choose:
- the type of the message
- the source
- and the message window, where it would be visible

Fig.22. *Message window*

After clicking on the name of the object or view, the information is activated in the chosen window and can be brought to front if needed. This information can have the form of text, images, pictures, web-sites, videos. It gives the possibility for explanation, elaboration (e.g. comparison with other situation or place) for the chosen object (topic) as well as for adding some hints for orientation.

Connections between windows are defined not only for additional information but also for movements over the terrain model. One can find the object on the list or on the orientation map and clicking on it causes the movement of the camera to the desire object or place (main window). That possibility allows answering some questions concerning specific places. But even if there are many elements, there is no possibility of searching for the particular one by the query. So prepared list of elements should be created in logical way (naming is also very important), because it would be the only help for finding needed object.

When the camera is moving over the terrain, its current position is shown on the orientation map. Receiver can follow all the time the position of the camera, which helps with not loosing the orientation.

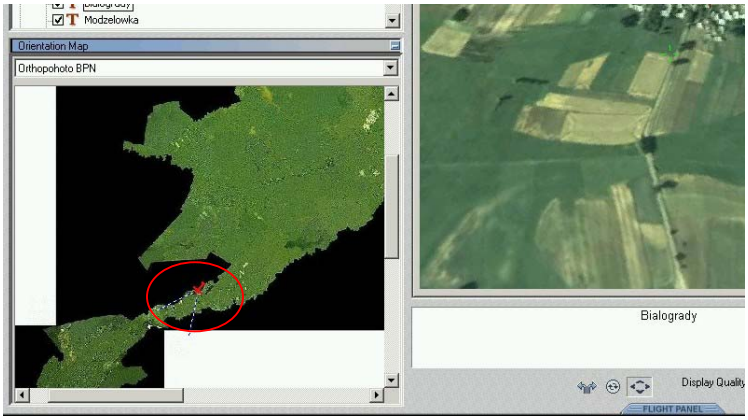


Fig.23. *Orientation map with the camera position*

Last component of the interface is **navigation tool-panel.** It is already prepared within the program and there is no possibility of changing the options. It can be shown or hidden if not used at the moment (by pressing the ‘flight panel’ button or small button below question mark).

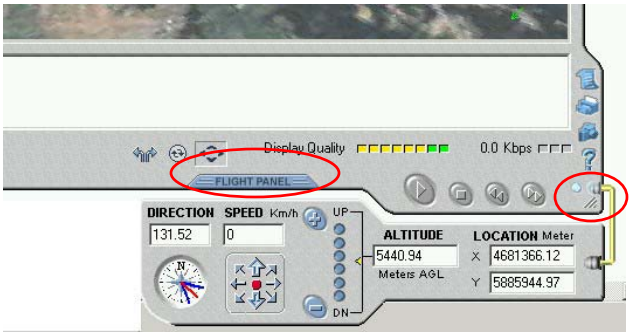


Fig. 24. *Tool panel with options for navigation and for moving through the terrain model*

Interface - functionality:

Conclusions concerning the interfaces (see section 3.2) show the needs for functionality. Thus this section explains how they are applied in Terra Explorer Pro. However in this program functions are fixed and cannot be changed. There are defined tools and connections between windows.

Basic display is necessary for viewing the model and its elements in the desired way. A presentation starts with a predefined view. The start view shows whole Biebrza National Park area. From that view-point one can go to certain interesting areas following the path without loosing the orientation. This movement is needs zooming, panning, rotating, changing the height and the perspective view. In Terra Explorer only panning is not available but one can **move freely** above the terrain model and then that function seems to be not necessary anymore. Via the tool bar one can define the exact height of the camera, direction of looking and one's location. Those settings allow placing the camera very precisely. It is very helpful for observing the landscape from needed perspective. If there is available very detailed data one can think even of seeing the situation from the window of the particular house.

Tools needed for **orientation and identification** were mentioned before (orientation window and listing window). These are important to give the user the feeling of **distances** by comparing to distances shown on orientation map or comparing to known (from reality) distances between familiar objects. The distance scale can be given on the orthogonal view. Only then it is applicable for the whole surface. For the oblique view everywhere scale is different and it should be chosen different way of describing the distances. In Terra Explorer Pro there is special tool for measuring the distances and always one can have the information about the length of the certain path together with the slope and differences in the height but in Terra Explorer only putting the scale on the orientation map can give the information about the scale.

Identification of objects and thematic layers can aid the possibility of **hiding and showing** them. But more often this tool has been using for setting the content of the scene. At once cannot be shown too much information – then it will be not perceived properly by the user. Choosing displayed information is necessary for understanding the information. By default Terra Explorer shows all created layers at the first view. User has to put them off at the beginning leaving the only needed ones.

For giving the proper view of the terrain model, **multiscale** information should be accessible in the presentation. If we come closer to the model, different and other information plays the main role comparing to the view from further distance. This means that different information should be visible on the model. The scene should stay readable. There is the need then for the tool, which can hide too detailed information (which is no longer necessary in the view). It refers to bitmaps as well as to vector data. In the program there is an option to make vector data (and created 3D objects) visible only from certain distance but bitmaps have to remain not changed. If there are applied aerial photographs or satellite images, with enlarging the distance, details naturally disappear, and only general patterns are playing role. If we deal with maps on the terrain model, then their exchanging would be necessary when the viewing distance is changing. Otherwise applied graphical methods for coding the data cannot be properly understood. (About the way of working the data on different detail level see chapter 5.4).

Query the data is useful to analyse complex datasets. If there are only few layers for one topic, one can choose them directly from the list without the difficulty. In Terra Explorer there is no option for querying the data. The only option is to find the place by the name from the list. Clicking on that name will show the view on that area (but only if it was previously defined). For the presentation, the list of objects is ordered first by the category and then by the name to facilitate the searching.

It could be profitable to add new layers from the database. This is only possible in Terra Explorer Pro (importing the shape files, which should be already prepared earlier in other program).

Linked views were mentioned above (connections between windows).

Animations for the data, which is depending on time, would be very profitable for viewing the patterns within time. Such animation needs big datasets. For the data e.g. about flooding, it would be useful to show a range of the changing area below the water for each day per year. For such a ‘movie’ in Terra Explorer we would need 360 layers. Animations should be used when they can convey new information. If users are interested only in particular (time dependent) situations to analyse, then showing statically those layers will give enough information. In the

program there is no possibility of making that kind of animations. The only option is recording the fly over the terrain but it does not concern the changing of thematic layers.

The above explanation of preparing the interface contains a description of needed **interactions** (see chapter 3.1). The selection of objects and manipulation of them was not mentioned. For showing the situation of the landscape depending on the flooding, these interactions seems to be not needed. Receiver (target groups) is interested in the range of flooding water depending on the scenario. For seeing the situation of the region during the flood, one does not need to interfere in the terrain objects. If there would have been the discussions e.g. of searching for the places for dams and based on that analysing the result of flooding, one would need to be able to shift the dam and put it in a different place. Then also much more complex program would be needed to calculate the water range depending on the place of the dam and show the results immediately in the viewer. In Terra Explorer Pro such calculations (analysis of data) cannot be performed.

4.4 GRAPHICAL DESIGN OF THE PRESENTATION

To be able to prepare 'understandable' and 'informative' presentation, the attention has to be paid on the graphical design. Below it is explained how it is possible to fulfil the criteria (see chapter 2.2) using Terra Explorer Pro as the tool for creating the presentation.

Within this program there is no possibility of changing the graphical appearance of the interface. But for putting new elements for terrain model, there are several options, which can be used.

Terrain model

To show the terrain in the realistic way, the best is using photographs. But they can be useful only in very big scales. If there is a big part of the terrain to show, then other means should be used. One of them is elevation model. For the presentation it was applied DEM together with aerial photographs and satellite image (the topographical map was rejected as too abstract way of presenting the area). Satellite image is put in the presentation in natural colours not to confuse user e.g. with red vegetation. That data was available for Biebrza region. If it had been possible, only aerial photographs would be used.

Legend

All elements, which cannot be intuitively understood, should have the explanation for the user; otherwise the information cannot be transferred. This theory is coming from cartography (Grygorenko, 1970) to other fields of visualization of spatial data. In the prepared presentation,

there is an explanation of the background (elements on bitmaps) as well as of thematic layers. Needed explanation should be accessible together with presented data. Then it is easy to match corresponding elements and also can be avoided mixing similar objects.

In Terra Explorer there is a possibility of attaching legend as the message to the object or view and showing it in one of the windows. If it is shown in the bottom window or orientation window, it will be visible together with main viewer. And if all elements are explained on one page, then it has to be shown in the main window. In that situation seeing the legend closes the main 3D viewer and receiver has to remember the meaning of objects while they are presented.

Fig.25. *Example of the legend in the message window*

For the presentation, both ways of putting the legend were applied. The summary legend gives the advantage of seeing together all shown elements. It is possible to see at once the thematic range of the presentation, which is not visible seeing the small versions of legends in the message window (there is the limit of available space).

Thematic layers

Themes used in the presentation are about range of the flood. Flooding water can be shown as homogenous surface (using one constant tone for whole layer). Then it is communicated only the range of the flood by covered surface and the information on the nominal level by the tone (e.g. about scenario). If there is a need (and there is available appropriate data), it is also possible to use hue to convey additional related information on qualitative level (Ratajski, 1989). It could be e.g. the depth of the water or duration of staying of the water on the surface for certain year. Such themes can be presented as several vector layers. As the layers at the same importance level, they should be shown in the similar way (Ratajski, 1989). But then there is a limit of the number of layers, which can be readable at the same time. But if we talk about hydrologic data, most probably there will not be a need for showing them altogether, because mostly there are discussions over one hydrologic topic at the time. For the comparison, there is the possibility of showing together 2-3 layers, like for example results of different scenarios and then one can switch them off to show the other.

In Terra Explorer on the top of the terrain model is possible to put thematic layers. Data should have the form of the shape file (so it should be first prepared in GIS programs). Terra Explorer Pro cannot import Bitmaps. The program gives several options for importing shape files (thematic layers) from Arc View or Arc GIS, which give different result in presentation:

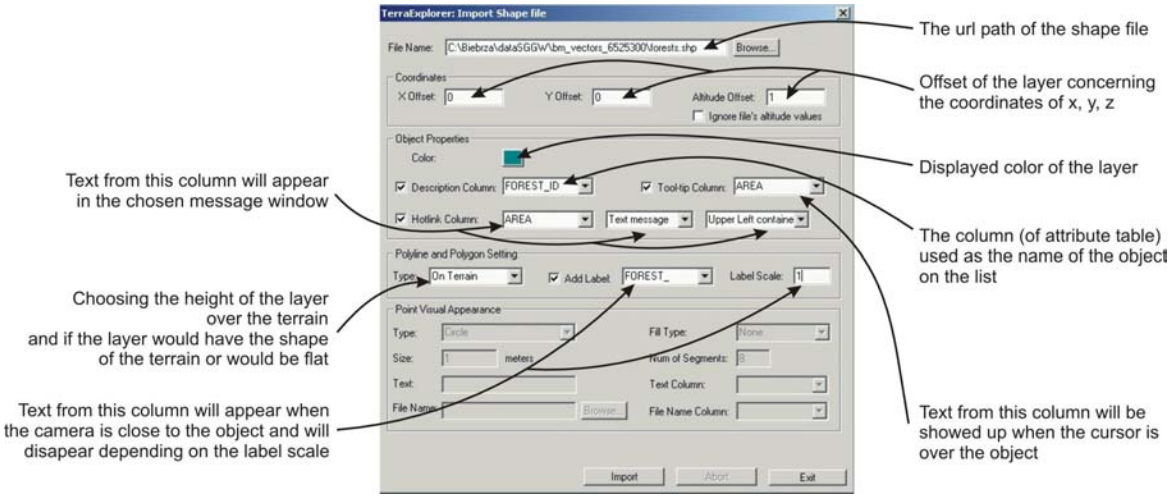


Fig.26. *Options for importing shape files*

The information linked to the objects is taken from the database (attribute table), which was build for the particular theme. Some of above options can be changed after importing (like colour or position of the layer). The program create separate object from each part of the layer: each part of the line or for each area. User should be aware of that when prepares the data because afterwards there can be thousands of objects created. For distracted polygons there is no solution to avoid the big number of objects.

In presentation blue colours are used for the layers of the surface water for different scenarios. It can be easily related to the colour of water in reality. This convention is widely applied, so most likely receiver already saw this kind of representation of water.

Reference information

Reference information has the role of helping with orientation. It should be related to knowledge, which receiver already has and also to the presented topic (if there is presented flooding, e.g. rivers should be visible). For the presentation there are put names of towns, rivers, and some known places and regions. Also some 3D objects were created. They can be visible only from close distance (see chapter 5.4).

For the presentation colors of names were chosen according to their relation with named objects. Names of rivers have blue tones, names of forests – green, etc. Names of towns or known areas have ‘abstract’ colors, which are well visible. 3D elements should be similar to natural

objects as much as possible but for that creation, program gives some limitations (e.g. the roof of houses cannot be inclined).

Fig.27. *Extruded forest*

Fig.28. *3D objects*

5. BIEBRZA APPLICATION

Visualization of the data of Biebrza region is not the easiest to show it as 3D terrain model. The terrain is very flat and big, so there is the limit of making the advantage of 3D visualization form. Also the data is not very solid and accurate. In detail these problems are presented below.

5.1 GEO-DATA AND ITS PREPERATION

This paragraph contains the overview of available data in the frame of the PIN Matra project.

The data is gathered by research institutes in the frame of projects, which were previously developed in Biebrza Valley and also for needs of the present one, PIN Matra Project. The available data is originally geo-referenced by coordinate systems – uklad 1965 (Polish local coordinate system being used for administrative purposes from 50's till 90's) and uklad 1942 (Russian coordinate system used in Poland for military proposes from 50's till 90's and later also for civil ones) are used. Both data sets are now transformed into one geo-referenced set.

The available data, chosen as possible to use for the presentation, contains both kinds of thematic layers raster and vector. Most of gathered data by Agriculture University covers only Biebrza National Park, so they could be used to show the possibility of the program but not used during discussions with target groups. In detail chosen the data is presented below:

- a DEM of the middle part of Biebrza valley – made based on the topographical map 1:25 000 with the height accuracy of 0.75m.
- some satellite images – TM, 7 bands, bitmap with spatial resolution 25x25m – from May 1997 and from August 1997
- an orthophoto of the part of the valley, which is in Biebrza National Park, bitmap with spatial resolution of 4x4 m
- some aerial photos of Rudzki Canal, bitmaps
- a soil map – types of soils, vector layer
- a map of rivers and canals – based on the topographical map 1:25 000, vector layer
- a map of forests, vector layer
- the borders of the Biebrza National Park, vector layer
- a vegetation map – for the part of the valley, which is in BNP, vector layer
- the roads within BNP, vector layer
- a division of parcels (without data about ownership) within borders of BNP, vector layer

- some topographical maps 1:25 000 (updated in 80-ties) – scanned (bitmaps)
- the outputs of hydrological simulation model, tables

Digital elevation model had to be converted to .tiff format (original binary file was imported to Erdas Imagine and then exported to .tiff format, which next was imported to ER Mapper and saved as internal .tiff file readable by Terra Builder). In other form it could not be used to build the terrain model. Satellite images have the .img format and they could be easily used for the terrain model. Orthophoto, aerial photograph and topographical map have the .ecw format and they had to be converted in ER Mapper to be able to combine them together with the satellite image and the DEM. Thematic layers have the form of shape files and they could be directly imported by Terra Explorer Pro. They contain a lot of separate objects and imported together much slowed the program. E.g. the layer of ownership contains over 30 000 objects and if there is imported another numerous layer, moving over the model become to be very slow.

Outputs from hydrological module are the main data of interest for this thesis project and it will be described below in detail.

5.2 HYDROLOGICAL MODULE DATA

This sub chapter explains the role of the hydrological module and gives the idea of outcome information obtained from calculations.

Hydrological module, the part of Management Support System, predicts the changes in water conditions as a function of changes in climate and nature management regime. It consists of mathematical and statistical models of water quantity and quality (models of surface water and groundwater sub-systems as well as nutrient load model). The models are integrated on output level – the output from one model is an input to another mode (*Man and nature at Biebrza*). The calculations from the model will be used to develop different water management plans for Biebrza catchment according to modeled scenarios.

Within the module the calculations are made for 3 scenarios (including the present situation, wchich is prepared for calibration of the module). “The scenarios will focus on technical water management like: restore discharge through old river channel sections, closing canals, ditches, changing elevation of weirs and culverts, etc.” (*Man and nature at Biebrza*). At the canals connecting the water system there are already existing dams and will be created also new ones for regulating the flow of the water at the Valley. The outputs from the module have the form of

tabular database and based on that – maps of groundwater level, surface water level can be created.

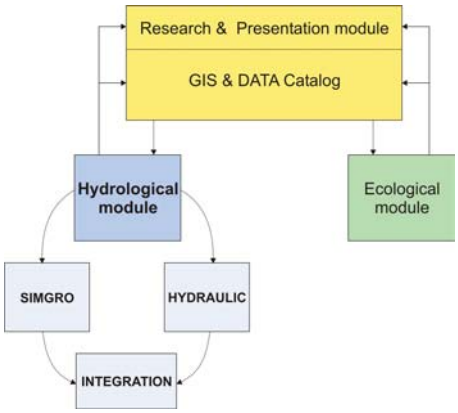


Fig.29. *Hydrological module in MSS*

Prepared hydrological module is built from 3 parts:

- hydraulic module – models surface water – water level is calculated in cross-section, then interpolate to all extend of floodplain
- SIMGRO module – models ground water
- integration module – it spatially combines the results of above two modules having one interface (Kardel, 2003)

Within the integration part calculations are made for 3 scenarios:

- 0 – present, natural situation – this scenario is used also for calibration of the module
- 1 – situation, when the water is going through Martwy Elk River and the Rudzki Canal in proposion 20% : 80%
- 2 – situation, when the water is going through Martwy Elk River and the Rudzki Canal in proposion 80% : 20% (Kardel, 2003)

The hydrological module can operate to for calculate hydrological conditions as parameters of ecological models.

The outputs of the hydrological module are based on the measurements of the cross-sections. Those points are localized on main rivers and canals: Biebrza, Jegrznia, Elk, Woznawiejski Canal and Rudzki Canal.

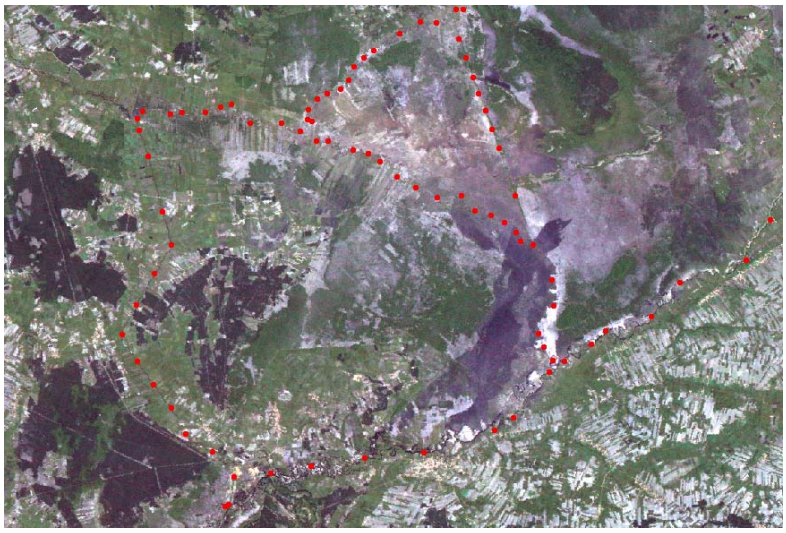


Fig.30. *Map of cross-sections – 85 points*

Hydraulic module uses directly those points to build the tabular database with the values. There are obtained separate tables for each scenario:

Surface water level – scenario 0

Surface water level – scenario 1

Surface water level – scenario 2

This tabular data is calculated for 36 hydrological years (from 1960 till 1996). It contains fields: date (for each day from 1.11.1960 till 31.10.1996), id of cross-sections, and the values of water level [m a.s.l].

The attribute table of the map with cross-sections contains: id of cross-section, coordinates x and y for "Uklad 1942", coordinates x and y for "Uklad 1965", and value z, which is the height of the terrain taken from DEM.

Above data can be related to each other and then from the map we can obtain the information about the water level in main rivers for each day of the year. The data can be extrapolated for the adjacent areas and together with DEM we can have the information about the water level in the basin. This extrapolation will give us not accurate results for areas, which are far from the cross-section points, but for general purposes it can be accurate enough.

Calculations for **SIMGRO module** are based on the grid points (the distance between them is 600 m). The attribute table for those points contains the information about coordinates and the height.

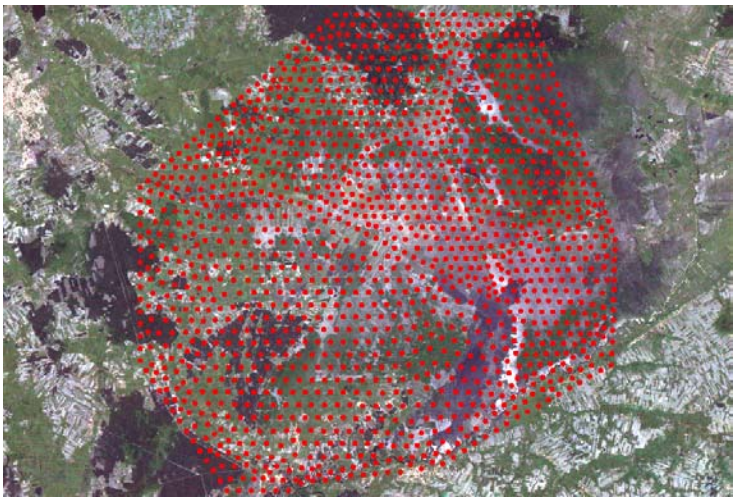


Fig.31. *Map of SIMGRO grid points – 1493 points*

Calculations made for **Integration module** are based on the grid points (distances between them is 50 m). The attribute table for those points contains the information about id, which is a linkage with SIMGRO module and name, which is the linkage with hydraulic module.

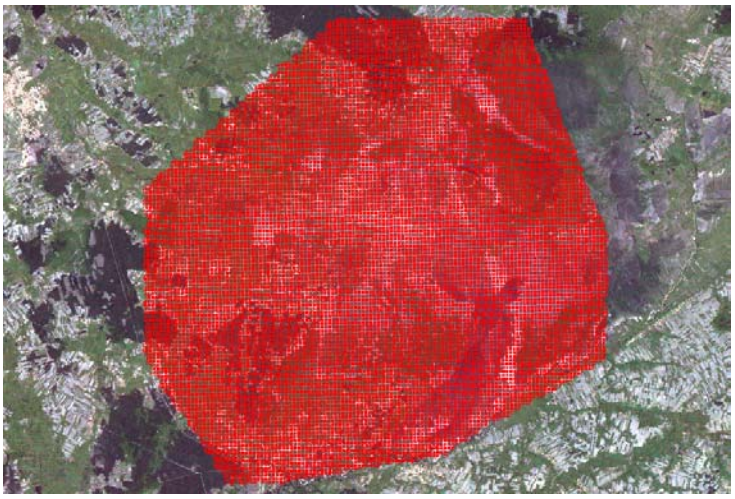


Fig.32. *Map of integration grid points – 144 946 points*

The outputs of the calculations are tables prepared for each year. For the thesis there are chosen only the characteristic years (driest (1969) and wettest (1975)). In the database there are the tables:

Year 1969 – scenario 0 average maximum

Year 1969 – scenario 1 average minimum

Year 1969 – scenario 2 average minimum

Year 1975 – scenario 0 average maximum

Year 1975 – scenario 1 average maximum

Year 1975 – scenario 2 average maximum

Tables contain the name (linkage with hydraulic module), id of points (the linkage with grid map of integration module), the average, min, max value of water level and number of weeks with the water above and under the ground.

Connecting above data gives the possibility of creating the maps of:

- average, maximum, minimum, amplitudes of water level for each scenario for each of three years
- number of weeks with the water above the ground for each scenario
- daily water level for each scenario (but extrapolation for whole area will be weak)

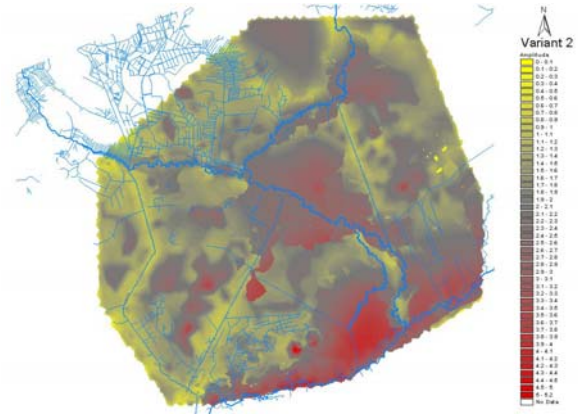


Fig.33. *The example map of amplitude of water level for the scenario 2*.

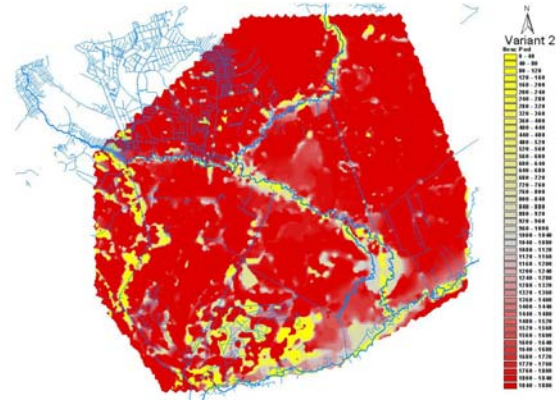


Fig.34. *The example map of number of weeks with the water under the ground for the scenario 2*.

Calculation (made in Arc Map) was done to obtain the water level in the study area. Achieving the data based on linked table takes a lot of time but it gives quite accurate extrapolation. Because of the available time only maps of water level only for whole year 1975 and 1969, for the wettest and driest month of those years and wettest and driest day (for 3

scenarios) are calculated. Reclassification (to obtain the surface water level on the terrain) and converting to shape files are also done in Arc Info.

5.3 PRESENTATION PRESUMPTIONS

Based on information about the project on Biebrza region and the available data, it is possible finally to formulate the **goal** of the presentation. It is being made to:

- show extreme surface water levels according to calculations obtained from the hydrological module – there are chosen: the wettest (1975) and driest (1969) year
- show the differences in water regime due to 3 scenarios
- show the places for regulating the water flow

It is important also to characterize target groups and needs of users. That information together with the already known possibility of the program is essential for making the decisions during building the presentation.

5.3.1 Target groups and users

Target groups, groups of people, who have the interests in Biebrza region and involved in the project, are different. They range from farmers, who are owners of the land in Biebrza Valley, to sponsors of the hydrological works, which will be done in the frame of the project and policy makers. The groups have different concerns in the region. Farmers are interested in creating the best conditions for the agriculture. If the hydrological conditions on their fields get worse they will look for better places. People from sponsoring foundations look for the best solutions for the environment. They want invest money for preserving reach and unique Biebrza wetland ecosystems. They will pay attention of keeping the balance between the best and the cheapest management system for saving the nature. Policy makers (Biebrza National Park, Water Board) should find the solution for stability between preserving the nature and developing the tourism. To achieve the agreement it is needed the cooperation between them. For creating the land use system profitable for whole Biebrza ecosystem, it is necessary for target groups to be provided by the efficient information gathered by research institutes. Then the discussions can be fruitful.

Farmers use the land mostly for mowing and grazing the cows. Regulations of water conditions will change the moisture of their fields and they "may experience negative effects from restorative measures" (Wassen, M.). So farmers will pay attention on possible changes in the land. If the effects of changing the water regime are too serious, and it would not be possible to utilize the fields anymore in the way they were before, farmers will be given another part of

land. After setting the water management system, there will be provided the negotiations connected with the future land use.

The information needed to obtain by farmers from the presentation would be:

- where is their field relatively to the river/flooding water
- what would be the situation with that field when the water is high (the most wet year) and low (the driest year)
- for how much time in the year the water is close/it is on the field of the farmer
- where is the "safe" area, potential land for exchange with the fields farmers already have
- how far it is from their fields
- what are possible changes with their fields in the future (*not in this visual presentation*)

The abilities of perceiving the spatial information by farmers:

- Education level

  The majority of farmers have completed primary education, so they experienced 3 years of geography education (1hour/week).
- Experience with analyzing visualized spatial data

In primary school contact with geographical data is only by general geographical maps and atlases. Probably farmers didn't have any contact with topographical maps. Access to the Internet is very rare, so the only source of seeing maps is over the television. They are mostly forecast maps and maps illustrating the location of important events.

- Farmers have generally good orientation in the terrain, so they don't use maps of the surroundings
- Mostly farmers don't travel for long distances, so they probably didn't experience the view of the land from the height (like from the airplane)

People from sponsoring foundations and **policy makers** will be provided with the results of researches done by scientists to be able to make decisions for whole protected area.

The information needed to obtain by the persons from sponsoring foundations and policy makers from the presentation is:

- general view of the region of Biebrza valley
- changes of water levels due to different amount of water available in the valley (different scenarios for water flow in old Elk river)
- the localization of possible new dams on the canals
- possible changes of the range of water flow comparing to the current situation (most wet and driest year)

The abilities of perceiving the spatial information are:

- Education level
- That group of receivers mostly have university education
- Experience with analyzing visualized spatial data

At high schools the students work with geographical maps as well as with thematic maps. It is demanded to make own analysis based on compilation of information from thematic maps. Sometimes also topographical maps are introduced. During studies usually students take tourist maps for the orientation in the new terrain.

- During studies most probably electronic/internet maps were introduced
- If the field of studies wasn't connected with geography, geodesy or GIS, then most probably interactive maps related to geo-data bases weren't used by that group of people

Users, the coordinator of the project, collect all the information from the research institutes and will use the presentations to communicate the results to other involved groups. They should be able to answer questions from the audience. And the available functions within the presentation should facilitate this. They should be able to show particular places and the flooding.

After agreement with target groups it will be decided which scenario for the water distribution will be applied for the Biebrza Valley.

5.3.2 Some conclusions

The conclusion from above analysis is that the **presentation** should show the terrain in a realistic way (this conclusion is the same as the assumption for the presentation). Then the effort putting for interpretation of the geographical information is minimized. For people, who are not experienced with analyzing maps and other kinds of presenting the spatial data, it would be possible to understand conveyed information. And for people, who have the experience of working with geographic data, such kind of presentation would be easier and faster for interpretation. If data, which does not remind the view in the real world, is used, then there is a need of using the legend, which should be explained by the presenter. 'Realistic' presentation of the terrain suggests preparing 3D model of the terrain. The way of showing the model should be similar to the view we have in reality. It means that the view on the model would suggest the standing position and it would be possible walking through the model. For smaller scales it is not possible, then the movements over the terrain the similar to flying over it should be applied. But the scale should be flexible enough to show individual field (in that information farmers are

interested) and whole Biebrza Valley as well (policy makers should be able to have the overview of whole terrain, which would be affected by hydrological changes). Also the information about distances should be shown, when there used different scales. Otherwise the visible size of area could be confusing.

Using local names is essential for facilitating the localization in the model.

The presentation should be interactive enabling to show chosen information (if there is an interest for that) and should have a possibility of adding new data to it after researchers gather. There is no need of making the presentation small as data can be used from hard disc.

How it is possible to fulfill above needs in Terra Explorer Pro together with previously formulated criteria for the presentation, it is discussed below and in chapter 6.

5.4 LEVELS OF DETAIL, RESOLUTION AND REFERENCE INFORMATION

Available data for the terrain of Biebrza Valley is a very good example to analyse the way of working the **data of different detail levels,** which is described below.

Aerial photograph is the most detailed available data. The terrain image shows the view from the aeroplane. The significant information can be read from that between 4000 and 180 m in scale above the terrain model. From high distances easily are noticeable big features of the terrain like dense forest areas, mosaic of fields, main roads and rivers. When the viewpoints are set closer, from around 800 m, the elevation model starts to be visible. If we come closer, the way of looking at the image starts to remain more the way we observe the world in reality. And it means that comparing the model to the reality becomes easier. But at the same time there is applied the reducing scale, and it gives advantages of familiar landscape view and seeing big part of the terrain on one scene. Familiarity of perceiving the landscape is due to the oblique view, which we know from every day life. New elements, like seeing the canopy or buildings from above, are explained in the legend.

Fig.35. *The part of the legend of the aerial photograph*

The legend can be also necessary due to limited range of view in the computer window. If it is seen only the part of the photograph, then users can have difficulty with identification of the

objects like in the above example of the legend (look at the forest as the whole available view). If the camera goes higher, the context for the objects will be visible and its identification easier.

To understand the model and orientate on that, people look for familiar objects or patterns. The first step is to find the place one lives. If it is not on the mapped area, then one checks other known or characteristic areas like towns, main roads, rivers (Zyszkowska, 1993). So putting the names of such places will help for geographical orientation. In the prepared presentation, the list of such places is in the left window. Clicking on one of those will move the camera to the requested place.

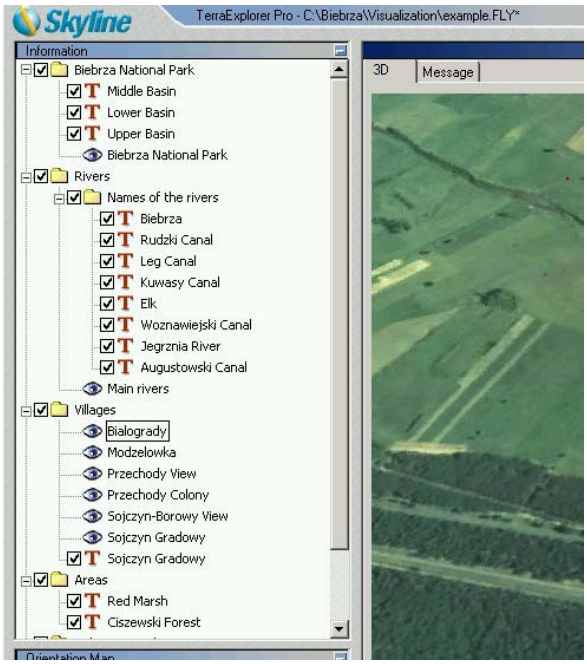


Fig.36. *The list of named elements.*

Also other characteristic elements can facilitate moving onto the area. In the terrain we pay attention e.g. on the separate big trees, distinguishing buildings, obstacles for walking or driving. If those elements would be placed on the model, they can be good orientation signs. It was already said before that 3D visualizations are easiest for interpretation. In Terra Explorer there can be imported 3D objects, others can be created within the program or some of them, like buildings, can be extruded from the surface.

Fig.37. *Extruded buildings and forest and 3D trees models – close view*

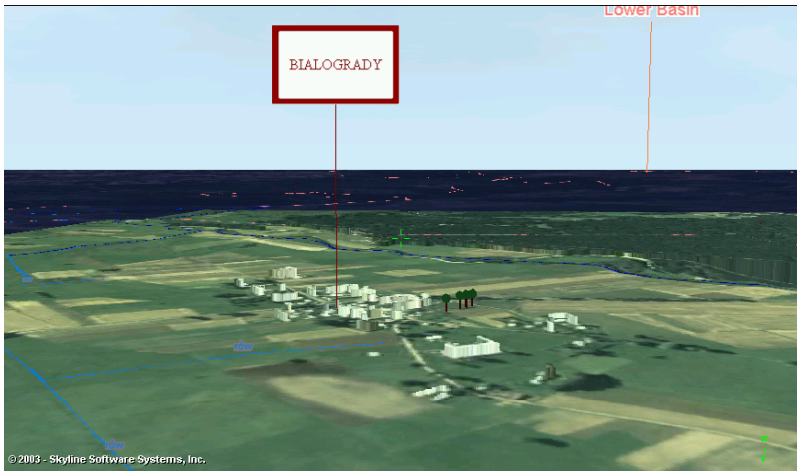


Fig.38. *Further view on 3D elements*

Such elements help much with orientation but they are visible only if we deal with big scales. If we are far above the terrain they become too small to play the role in the image. The same situation is with elevation data. Biebrza Valley is a flat area and the small differences in height can be noticeable only in big scales. Coming to the smaller scales, differences in elevation are not the prevailing features for the landscape. In those scales are visible other dominant elements. Those features will be easily readable for experienced user of geographical models of the reality. It is because they are not more similar to the perspective we have in the real world. It starts to be more abstract information, which needs to be explained broader. It means that the legend starts to be more important.

To illustrate the range of flooding, the terrain model does not have to be very detailed. There is no need to see e.g. the windows of the houses. People are interested in the areas, which would be flooded. On aerial photograph, there are clearly visible individual fields and this information is the most detailed, which needs to be shown. Unfortunately aerial photograph is available only for

the small part of the Biebrza Valley – for Rudzki Canal. And this area is not flooded during the year. Below (Fig.39) is the illustration of the range of the study area. Flooding water is visualized in the similar way.

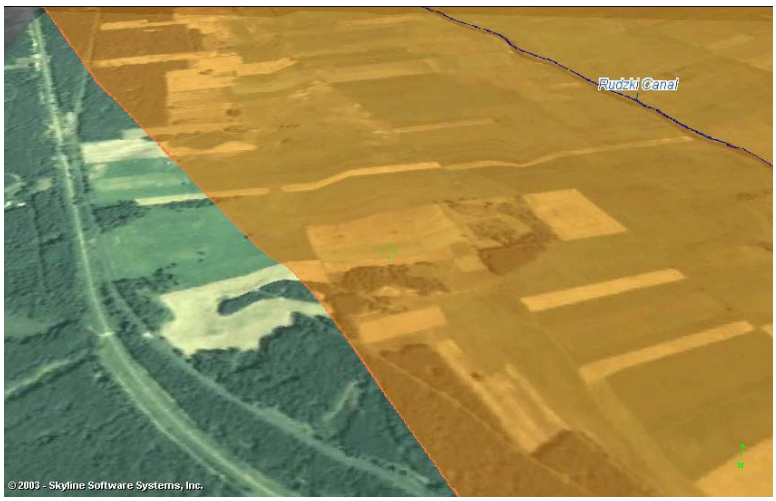


Fig.39. *Border of study area*

Less detailed information about the surface of the terrain than aerial photograph, gives another available data for Biebrza National Park – **orthophotomap**. The information, which can be easily distinguished from the image (with the help of the legend), contains rivers, roads, forests and grasslands. If the viewpoint is near the orthophotomap, agriculture fields, towns and bushes are distinguishable. This all information is well readable from around 600 m to 9000 m from the terrain in the model. The height information is combined with that bitmap but even if we look from the lowest distance (lowest – the height, where the orthophotomap is still well readable), it does not give any additional information (Fig.40). It means that it can be neglected for that range of viewing scales.

Fig.40. *Height information combined with orthophotomap*

For the views from the bigger distances, elevation data is not visible anymore. The view starts to be more abstract. As it can be seen at the Fig.41, for interpretation of the image it is necessary to read first the legend. Without that information we can possibly guess where rivers are but the rest of the information will not be communicated without helping explanation.

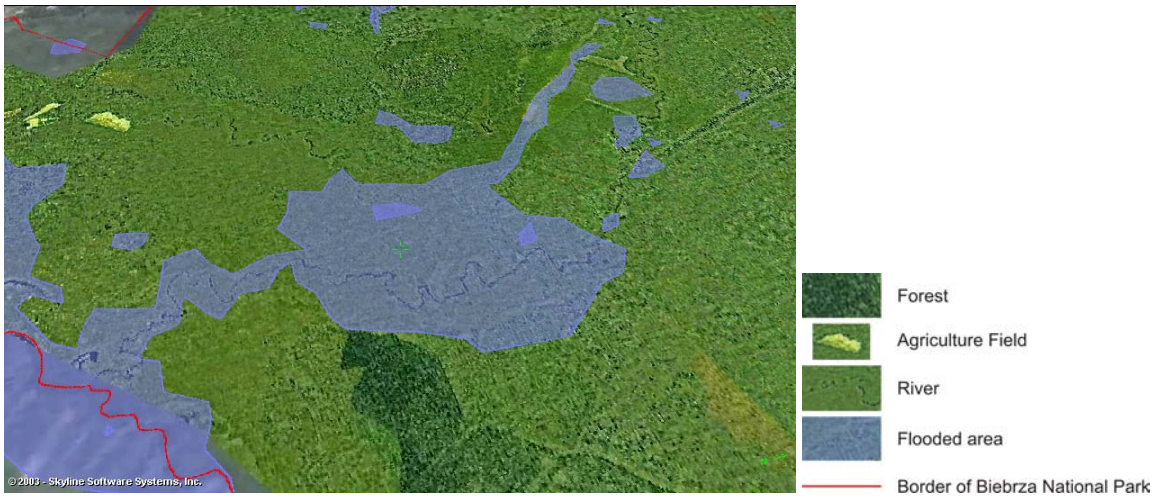


Fig.41. Orthophotomap as the background information about the terrain

When user becomes familiar with the way of presenting the features of the terrain, still he/she can have the problem with orientation. That is why additional elements (reference data) are necessary to be included in the model. On the aerial photograph there are helpful visible individual fields, trees and houses. On orthophotomap those finest elements are rivers and roads. They are helpful for orientation but mostly are not sufficient. Theoretically the shapes of the big objects (lakes, forests, dunes) could be helpful with orientation. But in the terrain it is almost impossible to notice features of such objects. They are only visible in the reduction scale. So if somebody knows from maps the localization and the shapes of big objects, they can use this information to place oneself on the model. But for most of users, this information was not accessible. They only have the experience from observing the reality.

The most important elements, which should be included for better orientation, are names of known objects and places. For several people (mostly those, using road maps during driving) the network of roads is familiar. But in Biebrza National Park (orthophotomap is only available for this area), there are almost no roads, so one cannot use the advantage of them. Another thing, which helps using the terrain model, is the distance scale. Knowing how far certain places are from each other on the model is beneficial for learning the orientation on the model.

The similar background role to orthophoto plays another kind of data available for Biebrza region – **satellite image**. This is the least detailed data. It covers whole Biebrza Valley. There are distinguishable forests, agricultural lands, roads and towns. This data is readable from 1600 m to 30 000 m (this is the limit for the model) above the terrain model. The information on the image can be meaningful with the help of the legend only for the experienced user. For not experienced one, it could be hardly understood. We do not face such kind of view of the Earth in everyday life and normally it takes time to learn how to feel the scale on the model and place already known areas if we do not deal with known forms of the objects (houses, trees, etc.). So if the user is familiar with maps of the region, he/she can recognise the mosaic of the forests and agriculture fields and it can be helpful with the orientation on the model. The user, who is interested in the general information about whole Biebrza basins, most probably is already familiar with several kinds of presentations for that region. So probably after knowing the legend will have no difficulties with reading needed information.

There is necessary additional information to make easier the orientation on the model. E.g. for users, who mostly work with data of Biebrza National Park, the border of the park will give good hint for localization. For hydrologists, the most familiar element is the network of rivers and this thematic layer will place this user the best. The most universal information gives names of big objects – important towns, big rivers, main roads, etc.

Fig.42. *Names and the border of Biebrza National Park as the reference information*

For users, who are familiar with maps, the best orientation help can give the location map. Location map shows the visible part of the terrain on the model in the smaller scale, to be able to build the impression of the scale and at the same of the distances within the model. Within Terra

Explorer Pro, it is possible to place such a map in the left bottom window. It is connected with the model and it shows the current position (see chapter 4.3).

For the flooding region within the study area only orthophotomap or satellite image is available. The resolution of those two bitmaps is quite low and that is why they can be read only from high distance from the terrain model. It gives the abstract information, which cannot be easily compared with our experience from reality (neither as any other way of presenting the world in the small scale). Satellite images give all information from the earth surface, without any selection. That is why they are the most realistic surface representations from abstract information about the terrain. Because none of elements are underlined or exposed better than the others, this kind of information is quite difficult to interpret. The alternative solution gives maps as the illustration of the terrain. Maps contain only the desired information but still they are not easy for interpretation for not experienced user. It is just because of their abstract way of coding the information (symbolization), which first should be explained to enable the user reading easily the content of the map (Pasławski, 1994). So still for presenting the information about the terrain for different users, is better to use satellite images. They give the most realistic impression of the terrain and with the help of legend and additional elements are feasible to be read.

To reach out the needs of the different target groups, as they were analysed in section 5.3.1, there is a necessity of using **different detail data for different scales**. Building several presentations is possible but the more interesting solution is to try using it in one. Each bitmap should be visible only in the range of scales, where the information can be easily read. Together with the bigger scale the bitmaps should be exchanging for the proper one. Then there are created "different levels of nearrealism" (Lammeren, 20003). This solution already is used in several electronic atlases when different density of the data is accredited to different scales. When the information on the bitmaps is classified or coded and structured (like on maps), then number of objects should change with the scale (also methods of presenting the objects). It is done to avoid overloaded surfaces or on the contrary too empty spaces. And if we use satellite images, with the scale should change the resolution. The good example of using multi-resolution satellite images can be found on the web-page: http://www.earthetc.com/ecwearth/asps/ecwearth_frame.asp?Image=geodetic/world/landsat742. The resolution is projected dependently on the area, which is at the moment on the screen. But to be able to prepare such presentation the data has to be huge. This example of multi-resolution satellite image of the globe is 2113.21GB big and this is far too much for the commonly available

space on the computer hard discs. And also such range of resolution normally is not necessary for most purposes. One should keep the balance between the size of the data, the quality of that according to the purpose and costs.

In the case of the Biebrza region, three kinds of bitmaps are available and that set seems to be good enough to show the information in which each target group is interested. Available GIS programs do not offer the possibility of changing the background in the certain range of scales. In Terra Explorer Pro it can be done but the height information would be available only for one level, which is reasonable for the flat Biebrza region. Other levels are put on top of each other and there is a small space between them. Elevation model combined with aerial photograph gives significant information, but already if it is combined with orthophotomap, differences in height are not noticeable. Unfortunately there is no place for Biebrza Valley covered by all three bitmaps. That is why it was not possible to prepare such a model for that region. If there are gained new photographs, then will be feasible to use them. In the example (**detailLevels.fly** or **detailLevels.avi**) prepared in Terra Explorer Pro, one can see the idea of such a solution.

The effect of changing bitmaps (backgrounds), what depends on the viewing distance, is good if the view is vertical or near vertical. If the camera is in the oblique position, the scale of the visible part of the terrain differs much on opposite sides. For this situation the technique of replacing whole background at once still will not solve the problem of seeing not appropriate density of information to the ability of reading that because of the distance. In such situation multi-resolution image should be used, which is unfortunately not available for Biebrza region at the moment. Then it can be used only one image. Terra Explorer applied the technique of working with such images and enables to show different resolution according to the viewing distance of the background file. The part of the image, which is closer, is showed with the better resolution than the remaining part.

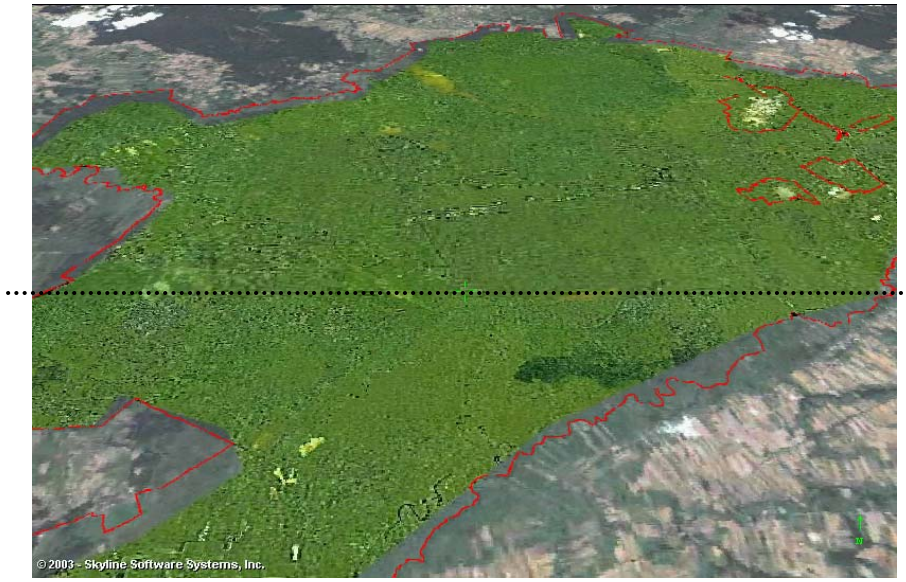


Fig.43. *Differences in the resolution of the front and back part of the scene.*

Summing up the above most important issues:

- there is the need of using different detailed data if we deal with changing scales
- changing the scale is closely correlated with the changing resolution of bitmaps, with the changing height over the terrain model, so also with changing the abstraction of the terrain representation
- big scales (close view) allows taking advantage of elevation model and 3D objects. The closer the view is, the more detailed 3D objects can be seen
- if we deal with the oblique views, the scale differ a lot comparing opposite sides of the scene
- referencing data should always refer to the previous users knowledge, then one can use the advantage of that for orientation

5.5 PROCEDURE FOR PREPARING THE PRESENTATION

Below one can read about some details of preparing the presentation in Terra Explorer Pro. It gives the overview on the specific needs of that program.

The terrain model:

Working with Terra Explorer Pro has to start from opening the prepared (in Terra Builder) terrain model (.mpt file). Then there can be imported several elements:

Another Terra Explorer project (.fly file)

ArcSDE file

ASCII file
DXF file
Oracle Spatial files
and Shape files

To build the terrain model there is a need first to prepare the **raster layers** and digital elevation model. They are the reference layers for the vector thematic data. Those files together with digital elevation model are taken to build the .mpt model, 'earth image'. This is the base for Terra Explorer Pro. Already all possibilities of the program are available for that file. For building .mpt file it is needed Terra Builder, and only with that tool allows changing something within .mpt.

Raster layers should be in the format of:
TIFF, GeoTIFF (.TIFF, .ITIFF)
Windows Bitmap (.BMP)
ERDAS IMAGINE (.IMG)
User defined binary raw
MRSid compressed (.SID)
ER-Mapper (.ECW)
NIMA formats: CIB, ADRG, CADRG

Otherwise the bitmaps cannot be imported. The coordinates are kept the same as in the original files as well as the units. If there are some problems with combining different raster files, they can be manually put in the right place using the original coordinates. Sometimes it can happen with .ecw files or with combining different kinds of files. Then the conversions within ER Mapper should help. Terra Explorer package reads well the files prepared with the help of that program.

Elevation data should be prepared in the format of:
TIFF, GeoTIFF (.TIFF, .ITIFF)
Windows Bitmap (.BMP)
ERDAS IMAGINE (.IMG)
User defined binary raw
ASCII - X, Y, Z or Z (regular grid)
NIMA formats: DTED

In Terra Builder there is possibility of using the parameter of exaggerating heights. Then the model can be better visible, depending of the purpose of visualization.

The model prepared in Terra Builder can be read in Terra Explorer Pro, and here it is possible e.g. importing vector GIS layers, creating text labels and defining walking paths.

Preparing the shape file from the tabular data:

Tabular data mostly is managing in data base program – Access. Within that tool it is possible to build the relations between different tables achieving the needed information in one table. Selecting information can be done using the help of filtering. Then prepared tabular data can be exported and consequently linked to the attribute table of a thematic layer in Arc Map (Arc View or Arc Info). Next step is extrapolating the values for the study area. The fastest method of reclassifying and converting into the shape files is using Arc Info. Then Terra Explorer Pro can import prepared layer.

Fig.44. *Shape file of flooded area on the satellite image (Arc Map)*

The out form of the presentation:

Creating "the Terra Explorer Basic Kit" can save on disc all the above elements of the presentation in one place. This function makes a copy of the terrain model (.mpt file) and all the data, used for as the additional information (in the 'data' folder) and the 'managing' file (.fly). It makes easy taking or copying whole presentation in another place. For new users, there is an option of copying to the folder also the installation version of Terra Explorer with the user instruction.

5.6 CHARACTERISTICS OF THE HYDROLOGIC THEME

From following sub-chapter explains the hydrologic topic.

Hydrologic data is thematic data and fulfills all characteristics of thematic themes. Hydrology is a very wide term and each topic under it has its own characteristics. Theory of showing thematic layers has the base in cartography (e.g. Ratajski, 1989, Robinson, 1995). On maps at first were shown results of calculations or interpretations of thematic data having spatial distribution. To show any theme, there is a need to have prepared background, which is already in needed coordinate system. It allows putting the theme into existing situation. This background gives information about localization of the mapped objects. And also allows answering questions based on the relation between objects in background and objects from the theme. Always it is important to predict the range of questions, which receivers are interested in. Then include information on the map complements presented topic. Hydrology problems are related to geomorphology, soils, climate, and lot of economical issues. Depending on the purpose of presented hydrology topic, some of those themes should be also visible (accessible).

For this thesis presentation, the interest is in showing the range of the surface water. The interest of receivers is in the landscape under certain water conditions. So the complement information should include general topographical information, which is common for all topics as the background. Of course from this general information the water topic is central, so mainly attention should be paid for that part (there should be the e.g. names of all rivers, canals in the area of interest).

Surface water is on the nominal level and to show it, it is needed only hue from graphical variables of Bertin (1974) to show the range of it. That rule is applicable in the same way to this topic and to all others, where only spatial distribution under the interest.

Other important aspect is the level of detail of the presented theme. If the data is rough, the presentation method cannot give the impression of being very detailed. Then during the interpretation one can take into consideration the certainty level.

Data calculated from the hydrological module is not very detailed. The character of the borderlines suggests it on the presentation.

Fig.45. *Border line of the surface water is fuzzy*

The property of calculated flooding data contains apart from spatial distribution, also time distribution. And if we deal with the time, it is valuable using animations for showing the changes of flooded terrain. Creating this artificial way of perceiving the time, one makes possible seeing the patterns, which would be not noticeable looking at only one date (Kraak, et.al., 1996). This remark considers all thematic layers, where the time is involved, so the hydrologic themes are not the exception.

For this thesis presentation calculating the data of flooding range for one date, was time consuming and it seems to be not feasible creating layers for each day of the calculating period (36 years) for each scenario (even then the animation could not present continuous change but only steps). That is why there were chosen specific dates for whole available time, which can characterize the range of changes in Middle Basin. And it was decided not to make animations.

There is the possibility of adding new vector layer, as the additional information to the presentation. It would be calculated (from the database of hydrologic module) depth of the water, duration of staying of the water on the surface for certain year, within study area. Prepared layers can be added or deleted from the presentation (it has to be done in Terra Explorer Pro).

It can be conclude that hydrologic theme is typical thematic layer and has also typical characteristics. As the theme connected with water, it should be presented (if possible) in bluish tones to underline this relation. If there are used patterns or signatures for coding the hydrologic data, also should be visible the relation between reality and used symbols.

6. EVALUATION OF THE APPLICATION

This chapter explains the results of the questionnaire, which was sent to hydrologists from Warsaw Agriculture University, who were gathering the data for the PIN Matra project, and to WWF, coordinator of the PIN Matra project.

The idea of this thesis project comes from the fact that existing maps and visualizations of data seem to be difficult to interpret and understand for users who are not experienced to do so.

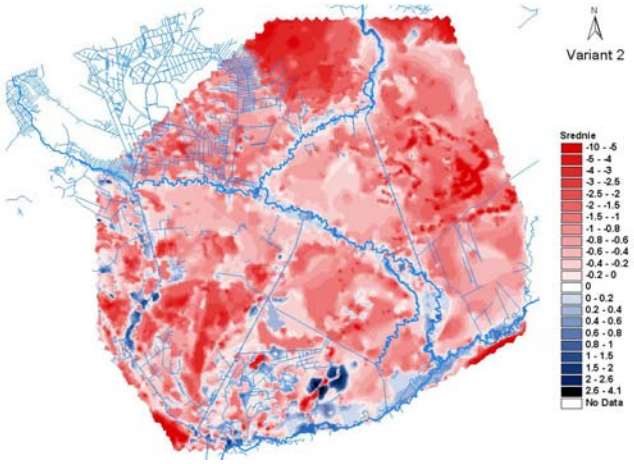


Fig.46 *Visualization of the output of the hydrological model – annual average water level, scenario 2 (see chapter 5.2) (Warsaw Agriculture University)*

Above example (Fig.46) and other thematic maps prepared by Warsaw Agriculture University do not contain the background of topographical information, which can help with the orientation and localization of the presented topic. If the receiver is not familiar with the shape of the river network, then he does not have any other information, which could help with the interpretation of coded information. At the end the map will not transfer any information. Receiver will have to make use of other maps to understand the situation in the area under the flood. Such kind of interpretation seems to demand too much effort from the receiver.

During the creation of the presentation I paid attention of making presented information easy to understand. That is why I chose the most realistic available data for the terrain model of Biebrza region and the most 'natural' and simple way of presenting the flooding, which was possible in the chosen program. If the way of presenting data is easy for the interpretation by not experienced user, it means that it will be easy to interpret also by other groups of receivers. Then the presentation can be more universal.

Created presentation can be seen using the attached file (**Presentation.fly**) in the program Terra Explorer (available on attached CD).

In sub-chapters 4.3 and 4.4 the possibilities and limitations of Terra Explorer Pro are explained in the context of applying the assumptions of the presentation, mainly the needs for interface elements and way of presenting the terrain and thematic data. If the result is 'understandable', 'easy to use', ' and informative' and if it is better than previous visualizations I asked hydrologists (2 persons) from Warsaw Agriculture University (they were gathering the data for the PIN Matra project) and coordinator of the PIN Matra project – WWF (1 person). They have the experience with discussing with farmers as well as with sponsors of the project, so they are able predict how those target groups could perceive the presentation.

The questionnaire itself is attached in appendix. In the following section there are presented conclusions from received answers.

Asked questions mostly demanded longer comments. It gave the possibility to build the opinion how responders perceived the presentation. The assumption of the questionnaire was, that based on responses of people involved in the project, it is also known how the target groups could perceive presented data. If something was not clear enough, I asked additional questions personally. It was not possible in the available time to prepare the questionnaire and address it directly to farmers and sponsors of the project. Then questions (especially questions about orientation) should have been asked within the presentation and presented by coordinator of the project.

The first questions were concerning the content of the presentation and the way of presenting the data. It was checked if receivers could **understand** the background information and **orientate** themselves by the model.

Responders did not use the legend to understand the details of terrain representation. The only difficulty was the information from satellite image. Then they could find needed explanation easily in description of that image. The legends were easy to understand. The additional comment was that the oblique view on the terrain model is more familiar to receiver than the traditional perpendicular view and it helps with the interpretation. It confirms the theory of Dykes (2003) that more realistic (reminding real world) presentations are better understood (demand less effort for interpretation). If the presentation is understood, the receiver is involved in exploring it and

more willingly searches for the needed information, because it does not take too much effort to achieve it.

The reference information (names, border of BNP, rivers) gave enough hints for orientation on the model for responders and they did not have difficulties with placing themselves on it. It means that during showing the presentation to target groups they can always explain the localization of the viewed place if needed.

The next questions referred to thematic information within the presentation. They were supposed to check if way of presenting them is **understandable**.

The aim of the presentation was rather clear for responders and formulated correctly. Within the presentation I put some elements (3D houses, 3D trees, extruded of vegetation, additional thematic information) only for showing the possibility of the program. It blurred a bit focusing on main topic. That is why the aim of the presentation was not very sharp visible.

The way of showing flooding was understood and attractive to responders. The comments contained the suggestion that if it would be possible in the program, water could be shown as 3D mass with the texture reminding the water surface visible e.g. at the sea surface. They suggested adding to the presentation descriptions of scenarios. Within the presentation the information about differences between scenarios is not mentioned and according to responders it should be included to help for better and easier conveying the information about flooding. It should be included together with the information about dams making role with planned water distribution.

Responders mentioned the possibility of adding complementary information for flooding layer. Then wider interpretation of whole presentation would be possible. Proposed topics were: depth of the flooded water, time of remaining the water on the certain areas, agriculture areas with division for well and bad reacting for flooding, inhabited and cultivated areas. That information could give the context for flooding topic. I did not put that kind of layers into the presentation because it would take too much time to calculate the polygons (depth of water and time of remaining the water on the areas) or they were not available within the project. Using Terra Explorer Pro it is possible to add new vector layers and after preparing them in GIS programs, they can be easily included in presentation. Based on different composition of selected topics it is possible to create different presentations, which can fit to certain titles (depending e.g. on the purpose of particular discussion with target groups).

The next group of questions were created to find out if the presentation is **informative** and if it can facilitate the dialog with target groups.

Responders' opinion is that such kind of presentation can be helpful during discussions with farmers, and also it enables to answer their probable questions. But the role of presenter is significant with conveying the information. It would be beneficial to add the information describing the advantages, which give flooding if discussions are provided with farmers.

Responders were not sure if this presentation could facilitate the discussions with sponsors of the project. They could not predict their probable questions and could not point out missing information in presentation, which could be useful for dialog with sponsors.

General opinion about the way of showing the Biebrza area was positive. Although responders pointed out few things they did not like in presentation. They mentioned bad quality of bitmaps, difficulties with managing of moving over the terrain, not regulated size of message window, where are shown legends, and also that sometimes they had to manually come back to initial information in left bottom window (to show orientation maps). First two problems can be eliminated – bitmaps can be replaced when they are available, the ability of moving over the model can be achieved with training with the program. Other disadvantages depend on limitations of the program and they cannot be eliminated within this version of the program.

Responders mostly liked the way of moving through the model. It is a nice experience and gives the advantage of seeing parts of terrain, which are hardly achievable in reality. They also liked the way of presenting all layers. They underlined that visualization of the data gives the advantage over analysing thousands of numbers.

When user enjoys working with the presentation or map, he can easily remember the content of it. It gives the advantage of saving the time (and effort) with becoming familiar with big amount of data.

The other group of questions had the aim of finding if the presentation is **easy to use**, which depends on the interface of the program.

Responders have the opinion that all windows are necessary within the presentation and even they would add another window, which would contain additional information – about height of the terrain, information about scenarios or separated window for the legend. Such window could be added at the bottom or as a floating window. In my opinion if the mentioned information would be added within the existed windows, there would not be a need anymore for the additional window.

Responders did not have difficulties with finding the needed information. Using the scale from 0 to 5, they pointed 0 or 1. The navigation bar was easy to use for one person. One had

difficulties with placing herself in the desired area, and the last person did not use it. Getting experience with using this tool-bar can eliminate problems of achieving needed aim. The most difficult was the tool for changing the height over the terrain. But it was mentioned only by one person, the others did not have any difficulties. Options of hiding and showing layers, going to defined places were easy to use.

In the responders' opinion there are no missing functions for the presentation. Moving on through the model and searching for needed information can be done using existing functionality.

Options available for using the interface were easy to learn. They use standards from Microsoft Windows system and have sufficient explanation.

Last group of questions were created to know general opinion of the presentation.

The presentation was considered as interesting and attractive. If it is possible to choose the set of vector layers, then there is a chance to make it fit into provided discussions.

Opinions of the person from WWF and hydrologists from Agriculture University were similar to each other.

7. CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

This chapter gives some remarks of the thesis work and some final recommendations.

It is difficult to overrate the advantages of visualization. It is made for facilitation of perceiving the data and also for giving additional information, which is not accessible from not graphic form of presenting the data.

Available data set for Biebrza region is not good quality. Some errors became distinguishable only after visualization.

At first look the combination of raster data and elevation data offers the opportunity for a **visual check of the data quality**. Together with the aerial information we can check if canals and rivers are flowing exactly through the lowest part of the valleys, if there are no hills in the middle of those valleys and generally if the terrain looks similarly to the reality, if it has the same character. This is fast and the complex method for checking the data. The whole set of the data (images with elevation data in this case) is visible at once.

In the case of Biebrza data, this checking has a negative result. Observing the terrain model, there is little trust to the data.

Fig.47 *Hills in the middle of the canal route!!*

Fig.48 *The canal on the hill!!*

Even the terrain looks as it has more karst features than the original glacier.

Fig.49 *Holes give the impression of the karst origin of the terrain.*

Checking the accuracy can be done by adding the additional vector data to the raster base. Then it is possible to see if they fit altogether. The details of the aerial photograph allow comparing the features. Well visible features are the forests and we can easily compare that theme with the vector data. On the figure below there are noticeable differences in the areas covered by the forest. Vector layer was made based on the topographical map, which is older (around 10 years) than the aerial photograph. And this can cause the differences.

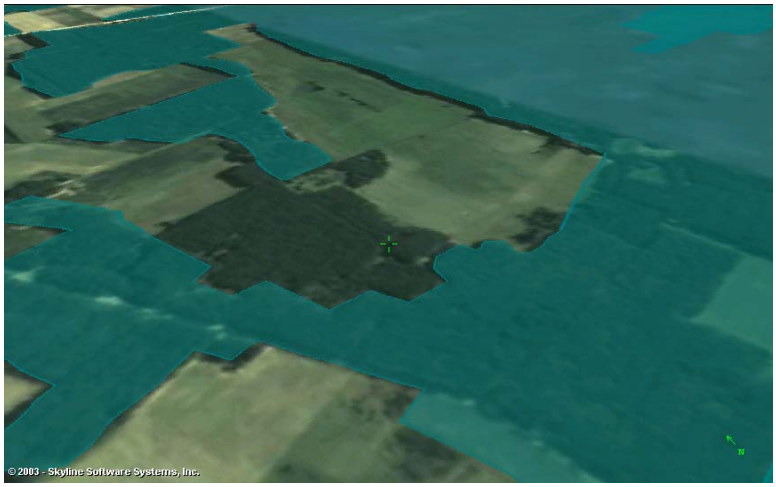


Fig.50 *Comparison of boundaries of the forest: aerial photograph and vector layer made based on topographical map.*

It is also necessary to check if the distances, coordinates and units are correct. The easiest is to compare the model with the original data (topographical maps and original files). Terra Explorer has the special tool for measuring the distances and differences in height between the points on the model.

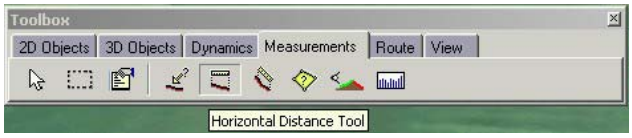


Fig.51 *Measurement tools available within Terra Explorer Pro*

Visualization of the data can show probable error in the data, but we should concentrate on the appropriate detail level. It is because e.g. showing the percentage of the flooded area in the Middle Basin of Biebrza Valley, the differences of few meters are not very important. It will be the opposite if we are concentrated on individual fields, which are under the risk of being under the water.

This thesis has the aim of creating example presentation based on available data for Biebrza region. So even if the data is not accurate, still it is possible to concentrate on showing the tools for creating presentation and showing advantage of choosing the best possible way for visualization the data.

Created presentation is supposed to be understandable, easy to use and informative. It was checked by the questionnaire given to people working with different kind of data about Biebrza region. It showed that presented information was understandable, responders could easily learn the way of working with the program and if this presentation is showed to target groups as the

illustration of the topic, it could be helpful with communication with them. It means that thesis project achieved the **aim**.

Concerning **research questions**, the questionnaire approved that conclusions made from theories of interfaces are correct. WIMP style interface is easy to use. The **components** proposed in interface for the presentation are sufficient for users and there are no missing **functions**. It would be better if all windows have regulated size. Then depending on information, presenter wants to underline, or the questions from audience, certain window would be enlarged.

Using questionnaire was also checked that more realistic representation of the terrain (the representation of objects and way of looking at the terrain model) is better understood than abstract one (like maps) even if they are simple (contain few layers).

For characterizing presentation the term **scale** is not useful. If we deal with perpendicular view, then the rate of reduction is constant for whole surface and characterizes it well. But if we deal with oblique views, scale is different in each point and giving this characteristic would be confusing. The view is defined better definition by parameters of height over terrain model and angle of viewing. Together with speed of moving over terrain, the scene is described precisely. Defining appropriate views (range of heights and angles) for the presentation depend on interests of target groups. This information determines the smallest needed detail, which should be visible within the presentation, and also the range of the terrain, which should be visible in one shot. Those border views with all the range, which is between them, should be shown using background on appropriate **level of detail**. Used bitmaps for creating presentation had the limitation of readability depending on height of the viewpoint. A viewpoint cannot be too close, because objects are not distinguishable. It can be due to the resolution of the image or due to size of objects. There were used the photographs of the terrain, not special coded pictures, and that kind of data does not the limit of too high views. Objects are distinguishable the best in certain range of height but still from big distances the information can be read.

For better orientation on the terrain model **reference information** was used. The results of the questionnaire showed that names of important places and the most known objects – like rivers, border of Biebrza National Park – are giving enough information for good orientation. For presenting flood, should be also put the complementary thematic information. Then analyses of this topic can give much more rich conclusions. Exact choice of those thematic layers depends on the problem, which should be discussed with certain target groups. They can be changed when the topic is different.

Analysing the **hydrologic data**, it was conclude that it has the same characteristics like other thematic layers. Flooding is visible in reality and it can give some hints for way of presenting this topic.

Preparing the appropriate data set for such kind of visualization with care is recommendable as correct data improves highly the quality of the final result. If there would have been used aerial photographs with elevation data as the background for the flooding data, then such presentation could be more universal. It could be understandable in all scales and at the same helping with communication with all kind of target groups.

After discussions with responders of the questionnaire it was noticed that the graphic form of presenting the data can be memorize much faster and for longer time than text or charts. It is because data is presented on already experienced (in reality) background and it can be easily related to known objects or areas.

If the presentation is perceived as attractive and people enjoy working with, this positive impression can be the advantage in convincing receivers for proposed solutions.

Tools within chosen program, Terra Explorer Pro, are created to build the objects visible from close distance to terrain model. This program seems to be the best to show e.g. towns in detail but it is not specialized in showing the terrain from high altitudes. Separate buildings, details of vegetation do not play role anymore when seen from further distances. Analyses within the program are very limited. It is possible to measure distances, differences of heights between points and check visibility from the certain point. There is no possibility of analysing vector data, which could be useful for presenting the hydrologic data. All needed information should be then prepared separately and import to the program. Terra Explorer got very good opinions for showing the data (based on the questionnaire). The way of interacting, moving over the terrain model is attractive. It can be considered to be a good tool for visualization of already processed data.

LITERATURE:

1. Banaszuk, H., 1996. *Natural and antrophogenic changes of the Upper Narew Valley* (in Polish). Bialystok, 220pp.
2. Bauters, 2001. Graphical Design of the Interface. The Planning of GUI. http://netpro.evtek.fi/team/wp5/resources/userInterfacelecture-Bauters.pdf
3. Bertin. J., 1974, *Graphische semiologie. Diagramme Netze Karten*. Walter de Gruiyter, Berlin, New York.
4. Bishop, I.D., 1994, Rhe role of cisual realism in communicating and understanding spatial change and process. In H.M. Hearnshaw, & D.J. Unwin (Eds.), Visualization in Geographical Information System. Chichester: Wiley.
5. Byczkowski, A., Kicinski, T., 1991. *Hydrologia I hydrografia dorzecza Biebrzy (Hydrology and hydrography of the catchment of Biebrza River*). Zesz. Probl. Post. Nauk Rol. z. 372
6. Crampton, J.W., 2001, *Maps as social constructions: power, communication and visualization*. Progress in Human Geography, Volume 25, No. 2.
7. DiBiase, D., 1990, Visualization in the Earth Sciences. Earth and Mineral Sciences, Volume 59, No. 2.
8. Dykes, J., *Creating information-rich virtual environments with geo-referenced digital panoramic views*. In Capita Selecta Geo-Visualization. Laboratory of Geo-Information Science and Remote Sensing. Centre for Geo-Information, Wageningen University, 2003.
9. Egenhofer, M., Herring, J., 1993. *Querying a geographical information system*. In Medyckyj-Scott D, Hearnshaw H (eds) Human factors in geographical information system. London, Belhaven Press: 124-36.
10. Egenhofer, M., Kuhn, W., 1999. *Interacting with GIS*. In Geographical Information Systems, Principles and Applications. P.Longley, M. Goodchild, D. Rihn and D. Maguire (eds), J. Wiley & Sons. Vol. 1, pp. 401-411.
11. Fairbairn, D., Parsley, S., 1997, The use of VRML for cartographic presentation. Computers and Geoscinces, Volume 23, No. 4, pp. 475-481.
12. Grygorenko, W., 1970. Grygorenko W. ; *Redakcja i opracowanie map ogólnogeograficznych (Edition and elaboration of general geographical maps*, in Polish), Państwowe Przedsiębiorstwo Wydawnictw Kartograficznych (National Enterprise of Cartographic Publishing Houses), Warszawa.
13. Kardel, I., 2003. Description of the data from hydrological module (available on the SGGW server in Polish – ftp://pinmatra:biebrza@levis.sggw.waw.pl/modelling/hydrology/MiddleBasin/).
14. Jansen, B.J., 1998. The Graphical User Interface: An Introduction. SIGCHI Bulletin. 30 (2), 22-26.
15. Kraak, M.J., Ormeling, F., 1996. *Cartography: visualization of spatial data*. Harlow: Longman.
16. Lammeren, van R., 2003. *Geo-Virtual Reality: an introduction*. In Capita Selecta Geo-Visualization. Centre for Geo-Information. Wageningen University.
17. Lange, E., 1994, *Integration of computerized visual simulation and visual assessment in environmental planning*. Landscape and Urban Planning, 30, 99-112.
18. Lo, C., Yeung, A., 1994. *Visualization if geographic information and generation of information products*. In MacEachren, A.M., Fraser Taylor, D.R. Visualization in modern cartography. Oxford: Pergamon/Elsevier Science.
19. Lovett, A., Sunnenberg, G., Dockerty, T., Appleton, K., 2002, Rural landscape visualization from GIS databases: a comparison of approaches, options and problems. Computers, Environment an Urban Systems, Volume 26, 141-162.
20. *Man and nature at Biebrza; Integration and dissemination of knowledge for sustainable nature managemen*t. Information about the project.
21. Mioduszewski, W., Querner, E., 2002. *Hydrological system analysis in the Valley of Biebrza River*. Wydawnictwo (Publishing House) Imuz, Falenty, Poland.
22. Mioduszewski, W., Szuniewicz, J., Kowalewski, Z., Chrzanowski, S., Slesicka, A., Borowski, J., 1996. *Gospodarka wodna na torfowisku w Basenie Srodkowym Biebrzy (Water management on*

the peat areas in the Middle Basin of Biebrza River). Bibl. Wiad. IMUZ 90, Falenty: Wydawnictwo IMUZ (publishing house: IMUZ).
23. Mioduszewski, W., Wassen, M., 2000. *Some Aspects of water management in the Valley of Biebrza River*. Wydawnictwo (Publishing House) Imuz, Falenty, Poland.
24. Okruszko, H., 1992. *Wetlands of the Biebrza Valley their value and future management*. Warszawa: PAN.
25. Operat generalny, 2001. *Plan ochrony Biebrzanskiego Parku Narodowego (The plan of protection of Biebrza National Park*). Red. Mioduszewski, W., Kajak, A., Gotkiewicz, J., Warszawa (not printed)
26. Pasławski J., 1994. *Mapy topograficzne na naszym rynku (Topographical maps on our bookmarket.* In Polish*)*. Geografia w szkole (Geography at school), Vol. 5, pp. 293-298.
27. Ratajski, L., 1989 2nd edition. *Metodyka kartografii spoleczno-gospodarczej (Methodology of socio-economic cartography*; in Polish). PPWK, Warszawa.
28. Reed, C. (2000), Importance of data integration and rendering to map visualization. GIM International, August, 50-53.
29. Rhind, D., Openshaw, S., 1998. *The analysis of geographical data: data rich, technology adequate, theory poor.* Proceedings, Fourth International Working Conference on Statistical and Scintific Database Management. Berlin, Springer: 427-54.
30. Robinson, A.H., et al., *Elements of cartography*. 6th ed. 1995, New York: John Wiley.
31. Schmidt A., Piorkowski, H., Bartoszuk, H., 2000. *Remote Sensing Techiques and Geographic Information Systems for wetland conservation and management: Monitoring scrub encroachment in Biebrza National Park*. Alterra-report 174, ISSN 1566-7197.
32. Slesicka, A., 2001. *Prognozowanie wplywu przeksztalcen sieci hydrograficznej na zasoby wod podziemnych metoda modelowania matematycznego (Prognosis the influence of the transformation of the hydrographic network on resources of ground waters by the method of the mathematical modeling*). Doctor thesis, Falenty: IMUZ.
33. Slesicka, A., Querner E.P., 1999. *Modeling of groundwater dynamics in Central Biebrza basin*. In: Assessment of the effect of changes in water management within the Central Biebrza Basin. Ed. Mioduszewski W., Wassen M., Falenty/Utrecht, 31-55.
34. Slesicka, A., Querner, E.P., Mioduszewski, W. *The impact of changes in the hydrographic network on river discharge*.
35. Sokolowski, A., 1991. *The protected areas in the Bialystok region (in Polish)*. Bialystok, pp.150.
36. Szulczewska B., 1993. *Planistyczna koncepcja ochrony bagien biebrzanskich (Planning concept of protection of Biebrza peat lands*). Biul. Infor. nr.1/2.
37. Unwin, D., Dykes, J.A., Fisher, P.F., Synes, K., and Wood, J., 1994. "WYSIWYG? Visualization in the spatial sciences", paper presented at AGI Conference, Birmingham, U.K.
38. Wassen, M., *Assessment of the effects of water management measures for restoring drained fens of Biebrza (Poland)*. Universiteit Utrecht, Faculty of Geographical Sciences.
39. Wiatr, A., Wroblewski, W., 2000. *Biebrzanski Park Narodowy (Biebrza National Park)*. Guide book. Multico Oficyna Wydawnicza (Multico Publishing House), Warszawa.
40. Wodtke, M. von. *Make digital models to represent realities*. In Capita Selecta Geo-Visualization. Laboratory of Geo-Information Science and Remote Sensing. Centre for Geo-Information, Wageningen University, 2003.
41. Zyszkowska, W., 1993. *Zlozonosc jako wlasciwosc obrazu kartograficznego i jej wplyw na odbior mapy (Complexity as a property of cartographic representations and its influence on perception of a map.* In Polish with English summary), Polski Przeglad Kartograficzny (Polish Cartographic Review), V.25, pp. 116-125.

Web-sites:

1. *Amatorski wakacyjno-weekendowy przewodnik po Polsce (Amateur holiday-weekend guide of Poland*), 2003. http://www.fuw.edu.pl/aw2p2/szlak/biebrza/biebrza.html
2. http://przewodnik.labnet.pl/index639.html
3. ftp://pinmatra:biebrza@levis.sggw.waw.pl/Public.www/
4. http://www.fes.uwaterloo.ca/crs/geog165/ccom.htm
5. *http://www.reliefshading.com/try_it/index.html*

6. *http://www.maps.ethz.ch/Imhof21engl.html*
7. http://www.wageningen.interstad.nl/?http://www.wageningen.interstad.nl/pages/plattegrond-wageningen.html
8. http://www.earthetc.com/ecwearth/asps/ecwearth_frame.asp?Image=geodetic/world/landsat742
9. http://www.skylinesoft.com/corporate/technology/technology_home.asp

APPENDIX:

1. Geography of study area

Biebrza region has glacier origin. The primeval valley used by Biebrza River is flat and long for 100 km. Due to meanders and big curves the main riverbed is 160 km long. These properties classify Biebrza as a typical lowland river. It has very small inclinations from 0.06 till 3.33 ‰, which gives the slope of 60 m for whole length of the river (Web-s. 1). The width of the riverbed varies between 10 and 34 m, the depth reaches maximum 2.5 m with average value of 1.8 m. Biebrza river is one of the average size rivers in Poland. The widespread valley is a wetland area with many oxbow lakes. The valley has several natural narrowing which divide it into three separate parts. They are called basins – southern (lower) limited by the narrowing near Osowiec, middle limited by the narrowing near Sztabin and northern (upper) (Wiatr, et al, 2000).

2. Previous activities in Biebrza Valley

For many centuries (from Middle Ages until shortly after Second World War) the land was valued for its good hay-growing meadows. The area was restricted to hunting, pasturage, woodcutting and harvesting of hay and reed. In XIX and XX century there were many hydrological works done for improving agricultural production and transportation of goods from Poland (Augustowski canal). Biebrza River was deepened and partly regulated and other canals were built there. Circulation of water was speeded up altering the structure of the water balance. Waters of the Jegrznia drain rapidly to the Biebrza through the Woznawiejski Canal while waters of the Elk River have been completely taken over by the Rudzki Canal. These projects benefited agriculture but also resulted in adverse changes in the river's hydrological regime. It has caused a substantial reduction, in places, even the discontinuation of spring flooding and the lowering of the groundwater levels (Mioduszewski, 2000). Small ditches and canals speed up the runoff of spring melt water, which previously remained for an extended period on the surface of the terrain (Slesicka et.al).

3. Research provided at Biebrza Valley

In Biebrza Valley there are provided works within the frame of PIN Matra project "MAN AND NATURE AT BIEBRZA. Integration and dissemination of knowledge for sustainable nature management". This project is carried out by two research institutes (Warsaw Agricultural University, the Institute for Land Reclamation and Grassland Farming) in Poland cooperating with Utrecht University and Alterra in The Netherlands and will be implemented by Biebrza National Park in close cooperation with two Polish NGO's: 'WWF-local Biebrza Branch' and 'Workshop of Living Architecture'. The results will be communicated with stakeholders in the area and local and national policy makers (*Man and nature at*

Biebrza). Financial support is given by Dutch Ministry of Agriculture, Nature Management and Fisheries and the Dutch Ministry of Foreign Affairs (MATRA Fund / Programme International Nature Management) PIN-MATRA 2001/039 (Web-s. 3).

The works within the frame of the PIN Matra project concentrated on hydrology are focused in the Middle Basin of Biebrza Valley. For this part of the Valley it is planned to raise the water level in the Woznawiejski Canal by building small dams and weirs and by reducing the flow capacity. Projects of this type have been initiated and a number of low 0.4-0.6 m dams in the canal have been built. Further raising of the weir height should lead to the increase in the flow in the old channel of the Jegrznia River and should reduce the draining impact of the Woznawiejski Canal. The next step should be the reconstruction of the natural hydrographical network by reducing the flow in the Rudzki Canal and directing most of its flow into the Elk channel. Those reconstruction works of the hydrographical network in the Middle Basin will cause the increase of groundwater levels (Slesicka, Querner, 1999; Slesicka, 2001) but it may also have some effect on water discharge in the river.

Questionnaire

Those questions were prepared to check how the presentation is perceived by the users. The presentation with questionnaire were sent to hydrologists from Warsaw Agriculture University and to the coordinator of the project – WWF. Those questions check the opinion of users. They don't examine in deep the all aspects of perception. This work would be too broad for this thesis project.

(English version is below)

- czy zeby zrozumiec, co przedstawia zdjecie lotnicze, czesto korzystales z legendy?

.....

- czy zeby zrozumiec, co przedstawia ortofotomapa, czesto korzystales z legendy?

.....

- czy zeby zrozumiec, co przedstawia zdjecie satelitarne, czesto korzystales z legendy?

.....

- Czy legendy i wyjasnienia w prezentacji sa dla Ciebie zrozumiale?

.....

- Czy jest jasny cel prezentacji?

.....

    - Jesli tak – jaki on jest?

.....

- czy latwo bylo Ci sie orientowac, gdzie sie znajdujesz, poruszajac sie po modelu?

.....

    - Jesli nie – jakiej informacji brakowalo? W jakiej formie powinna byc wlaczona do prezentacji?

.....

- Czy podoba Ci sie sposob przedstawienia zalewow?

.....

  - Jesli nie – jak powinien byc zmieniony?

.....

- Czy dodalbys jakas warstwe tematyczna w celu bardziej zrozumialego przedstawienia zasiegu zalewow?

.....

  - Jesli tak – jaka? Jakbys ja przedstawil (poligony, napisy, itp.)?

.....

- Czy Twoim zdaniem korzystajac z prezentacji, mozna odpowiedziec na pytania dotyczace zasiegu zalewow stawiane przy rozmowach z rolnikami?

.....

  - Jesli nie – jakiej informacji brakuje w prezentacji?

.....

- Czy Twoim zdaniem korzystajac z prezentacji, mozna odpowiedziec na pytania dotyczace zasiegu zalewow stawiane przy rozmowach ze sponsorami projektu?

.....

  - Jesli nie – jakiej informacji brakuje w prezentacji?

.....

- czy myslisz, ze taki rodzaj wizualizacji terenu i przedstawienia danych o zasiegu zalewow moze ulatwic dialog z rolnikami?

.....

- czy myslisz, ze taki rodzaj wizualizacji terenu i przedstawienia danych o zasiegu zalewow moze ulatwic dialog z rolnikami ze sponsorami projektu?

.....

- Czy jest cos, co Ci nie odpowiada w jakis sposob w prezentacji?

.....

  - Jesli tak – co to jest i dlaczego Ci nie odpowiada?

.....

  - Jaki masz pomysl, by to poprawic?

.....

- Co najbardziej Ci sie podoba w prezentacji?

.....

  - Dlaczego?

.....

- czy uwazasz, ze wszystkie okna sa potrzebne do prezentacji?

.....

- Jesli nie – ktore mozna by opuscic?

.....

- Jesli tak – jaka informacje powinno zawierac?

.....

  - Gdzie powinno sie znajdowac?

.....

- Latwo bylo Ci znalezc potrzebna informacje? (skala 0-5, latwo – 0, trudno – 5)

.....

- czy latwo bylo Ci korzystac z zakladki z funkcjami do nawigacji? (skala 0-5, latwo – 0, trudno – 5)

.....

- Czy miales trudnosci w korzystaniu z narzedzi do poruszania sie po modelu (zmiana wysokosci nad terenem, poruszaniem sie w pozadanym kierunku, itp)?

.....

- Jesli tak – z ktorym?

.....

- Czy latwo nauczyc sie uzywac opcji – ukrywania, pokazywania warstw, przenoszenia sie do konkretnego miejsca, itp. (skala 0-5, latwo – 0, trudno – 5)

.....

- Jesli nie – co bylo niejasne? Co powinno byc zmienione?

.....

- czy brakuje jakichs funkcji, ktore bylyby przydatne?

.....

- Jesli tak – jakie bys dodal?

.....

- Czy uwazasz takie przedstawienie terenu za interesujace?

.....

- Czy uwazasz takie przedstawienie terenu za interesujace za atrakcyjne?

.....

Jesli masz jakis komentarz, napisz ponizej

.....

Translation:

PRESENTATION:

Is the presentation understood?

Questions to find out if the representation of the terrain is understood (if creating it in realistic way helps with understanding):

- Did you often use the legend to understand the information on aerial photograph?

.....

- Did you often use the legend to understand the information on orthophotomap?

.....

- Did you often use the legend to understand the information on aerial satellite image?

.....

- Do the legends and other explanations are understood for you?

.....

- Is the aim of the presentation clear for you?

.....

    - If yes – could formulate it?

.....

Is it enough information for good orientation on the model?

- Did you have difficulties with orientation during moving over the terrain model?

.....

    - If yes – which information was missing? In which form it should be included into the presentation?

.....

Is flooding presentation well visualized?

- Do you like the method of flooding representation?

.....

    - If not – how it should be showed?

.....

- Would you add some information layer on the terrain model to make the flood presentation better understood?

.....

    - If yes – what kind it would be? How would you show it (polygons, names, etc.)?

.....

Questions to find out if the representation of the terrain is informative:

- Do you think that using the presentation is possible to answer questions concerning the range of flooding during discussions with farmers?

.....

    - If not – which information is missing?

.....

- Do you think that using the presentation is possible to answer questions concerning the range of flooding during discussions sponsors of the project?

.....

    - If not – which information is missing?

.....

Questions to check if the presentation fulfills the aim:

- Do you think that this way of terrain visualization and presenting the data of flooding range can facilitate the discussions with farmers?

.....

- Do you think that this way of terrain visualization and presenting the data of flooding range can facilitate the discussions with sponsors of the project?

.....

- Is there something, which you don't like in the presentation?

.....

    - If yes – what is that and why you don't like it?

.....

    - How would you improve it?

.....

- What you like the most in the presentation?

.....

    - Why?

.....

INTERFACE:
DESIGN:

- Do you think that all windows are necessary for the presentation?

.....

    - If not – which ones can be skiped?

.....

    - If yes – what information it should contain?

.....

        - Where it should be placed?

.....

Is the structure understood?

- Was it easy for you to find the needed information? (scale is from 0 (easy) to 5 (difficult))

.....

Is it easy to use?

- Was it easy for you to use the tools from navigation panel? (scale is from 0 (easy) to 5 (difficult))

.....

- Did you have difficulties with using the navigation tools (with changing the height over the terrain model, moving in desired direction, etc.)?

.....

- If yes – with which one?

.....

- Was it easy for you to learn how to use options – for hiding/showing the layers, moving to certain place, etc. (scale is from 0 (easy) to 5 (difficult))

.....

- If not – what wasn't clear? What should be changed?

.....

FUNCTIONS:

- Did you miss some functions, which would be useful?

.....

- If yes – which ones you would add?

.....

SUMMARY

- Do you think that this way of representing the terrain is interesting?

.....

- Do you think that this way of representing the terrain is attractive?

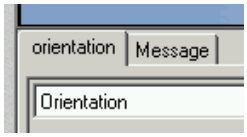
.....

If you have some comments, please write it below

.....

Instruction for the first work with Terra Explorer

This file was sent together with the application to explain the first steps with working with Terra Explorer.

1. You can install the program Terra Explorer using the file 'Setup.exe'
2. You can open the presentation using the file 'Default.fly'
3. In the upper left window you can click off layers, which are not useful at the moment (by default all of them are visible together).
4. The icon  means that the layer is visible
5. The icon  shows earlier prepared view point
6. 

In that window you can choose the orientation maps. Not all of them show the correct position of the camera (in the program one can find only very simple way of

geographic link with the main window). Sometimes when you want to come back to see the orientation map, you have to click on the tab window 'orientation'.

7. The sizes of the left windows are flexible. Only right bottom window has fixed size.
8. There are three tools enabling moving onto the terrain model:  for turning and changing the tilt,  for rotation,  for sliding. You can use the mouse scroll to change the height over the terrain.
9. 

This button opens the navigation panel and there you can set details of your navigation.
10. The presentation shows the possibility of the program, you have the example of 3D trees, houses and linking different type of additional information. That is why e.g. the photographs are don't illustrate the certain terrain or the houses look different than in reality.
11. Some of the information is taken from Internet. If there are some difficulties with connection, you can see the error page.
12. If you have some questions, please ask me – agnieszka.momot@wur.nl

Attached files:

DetailLevels.avi

DetailLevels.fly

Presentation.fly