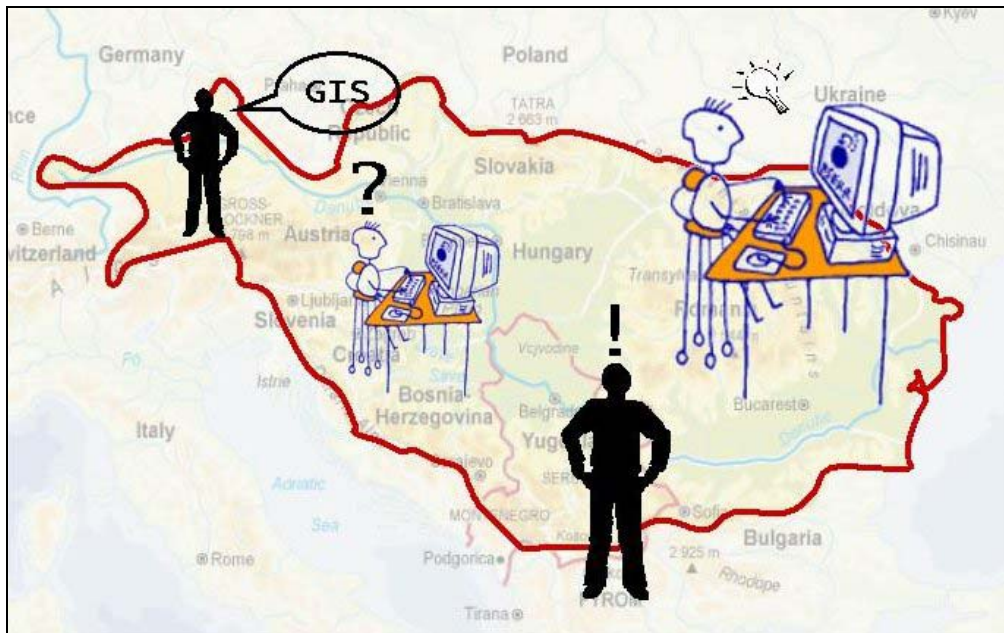


UNDP/GEF Danube Regional Project

Towards a Danube River Basin GIS: Needs Assessment and Conceptual Design for a Danube River Basin GIS System



Prepared by:

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KTH Land and Water
Resources Engineering

UNDP/GEF Danube Regional Project

Strengthening the Implementation Capacities for Nutrient
Reduction and Transboundary Cooperation in the Danube
River Basin

Towards a Danube River Basin GIS: Needs Assessment and Conceptual Design for a Danube River Basin GIS System

September 3, 2003

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PREFACE

During March to July 2003 a user needs assessment and a conceptual design of a Danube River Basin Geographical Information System was conducted, commissioned by the UNDP/GEF Danube Regional Project. The purpose of the assignment was to gain a clearer understanding of the needs and priorities and then subsequent development options, including anticipated costs, as a basis for making decisions about implementation.

It is increasingly being acknowledged that one core tool for river basin management will be a Geographical Information System (GIS). The recent EU Water Framework Directive (WFD) is currently putting strong pressure upon the EU member states and candidate countries in introducing GIS in the implementation of the WFD. The development and maintenance of consistent and harmonised multi-thematic GIS databases for river basins is both an institutional and a technical challenge and especially so in transboundary settings. The results of this report is meant to guide developers and managers through some of those challenges. The user needs assessment for a Danube River Basin GIS was primarily conducted by reviewing various relevant ICPDR and WFD documents and by interviewing selected representatives from the ICPDR secretariat and expert groups and some key actors. Based on identified needs a conceptual design of the Danube River Basin GIS is proposed.

The report was prepared by Fredrik Hannerz and Sindre Langaas at the Department of Land and Waster Resources Engineering, KTH Royal Institute of Technology in Stockholm, Sweden. Any interpretations, recommendations and conclusions in the report are completely those of the authors. Information about costs and labour needs should be interpreted as rough estimates.

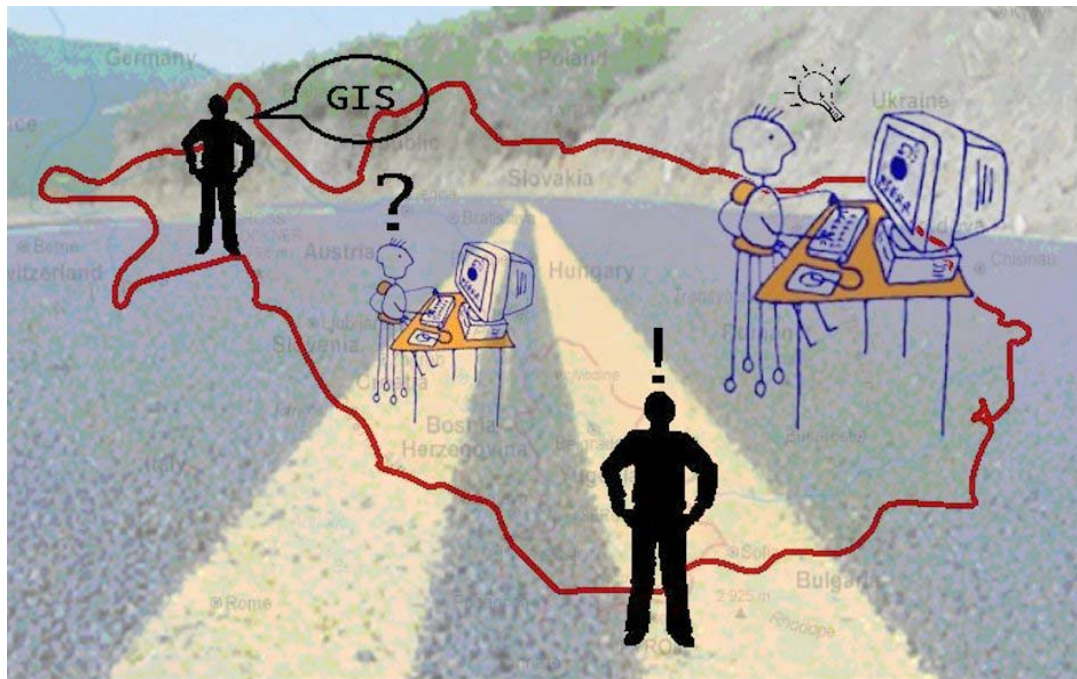
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Abbreviations

EGM	EuroGlobalMap
EMIS	Emission Expert Group
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute Inc.
EU	European Union
FP	Flood Protection
GD	Guidance Document
GEF	Global Environment Facility
GIS	Geographic Information System
GWP	Global Water Partnership
HELCOM	Helsinki Commission
ICPDR	International Commission for the Protection of the Danube River
IMPRESS	IMPact and PRESSure (EG)
IRBM	Integrated River Basin Management
ISO	International Organisation for Standards
JAP	Joint Action Program
JRC	Joint Research Centre
KTH	Royal Institute of Technology; Stockholm
MLIM	Monitoring, Laboratory and Information Management
MONERIS	Model: MODelling of Nutrient Emissions In RIVER Systems
NGO	Non-Governmental Organisation
PS	Permanent Secretariat
RBM	River Basin Management
SWB	Surface Water Body
TNMN	Trans-National Monitoring Network
ToR	Terms of Reference
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
VASAB 2010	Vision & Strategies around the Baltic 2010
WFD	Water Framework Directive
WG	Working Group
WWF	World Wide Fund for nature

1 Executive summary



1.1 Why use GIS for transboundary river basin management?

It is increasingly being acknowledged that one core tool for river basin management will be a Geographical Information System (GIS). What are the general reasons to introduce GIS based information systems into transboundary river basin management?

- Transboundary RBM applications. The GIS enables us to assess past, current and future development in the drainage basin. Better decisions may be made resulting from the review of more alternatives prior to committing to a course of action.
- Legal justifications - Conventions/ Directives. The recent Water Framework Directive requires use of GIS.
- Information Paradigm Shift: From water monitoring towards River Basin. Integrated river basin policy-making, management and scientific assessments on strategic levels call for relevant, yet not too detailed data and information from the entire river basin. The GIS enables us to integrate different information sources and thereby help us to work with both land and water based information. The GIS enables integration of Driving Force - Pressure - State - Impact - Response type information.
- Spatial visualisation helps us to interpret and understand the data.
- The GIS enables storage and dissemination of data and information
- Building common transboundary identity. As GIS is in many aspects visual, it helps us to build an identity by making maps and transboundary analysis.
- Bundled with the Internet, it is the most appropriate environmental information handling, production and dissemination tool for river basins including water bodies. The web-GIS also helps us to reach user groups not normally using GIS.

What are the reasons to develop a GIS for the Danube River Basin in particular?

- WFD implementation. The WFD is currently putting strong pressure upon the EU member states and candidate countries in introducing GIS in the implementation of the WFD. ICPDR is responsible for development of the “roof-report” including required transboundary maps and therefore need at least some GIS functionality to construct such maps. In many other large river basins in Europe (e.g. Rhine, Elbe and Odra River Basins) WFD driven GIS work is currently ahead of Danube in order to reach reporting deadlines in time.
- Integration of existing and coming information sources. Valuable existing databases (e.g. EMIS inventories, TNMN databases etc.) need to be integrated into a common GIS in order to increase usage and make usage more effective.
- The Danube GIS will be the basis for a common data and information base used for various river basin management applications, e.g.
 - Flood forecasting
 - Characterisation
 - Modelling of transport paths of pollutants
 - Source apportionment
 - Optimisation of pollution abatement strategies
 - Scenario based trend analysis
- Mapmaking. Visualisation of spatial information via maps and cartographics is crucial for decision-making, public awareness rising and strategic assessments
- Identity building. The Danube identity will be strengthened by transboundary analysis, decisions and maps

The main tool within ICPDR to achieve good river basin management is the implementation of the Water Framework Directive. The ICPDR thus need to fulfil the requirements from the Directive on GIS related reporting. Even though annex I and annex II of the WFD state that respective maps should only as far as possible be available for introduction into a GIS, it is obvious that the best way to provide most of the requested information will be in the form of GIS layers. This is due to the

fact that most of the data is to be presented in its spatial context and that questions like ‘where are the critical areas?’, ‘how much area is involved?’, or ‘which points are in a designated area?’ can easily be answered when the data are kept in their spatial context and when the background database has the appropriate design (Vogt, 2002).

Following a detailed analysis of the WFD and its annexes, the WFD GIS Guidance Working Group arrived at a list of 12 maps based upon 15 primary GIS layers that should be developed and reported to the European Commission at different occasions until 2009 during the implementation of WFD. The 12 “GIS maps” that have to be reported to the European Commission are:

- River Basin District Overview:
- Competent Authorities
- Surface Water Bodies (SWB) – categories
- Surface Water Bodies (SWB) – types
- Groundwater Bodies
- Monitoring Network for Surface Water Bodies
- Ecological Status and Ecological Potential of Surface Water Bodies
- Chemical Status of Surface Water Bodies
- Groundwater Status
- Groundwater Monitoring Network
- Protected Areas
- Status of Protected Areas

The GIS WG in their guidance document does not address how to use GIS in the analysis of pressures and impacts. This aspect, however, has been dealt with by the WG established to provide guidance on how to carry out pressure and impact analysis, an important aspect in the development of the River Basin Management Plans (IMPRESS WG 2003). On this aspect, however, the WFD is much weaker when it concerns the use of GIS. Thus, the possible use of GIS for such analytical purposes will be left to the current and forthcoming MS to decide upon. Essentially relevant GIS related data and information to support Danube River Basin management could be divided into two groups, which will both be covered in this user needs assessment:

1. GIS data and information required by the WFD (specified in the GIS guidance document)
2. Other GIS data and information supporting activities leading towards the aims of ICPDR (such as pressure and impact analysis)

There is no real alternative to GIS to collect, handle and disseminate the data needed for the reporting obligation. Concerning the first point the question is therefore not whether or not to use GIS to construct the maps or what to include as this is specified in the Directive itself, in annexes and in guidance documents. The question is rather how and when to do it. Deadlines for the reporting of “GIS-maps” start already in 2003 and by the end of 2004 several maps are required on the roof-report level. The integration of data from all member states of the ICPDR is a long lasting process and will require substantial amount time and monetary resources. If ICPDR intend to fulfil the requirements on roof-report level actions must be taken very soon to introduce necessary GIS components to support reporting and map-making.

Implementation success or failure

How can we reach a *successful implementation* of GIS in ICPDR?

- We need to work pragmatically with the implementation. Costs needs to be low, needs must be prioritised and we need to make use of existing data and infrastructure rather than constructing yet another set of measurement programs and improvement of technical infrastructure.
- Kraemer et al (1989) point out that an organisation in a strategic state such as ICPDR a GIS project implementation is most likely to succeed if an organisation wide perspective of the technology and the implication of it is taken into account. For ICPDR that would mean

including all user groups outlined in the user needs assessment and try to look to the needs with a broad user definition rather than looking to the needs from ICPDR only.

- Listen carefully to GIS skilled experts in the organisation

The development and maintenance of consistent and harmonised multi-thematic GIS databases for river basins is both an institutional and a technical challenge. Data defined as those most relevant need to be collected from multiple data providers, such as National Mapping Agencies, Statistical Agencies, Environmental Protection Agencies, the academic community and others. This obviously implies a need for organisational, cultural and technical coordination and harmonisation. Beyond the technical challenges, both institutional and financial arrangements need to be established that ensure an appropriate institutional solution and resolve the resource issues in the short and longer term. If technical and organisational challenges are not given appropriate attention, there is a large risk that GIS work within ICPDR will fail to be successful. We need first to define what a failure is concerning the DRB GIS implementation in general and the GIS database construction in particular. A failure is apparent when:

- The GIS database is being close to a data graveyard type of database with low usage rate. The developed GIS remain an expert tool only.
- The GIS database is being used for WFD reporting only and not as a basis for relevant transboundary analysis

What are the reasons for such a failure?

- Lack of clearly specified and jointly agreed upon aim and objectives concerning purposes, users, contents, and distribution policies
- GIS work focussed on technology while knowledge of existing GIS data sources, spatial information policy, diplomacy, political science and project oriented management skills are given lower priority.
- Far too many water managers and decision-makers involved in River Basin Management leading to:
 - Low awareness in the potential of GIS
 - Low priority of GIS
 - Low willingness to reallocate funding from current environmental information activities focussing upon State and Impact indicators/variables
- Sub-optimal 'design' or 'decision' of the body that will be responsible to carry out the work
- Conflicts between bureaucrats, ivory tower scientists and applied scientists
- Low awareness about how copyright restrictions hinders a widespread use of the GIS database.

1.2 User needs assessment

The user needs assessment for a Danube River Basin GIS, primarily conducted by reviewing various relevant ICPDR and WFD documents and by interviewing selected representatives of various ICPDR groups, the GEF/Danube Project and some other major stakeholders, forms the basis for the conceptual design. Phone interviews revealed that many needs and expectations upon a Danube RB GIS are similar between most user groups. Four common needs were identified from the majority of the groups

- We need maps.
- We need a system on the overview scale.
- We need a centrally initiated and developed GIS database.
- We need public access.

Stated needs correspond to some strategically important considerations for GIS database development. Visual components are important such as paper maps and web mapping. The database should focus on transboundary data and information rather than a detailed composition of national data. The system should be open and transparent. Interviewees further strongly stated the necessity

not to restrict the Danube GIS to WFD reporting but to expand it in order to suit transboundary analysis based on the database.

1.3 A conceptual design

Based on the needs outlined in the user needs assessment and the conclusions we have made concerning the organisation and how GIS might be implemented, we describe a conceptual design of the Danube River Basin GIS. The design is a mixture of technical and organisational considerations ranging from specific to general. We suggest a multi-component development approach to meet the needs of the various users and beneficiaries.

- Component 1: Development of a multi-thematic GIS database covering the Danube River basin. We have further suggested two different ambition levels for this component, termed Option 1 and Option 2.
- Component 2: A flexible 'systems solution' based upon a combination of stand-alone GIS software, Internet MapServer software and Web server software to exploit and disseminate GIS data, derived geographic information products, internally at ICPDR and externally

While interrelated, the suggested components can be looked upon as separate activities that can be considered as externally fundable or stand-alone projects or activities. Of the two proposed components, component 1 will most likely need considerable new financial resources beyond the ordinary ICPDR budget or national resource commitments of the Signatories of the Danube Convention. This component is typically one that can be defined as a time limited project, with reasonable clear inputs, outputs, resource requirements and a well-defined time schedule. Component 2 will also require substantive resource inputs, yet this activity can be seen as future internally funded and operated activities of the ICPDR. Obviously, as will be noted in the more detailed descriptions, each of these components can be further sub-divided into smaller components, activities or projects.

Based upon the consultants own experiences from the Baltic Sea region in developing, using, and disseminating GIS data and derived geographic information products, we have chosen to give most emphasis to the first component, the initial development of a multi-thematic GIS database covering the Danube River basin. This initial GIS database will be the core and heart of any 'Danube GIS', however defined. We make recommendations on the thematic contents of the database, on metadata and on overall technical characteristics and data flow.

1.3.1 Time frame and thematic contents

Based upon the interviews with representatives of the various ICPDR Expert Groups and others, and reviews of WFD Guidance Documents, it appears that the wishes or needs for thematic maps and GIS layers are very comprehensive, possibly reaching beyond 40 layers. Thus, there is a clear need to prioritise within this comprehensive list of needs and wishes. Our proposal is based on three development periods, the short time frame until 2004, the medium time frame until 2006 and the long time frame until 2009. These periods are based on ICPDR relevant WFD reporting dates. Additionally we suggest two options (Table 1) for the contents of the Danube GIS, option 1 being what we consider the minimum requirement for a 'Danube GIS' (what is required by the WFD). Option 2 is an extended GIS database expanding upon option 1 and include other data that will be crucial for effective and transboundary use of the GIS database. A lot more layers could be included in the extended database but time constraints will limit what is possible to achieve.

Table 1. Suggestion for time frames and contents of the Danube GIS

Timeframe	Contents of minimum database (WFD requirements)	Contents of extended database
SHORT – 2004	WFD reporting Dec. 2004 Layers necessary for transboundary harmonisation	
MEDIUM – 2006	WFD reporting Dec. 2006	<ul style="list-style-type: none"> ▪ Most important layers for transboundary analysis e.g. pressure and impact data that will be accessible within two years ▪ A number of cartographic layer necessary for mapmaking ▪ A few additional key needs of some ICPDR Expert Groups.
LONG – 2009	WFD reporting Dec. 2009	<ul style="list-style-type: none"> ▪ Additional layers for more effective transboundary RBM ▪ More GIS data on pressure and impacts ▪ Some additional key needs of some ICPDR Expert Groups.

1.3.2 Metadata, overall technical characteristics and data flow

Concerning metadata, overall technical characteristics and data flow the most important recommendations made were the following:

- It is recommended that the upcoming WFD standard profile of ISO 19115 is being used for metadata.
- ICPDR member states should be responsible for updates of metadata for data originating from national sources while other data must be documented and updated by the constructor of the central database.
- It is recommended to adopt the WFD guidelines on a geodetic framework.
- Concerning exchange format ESRI standards are recommended
- It is recommended to use the data model outlined in the WFD guidance on GIS for WFD reporting data and to develop new common data models for other data

1.3.3 Organisation of the development

The following five alternatives were outlined as possible contractors for the database development:

- A consultant
- A GIS resource person at the ICPDR permanent secretariat
- An institute or authority at member state level
- A research institute

The following was concluded:

- The technical outcome from the five proposals would probably be very similar if adequately coordinated by the GIS Expert Sub Group
- Other factors then merely the contents determine who should be contracted

In our recommendations, we would like to distinguish the period until end of 2004 from the time after. Considering the short time frame until end of 2004 and the amount of work that needs to be done very soon we would recommend ICPDR to contract a consultant/consultancy company to develop the necessary GIS data and maps with a deadline in September 2004. It will be difficult to arrange a more long-term solution before this date and at the same time produce the requested data and maps.

A long-term solution should be developed from 2004 and onwards. ICPDR would then need a solution with more continuity in service than the one of a consultant. We believe that such continuity in service, required skills and suitable professional background will be provided by either a national institute/authority (such as a hydrometeorological institute) or by a research institute.

1.4 GIS hardware and software considerations

In the report on GIS hardware and software considerations we identify existing technical structure concerning GIS hardware and software and try to make some recommendations on those aspects for the Danube River Basin GIS.

It was concluded that:

- The importance of hardware and software are generally overestimated. Such problems are today generally solved at low costs compared to other costs of the information system
- Hardware and software needs will become clear during the implementation phase.
- ESRI standards should be used for communication between users of the Danube RB GIS. Practically shapefiles, coverages, ESRI interchange files, alongside with ESRI grids could be used.

1.5 Evaluation of EuroGlobalMap

Upon request an evaluation of the suitability of EuroGlobalMap (EGM) for the Danube RB GIS was prepared. The results can be summarised as below:

EGM benefits

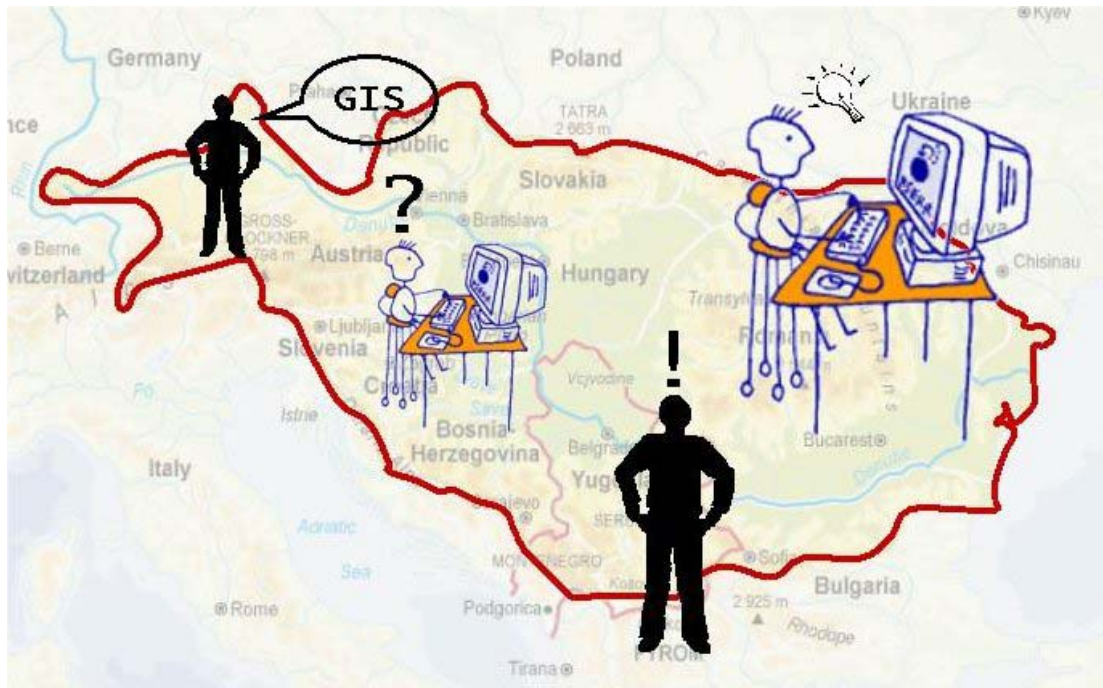
- Include some very important base data
- “Official” data on administrative boundaries
- Include updating

EGM drawbacks

- It is a compilation of national data and therefore not necessarily thematically harmonised
- Only a few of the included GIS layers are relevant for RBM purposes
- It is not a public domain dataset and will thereby have strict user rights. Public dissemination of the data will probably be impossible.

We would like to recommend ICPDR to work further with EGM. It should however be made very clear what actually concerns dissemination of data to third part both via web and other media

2 User Needs Assessment



2.1 User needs assessment introduction

GIS data and derived information have an important role in Integrated River Basin Management. With the ongoing implementation of the Water Framework Directive (WFD) GIS based information will be even more widespread as the requirements on existing and forthcoming EU Member States to report on environmental status in many cases should be done with maps or GIS information.

The main tool within ICPDR to achieve good river basin management is the implementation of the Water Framework Directive in the Danube River Basin. The ICPDR thus need to fulfil the requirements from the Directive on GIS related reporting. Essentially relevant GIS related data and information to support Danube River Basin management could be divided into two groups, which will both be covered in this user needs assessment:

1. GIS data and information required by the WFD
2. Other GIS data and information supporting activities leading towards the aims of ICPDR

Even though only annex I and annex II of the WFD explicitly state that the respective maps should as far as possible be available for introduction into a GIS, it is obvious that the best way to provide most of the requested information will be in the form of GIS layers. This is due to the fact that most of the data is to be presented in its spatial context and that questions like ‘where are the critical areas?’, ‘how much area is involved?’, or ‘which points are in a designated area?’ can easily be answered when the data are kept in their spatial context and when the background database has the appropriate design (Vogt 2002).

There is no real alternative to GIS to collect, handle and disseminate the data needed for the map reporting obligation. Concerning the first point the question is therefore not whether or not to use GIS to construct the maps or what to include as this is specified in the Directive itself, in annexes and in guidance documents. The question is rather how and when to do it. Deadlines for the reporting of “GIS-maps” start already in 2003 and by the end of 2004 several maps are required on the roof-report level. The integration of data from all member states of the ICPDR is a huge work and will requires some substantial amount time and monetary resources. If ICPDR intend to fulfil the requirements on roof-report actions must be taken very soon to introduce necessary GIS components to support reporting and map-making.

Concerning the second group of data and information questions are open and decisions on what, how and when needs to be taken by the ICPDR. Decisions need to be taken on the long-term goal of GIS activities to support other river basin management activities. Any decisions on what, how and when to introduce GIS for river basin management need to be based on user needs for the data and information. In this user needs assessment you will find stated needs for GIS data and derived information. Such needs may or may not coincide with the requirements of the WFD. It may therefore be necessary to expand the GIS activities of ICPDR to other areas than WFD reporting.

Implementation of integrated river basin management needs data, information and an information and communication system. The system includes the institutional set-up and the personal knowledge base required for the system to operate efficiently. Furthermore, it is widely recognized today that participatory approaches in water management yield better overall performance in the long run (e.g. GWP 2000).

A guidance document on the implementation of the GIS elements in the WFD was issued in December 2002. The document specifically outlines the 12 GIS data layers required to produce the 15 “GIS maps” for the mandatory reporting requirements. This guidance document, however, does not provide guidance in how to use GIS for integrated river basin management in a sustainable manner. Public participation in the WFD is a clear objective in the WFD but the discussion concerning GIS data to fill the needs of the public or research community is not covered in this guidance document.

2.1.1 Aims and objectives

The aims and objectives of this assessment are to :

Identify needs of the ICPDR for the development of a Danube GIS (see section 4.1 of GIS Issues paper) in cooperation with the GIS ESG, the ICPDR PS as well as other ICPDR Expert Groups.

- *Identify GIS needs:*
 - *Of the ICPDR for meeting WFD requirements,*
 - *for other RBM tasks,*
 - *for other ICPDR activities,*
- *Consider the suitability of the EGM data.*

2.2 Background

2.2.1 Integrated river basin management and GIS

Integrated river basin policy-making, management and scientific assessments on strategic levels call for relevant, yet not too detailed data and information from the entire river basin. The question of relevancy needs to be considered in light of the policy and management goals and priorities for the specific river basin, as well as related scientific issues. The handling, analysis and presentation of the river basin data and information can be done by means of various types of 'systems' and 'models', ranging from simple map-making tools, via expert and decision support systems to sophisticated integrated and highly distributed predictive scenario models. It is increasingly being acknowledged that a core component in many river basin 'information systems' and 'models' will be a Geographical Information System (GIS). The purposes of the GIS component in the 'systems' and 'models' may vary. It may range from map-making purposes, either stand-alone or as online webGIS services, as a tool for providing input data for various type of scientific models, or as database management tool to handle most or all the environmental data from the river basin, including monitoring data.

Despite the many good application areas (=arguments) for introducing GIS as a core environmental information technology in integrated river basin policy-making and management, its diffusion into this particular domain area has not been as widespread as could possibly be expected. A particular challenge in introducing GIS as an information tool for river basin management is related to the establishment of GIS databases. The development and maintenance of consistent and harmonised multi-thematic GIS databases for river basins is both an institutional and a technical challenge. Data defined as those most relevant need to be collected from multiple data providers, such as National Mapping Agencies, Statistical Agencies, Environmental Protection Agencies, the academic community and others. This obviously implies a need for technical coordination and harmonisation. Beyond the technical challenges, both institutional and financial arrangements need to be established that ensure an appropriate institutional solution and resolve the resource issues in the short and longer term. Another likely explanation to why GIS has not been introduced more widely in river basin management contexts is the lack of GIS usage tradition within those expertise areas that traditionally have dealt with water management. The introduction of the integrated river basin policy-making and management paradigm has implied a shift of emphasis from 'water' to 'river basin'. This will gradually lead to a shift in the focus of tools and expertise towards those more suited to describe and analyse variables and indicators from within the river basin. As any other paradigm shift this may take time. Another reason for the slow progress in introducing GIS in this context has been the absence of legislative obligations to use comprehensive river basin information and/or GIS in most national and international legal instruments that regulate river basin management activities. With the advent of the recent EU WFD this has changed.

2.2.2 EU WFD and GIS

For European countries being EU Member States, Candidate Countries and associated EFTA countries, there is an increasing number of EU Directives that will have a positive impact upon the introduction and diffusion of GIS into the area of national and transboundary integrated river basin management (IRBM). Most of these directives, of which some have entered into force and some are in the process of being developed, proactively try to improve access to, use and re-use of GIS (and

other types of) data and information that have been developed by public authorities. Two existing Directives with these ambitions are:

- The Water Framework Directive (22 December 2000)
- Directive 2003/4/EC on public access to environmental information (28 January 2003)

Additionally, a proposed directive on the re-use and commercial exploitation of public sector information, and another possible future directive that will address the specific key issues related to data access, the creation and maintenance of spatial data should be mentioned.

Among these, in the short and medium term, the most influential legal instrument on the EU level that will influence the use of GIS in integrated river basin management is indisputably the WFD. As the WFD has just started to be implemented across Europe, any analysis at this stage of the impact of the WFD upon GIS usage in IRBM will primarily be based upon review of the WFD text itself, its annexes and the recently developed guidance documents. The latter are legally non-binding documents that have been developed under the common implementation strategy of the European Water Directors. The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive. These guidance documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins.

The WFD is currently putting strong pressure upon the EU member states and candidate countries in introducing GIS in the implementation of the WFD. The guidance document on implementing the GIS Elements of the WFD (Vogt 2002) is tailored towards those preparing the geographic datasets for the preparation of maps required by the Directive, those preparing the final maps as requested under the WFD, and those reporting the maps and GIS layers to the European Commission as required by the WFD. The document focuses upon the thematic content and technical specifications for the GIS layers to be prepared for reporting to the European Commission. It does not, however, address how to use GIS in the analysis of pressures upon freshwater bodies and their likely impacts, neither does it cover how to use GIS in the preparation of river basin management plans nor how to use GIS for public consultation.

Historically, georeferenced data have been reported to the European Commission in the form of analogue maps. With the introduction of GIS, these maps or the underlying GIS layers can now be reported in digital form. In the European context experience with digital reporting is limited. The GIS guidance document, therefore, additionally suggests best practices for the immediate reporting needs of the WFD and at the same time formulates strategies for the long-term needs. The recommendations will have to be tested and further developed over the next few years.

Following a detailed analysis of the WFD and its annexes, the GIS WG arrived at a list of 12 maps based upon 15 primary GIS layers that should be developed and reported to the European Commission at different occasions until 2009 during the implementation of WFD. The 12 “GIS maps” that shall be reported to the European Commission are:

- | | |
|---|--|
| ▪ River Basin District Overview: | ▪ Ecological Status and Ecological Potential of Surface Water Bodies |
| ▪ Competent Authorities | ▪ Chemical Status of Surface Water Bodies |
| ▪ Surface Water Bodies (SWB) – categories | ▪ Groundwater Status |
| ▪ Surface Water Bodies (SWB) – types | ▪ Groundwater Monitoring Network |
| ▪ Groundwater Bodies | ▪ Protected Areas |
| ▪ Monitoring Network for Surface Water Bodies | ▪ Status of Protected Areas |

The GIS WG in their guidance document does not address how to use GIS in the analysis of pressures and impacts. This aspect, however, has been dealt with by the WG established to provide guidance on how to carry out pressure and impact analysis, an important aspect in the development of the River Basin Management Plans (IMPRESS WG 2003). On this aspect, however, the WFD is much weaker when it concerns the use of GIS. While the WG IMPRESS has given strong emphasis in their

guidance document to the benefits in using GIS based tools and models in the carrying out an river basin based pressure and impact analysis, and also provides a number of best practice examples on how this can be carried out, there are no mandatory obligations upon Member States (MS) to use GIS tools for such purposes. Thus, the possible use of GIS for such analytical purposes will be left to the current and forthcoming MS to decide upon.

It is also clear that any MS implementing the WFD could well improve public participation in the elaboration of the River Basin Management Plan by providing open Internet access to the primary GIS data, derived geographic information products, such as ready-made digital maps and statistical tables, and interactive webGIS. The guidance document on public participation explicitly describes this interactive WebGIS as a useful technique in public participation in particular with respect to public consultation and outreach purposes, but also in conjunction with possibilities for establishing interactive dialogues (Public Participation WG 2002).

A quite substantial fraction of the River Basin Districts (RBD) currently being designated by the current and forthcoming MS will be of transboundary nature. In these cases the requirements upon WFD implementation are relaxed relative to the pure national RBDs. This also concerns the use of GIS even for the mandatory reporting requirements. Still, the larger European transboundary rivers with mature International River Commissions - Oder, Elbe, Rhine and Danube - have strong ambitions to develop transboundary multi-thematic GIS databases to meet the demands of the WFD and have already started work in this direction (European Commission 2002). When it concerns most other transboundary river basin districts without existing or feeble formal regimes and management structures, the implementation of GIS has weaker prospects. This is in particular the case for transboundary river basins districts with one or more riparian states being neither current nor forthcoming MS and thus without strong incentives to comply with the requirements of the WFD.

2.3 Needs Assessment methodology

2.3.1 Introduction

A needs assessment:

- can be defined as a process for identifying the knowledge and skills necessary for achieving organizational (e.g., departmental) goals (Brinkerhoff & Gill, 1994).
- is a systematic set of procedures undertaken for the purpose of setting priorities and making decisions about program or organizational improvement and allocation of resources. The priorities are based on identified needs (Witkin & Altschuld, 1995).
- is a process for pinpointing reasons for gaps in performance or a method for identifying new and future performance needs (Gupta, 1999).

Needs assessments can be carried out with various approaches and should of course be adjusted depending on the information needs analysed and the structure of the body where needs are assessed.

2.3.2 Approach

The needs were primarily assessed by reading written sources and through semi-structured interviews of key informants in various ICPDR groups. For resource reasons, the interviews were conducted as phone interviews. Additionally some Best Practice examples of catchment based GIS on the Internet were considered.

2.3.2.1 Review of documents

A lot of documents possibly related to GIS user needs were examined. Roughly these documents can be divided into ICPDR related documents, Water Framework Directive Guidance documents and other documents.

ICPDR documents

Roughly the following documents related to ICPDR were scrutinized with respect to potential GIS data and information needs:

- Convention text

- Documents related to the ICPDR expert groups (ToRs, meeting documents, presentations) and in particular the documents related to the River Basin Management Expert Group.
- TNMN yearbooks, Joint Danube Survey reports, Danube Pollution Reduction Programme reports, Danube watch, ICPDR annual reports
- A small ICPDR library search was also conducted in order to screen documents not available via the DANUBIS system.

WFD Guidance documents

All the relevant guidance documents for the Water Framework Directive implementation were scanned through with the aim to extract anything of relevance for GIS and river basin information systems. The guidance document on GIS components was naturally highly relevant but guidance on pressure and impact analysis and guidance on public participation were found to be of high importance as well. All guidance documents can be found at the WFD part of CIRCA:

<http://forum.europa.eu.int/Public/irc/env/wfd/home>

Other documents

A lot of other information was read through

- Relevant research papers
- Presentations on conferences and meetings related to the management of the Danube drainage basin.
- Recent literature on WFD implementation (e.g. Chave 2002)
- Document stating user needs from similar regions.

2.3.2.2 Semi-structured phone interviews

A total of 14 persons inside and outside the ICPDR organisation were interviewed regarding the needs for GIS data, derived information products, information systems solutions and potential training needs as seen from their perspectives as representatives of various groups. The interviewees were informed about the interview shortly on beforehand via e-mail, including also following additional discussion material:

- Letter of introduction (Appendix 1)
- Interview questions (Appendix 2)
- A proposed list of GIS layers to include in a Danube GIS

A list of interviewees can be found in Appendix 3. The results from the interviews are structured according to the group the interviewed person represented. There is currently a separate training needs assessment being conducted by a consultant to ICPDR. Training needs will therefore not be given priority in this assessment. However, in cases where important views on specific GIS training needs were expressed these will be mentioned.

2.3.3 Needs for whom?

In this needs assessment the user of information is placed in focus while the type of requested information is subordinated. The reason for this is that the character of user and the group she/he represents to a very high degree determine what information is requested, both content and format-wise. It is for example not very likely that a strategic level decision making group would need monthly discharge and nutrient fluxes data nor is it plausible that a research group modelling the extent of Danubian flooding and floodplains would need overview maps on socio-economic parameters to fulfil their work. In that sense this needs assessment is user oriented, rather than object oriented.

In identifying users, one may use a narrow, exclusive user definition or a broad, non-exclusionary one. The narrow would include internal ICPDR users in Expert Groups, Expert Sub Groups and the permanent secretariat while the broad definition would also include all other stakeholders and interested parties that share the aims and objectives of the ICPDR, e.g. knowledge-makers (Danube science community) future-makers (Danube school-pupils) and others, e.g. UNDP/GEF. The use of a

narrow or broad definition makes a big difference during the implementation stage of the information service. If the narrow definition is used there is no need for public databases and the need for web-GIS services would be low. If, on the other hand, the broad definition is used, questions concerning dissemination of information and choices between stand alone GIS and web-GIS becomes more interesting, as well as issues related to copy-rights of the GIS database and derived information.

Other identified users are all outside the strategic "decision-maker" level. They are composed of various NGOs, scientists, people in the educational sector, other stakeholders and media.

2.3.3.1 ICPDR

Primarily the needs expressed by ICPDR expert groups are examined and with a special focus on the River Basin Management Expert Group. The needs expressed by other Expert Groups and Expert Sub-groups are also considered but then more briefly.

2.3.3.2 Other actors sharing the visions of ICPDR

Beyond the ICPDR expert groups there are several non-governmental organisations in the Danube drainage basin that are involved in the promotion of sustainable environmental management of the region. These organisations help to raise the public awareness of the environmental questions and help rising concerns of the public up to a higher level in the decision making processes. Examples of important NGOs in the Danube river basin are WWF and Danube Environmental Forum¹

Many international research programs deal with the environment and management of the Danube river basin. The research community plays an active role in producing background facts for development and decision-making. In order to do this they have a large need for reliable and updated GIS type information. Current there is a major 5th Framework EU RTD project, Danubs, which work with GIS integrated tools and have large need for GIS formatted environmental information. The Danube project is therefore given the role to represent the needs from the science community.

Information needs from UNDP/GEF are dealt with in a separate section.

2.3.4 Needs for what?

Different stakeholders need information for various reasons:

- For 'information for decision-making, priority setting and awareness building', e.g. for making a best possible RBM
- For 'doing a task', e.g. reporting to EU
- For 'designing a system', e.g. a (so-called) GIS
- For 'achieving the aim and objectives of the ICPDR'

For every user group defined in the previous section ("Needs for whom?") we tried to identify possible information needs through available sources as listed in section ("Approach").

GIS data and derived information have varying usability for the different user groups. Some users are able/have time/otherwise want to use the actual GIS data. Others may need readymade maps and cartographics for use in overview scale as well as larger scale applications. Some envisage that their information needs are dynamic and will vary over time. These may be in need for a systems solution.

2.3.4.1 Information & data

The data in the GIS database and the information derived from



Figure 1. Nice looking and informative maps can be downloaded at the Baltic Sea Region GIS site.

1 Danube Environmental Forum - <http://www.de-forum.org/en-home.html>

the database is not the same thing. Information is generally more aggregated and simplified and thereby more suited for decision-making and awareness rising. Information derived from the database should be made available on different levels of aggregation depending on the usage of the information. The information is the link between the professional part of the river basin information system and the non-professionals. The importance of comprehensive and easily accessible information products, in support of integrated river basin management, derived from the GIS data can therefore hardly be overestimated. The information and data consists of:

- **GIS data.** A database is the core of any GIS; the data contained constitute the base for information derivation. The data may be detailed or not depending on the scale and content and will thereby serves different needs.
- **Maps and cartographics** are ready-made products showing the geographical distribution of various features often used for overview purposes rather than analytic purposes.
- **Statistics** based on the GIS data can be derived with simple or sophisticated GIS methods. They can be made available in spreadsheet format, as GIS data attributes or in common text document depending on the preferences of the user. For some users ready-made statistical tables turn out very useful. Useful statistics can answer questions like: How many people live in Sava River catchment, How many potential risk spots do we have along river X, how large proportion of diffuse nutrient leakage into the Danube come from Austria, Hungary or Croatia?

2.3.4.2 Case study: Baltic GIS

Initially, the Baltic Sea Region GIS database (www.grida.no/baltic, Figure 2) was developed within the context of an EU environmental research project 1993-94. The original purposes were scientific and addressed the issue of sources of nutrient loads to the Baltic Sea. At the onset of the project period, it was decided to make the GIS database publicly available after the project had ended.

Objectives of the project were

- to develop a multi-thematic and consistent GIS database focussing on nutrient loads reduction and
- to derive information products, such as ready-made maps in various graphics formats, statistics and documentation, readily accessible to various user categories (Figure 1)

These engagements were driven by a strong recognition of the importance of making available seamless multi-thematic GIS data for analysis, assessment and map-making of a transboundary region with joint environmental problems. As such, a database of this kind could be considered a regional information infrastructure.

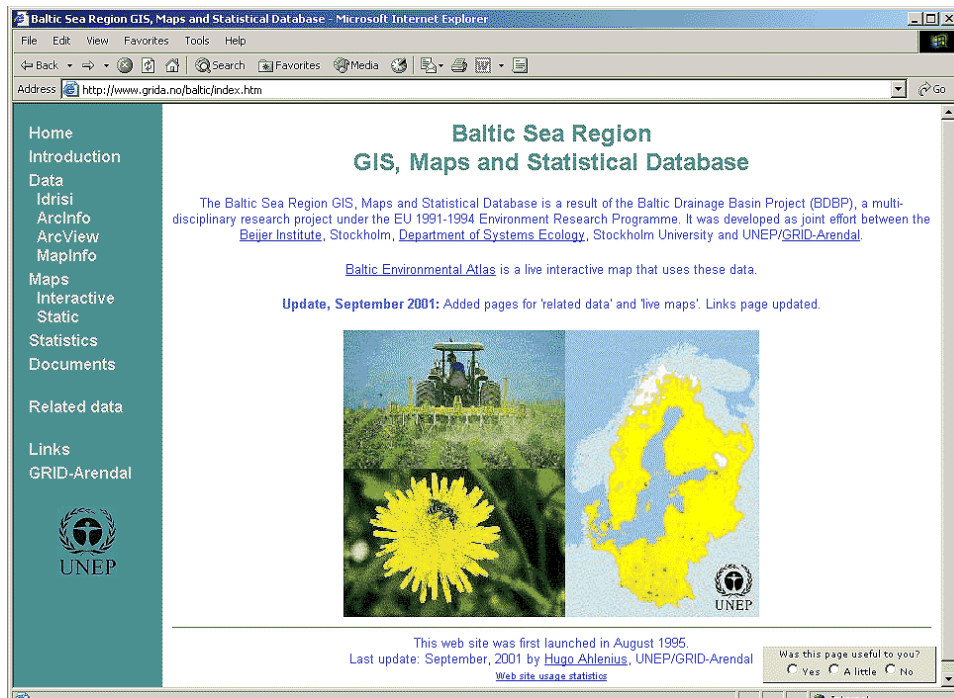


Figure 2 Front page of the Baltic Sea Region GIS site (www.grida.no/baltic). To the left there is a menu containing data, maps, statistics and documents display and download possibilities. Links are leading to among other sites the interactive Web GIS: Baltic Environment atlas.

Results and impact

- Better availability of consistent, seamless spatial information (GIS data in several formats, cartographics in several formats, statistics in several formats) on land cover, population, drainage basins, administrative units, etc., on the Baltic Sea region.
- Better institutional co-operation among the partners in the EU project.

Dissemination to and adoption/use by users

- The 'harder' data, notably the GIS data, have been used extensively by the environmental scientific community in various projects.
- The cartographics and statistics have been used by all sorts of user categories, ranging from school pupils to scientists.
- Additionally, feedback have been received from the intergovernmental bodies and initiatives, HELCOM, Baltic 21 and VASAB 2010, that all have used different types of information products for various purposes.
- The web site has been looked upon as a 'best case' model by UNEP, EEA, US EPA and others.
- The web site was announced widely in several mailing lists, magazines, newsletters, search engines, web directories, both at the launch in August 1995 and following new additions and changes (Figure 3). The number of external web sites linking to the site is, according to AltaVista, about 350.

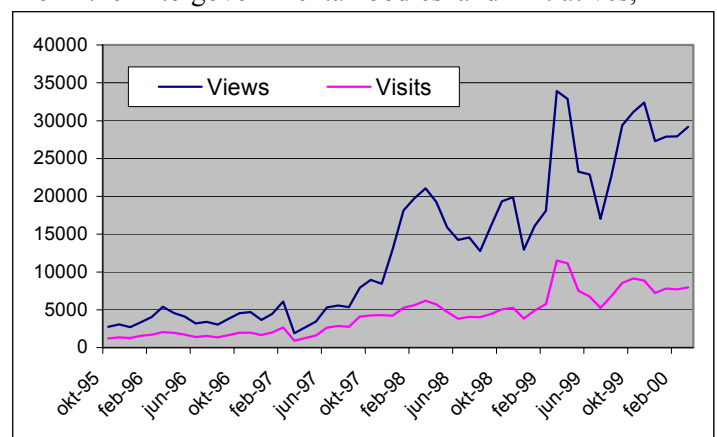


Figure 3. Total number of visits and views, respectively, per month for the period Oct 95 - Mar 00 (incl. humans & robots).

Case study conclusions

The project started out as a primarily a scientific undertaking. The subsequent public

dissemination of the resulting GIS data and associated derived information products using the Internet has proven to be a very successful undertaking. The wide range of types and formats of data and information products offered makes the information useable to most user categories.

2.3.4.3 Information systems

Some users have preferences regarding not only the contents of the information system but also concerning the structure of it. Technically the GIS can be based on a stand-alone structure or on some kind of Web-GIS solution enabling remote access.

Stand-alone GIS

The stand-alone GIS is the classic technical GIS solution. GIS software such as MapInfo, ArcGIS and IDRISI (see hardware and software considerations chapter) are installed locally on a computer and used for various purposes by the GIS expert. There are small possibilities for non-experts to make use of the data and to derive information. However, if available to the user the stand-alone GIS offer large analysis capacity, which cannot be compared to the much smaller functionality offered by the web-GIS.

WebGIS

Web GIS services are becoming increasingly popular as the GIS and Internet technology advances. It provides the non-GIS experts with an (hopefully) easily understandable interface to the GIS data. It can be used for simple map making and for overview purposes but gives very little opportunities for actual analysis of the GIS data.

More advanced types of Web-GIS such as WasserBLICK², a German data and communication platform allow up- and downloading of data as well as data display. Such a service offers unique possibilities for sharing of uploaded data. It requires a strong centralised organisation for setting of data exchange formats, contents etc.

Institutional solution

The importance of a good institutional set-up in a well working information system cannot be overestimated. From an institutional point of view the GIS development can be either centralised or decentralised. The centralised approach is built up around one institution with GIS skills coordinating all data gathering, updating, dissemination etc. While in the decentralised approach regional producers of data add their part of the data to the database. In the case of Danube the decentralised approach would build on national institutions contribution to the Danube wide GIS theme with the national part of the drainage basin. A drawback with this approach is the varying data quality and data content in the different regions. The region wide database will be compiled by data with varying reliability and level of detail. Positive is that national institutions probably need to have up to date databases for administration of their resources on national level. The decentralised way of working with databases therefore probably gives the database a more frequent updating.

GIS Training

Any more advanced use of GIS data and GIS require training. Available GIS software on the market today are often fairly easily used but very soon even users requesting simple GIS services run into problems if adequate training in GIS basics are not facilitated. GIS training can be based on literature review, on-line courses³ or regular GIS courses given by business companies or at universities. For the Danube GIS matters concerning the transboundary nature of the GIS is of high importance to agree upon among users. Data models, transboundary harmonisation, metadata standards and data communication procedures are important topics for GIS training.

² Wasserblick - <http://www.wasserblick.net/>

³ Examples of on-line courses can be found at: <http://campus.esri.com>

2.3.4.4 Case study: Chesapeake bay programme web

Chesapeake bay programme web⁴ is an interactive web site with environmental information on the catchment scale (Figure 4). It is bundled with web-GIS services for display of raster and vector based GIS data. It is highly relevant to consider in the light of the development of a Danube GIS as it represents a nice example of an information product with high impact potential. The reason for this high potential is the user friendliness of the site even though it contains a huge amount of information. Chesapeake bay resembles Baltic GIS in that it tries to reach many various user groups. There is information for all different user categories in a various formats. It does allow the user to download base data, access information about ongoing activities, background information on catchment and sub catchment level. Graphics are very appealing. One part of Chesapeake Bay net is the “watershed profiles”. Here the user can zoom in on catchments, view current and past pollution trend, see statistics on land use fertiliser consumption, nutrient transport etc. One can also compare different catchment with each other. Watershed Profiles assembles maps, charts and information that portray the environmental condition of Chesapeake Bay watersheds.

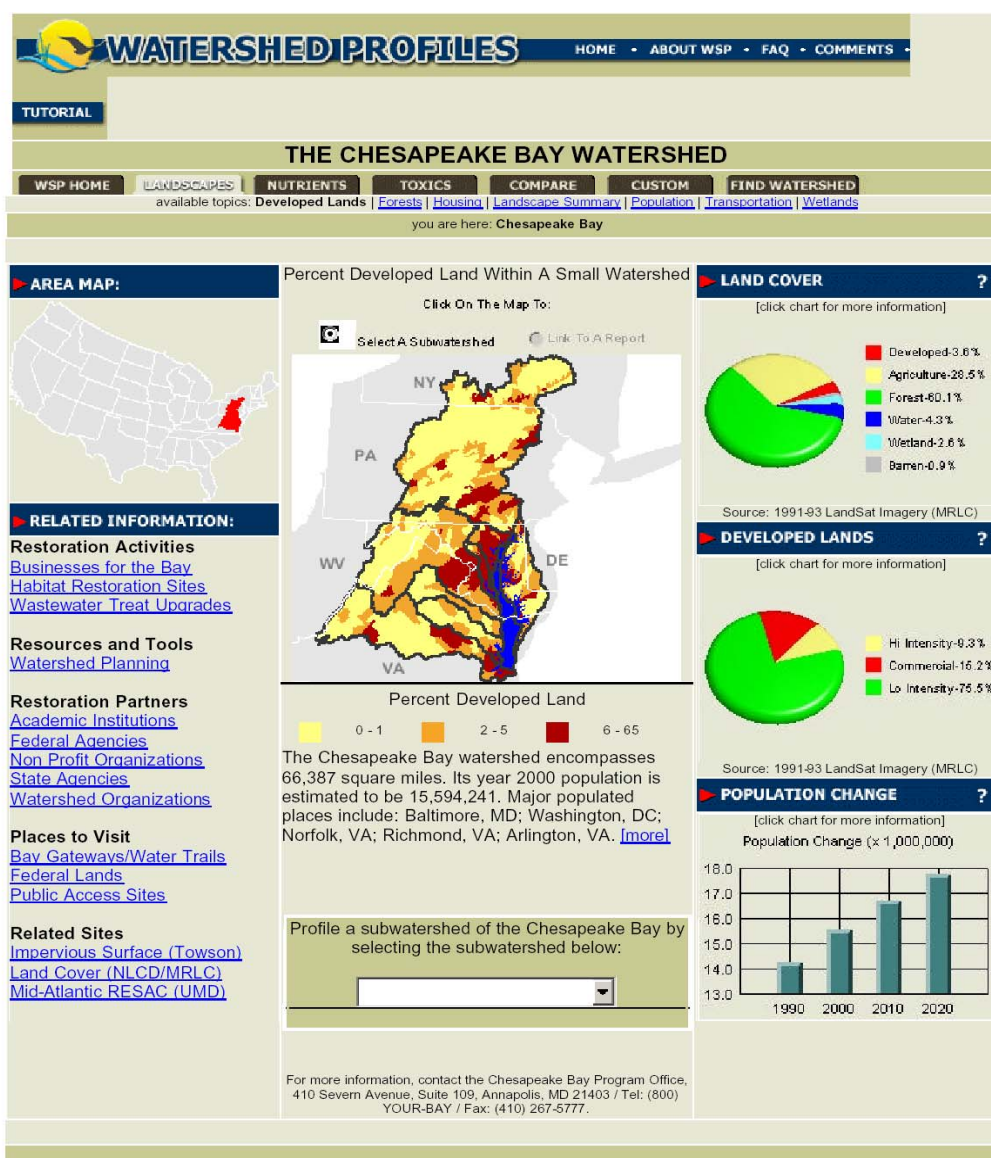


Figure 4. Watershed Profiles. The internet application operates at a variety of scales from the entire 64,000 square mile Chesapeake Bay watershed to small tributary watersheds. Information on landscape

⁴ Chesapeake bay programme web - <http://www.chesapeakebay.net>

changes, Bay Program activities, other organization activities, and places to visit are some of the information displayed in easy to read charts, maps, and tables

2.4 User categories and their needs

2.4.1 ICPDR

2.4.1.1 Situational analysis

A situational analysis is an important step to understand the organisation where a GIS or other types of technology are being introduced. The analysis is a way of describing the organisation and a help to understand the present stage of it. The basis is an analysis of technology maturity and organisational structure that is important for GIS implementation. The analysis is used for the subsequent implementation planning and conceptual design. The situational analysis framework that will be used here is described in Huxhold and Levinson (1995) "Managing Geographical information systems projects". It is designed to uncover "soft" and "hard" aspects of the organisation's makeup relevant for making decisions on how to implement GIS in that particular organisation. It includes a brief analysis of eight topics; fundamentals of the organisation, management philosophy and style, the culture or cultures of the organisation, driving force for GIS, technology maturity, available resources, the complexity of business functions of the organisation and implementation success risk/uncertainty. Below is an analysis of the organisational context into which the Danube River Basin GIS would be introduced. The organisation in this case is ICPDR in a broad meaning, including cooperative bodies on member state level (but not research institutes, NGOs and the public). The point of making this analysis is to form the basis on which recommendations of implementation strategy and contents of the Danube River Basin GIS is made.

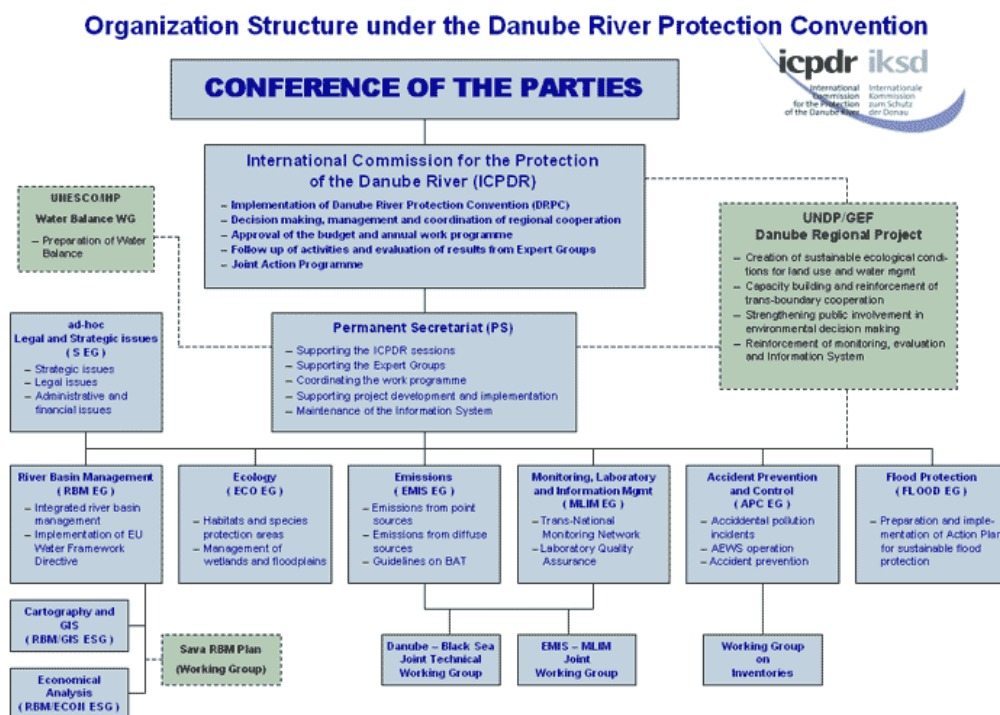


Figure 5. Organization structure under the Danube River Protection Convention

Fundamentals of the organisation

- ICPDR is a transboundary organisation composed of member state representatives and a permanent secretariat.
- The ICPDR operational work is to a large degree conducted by members of several Expert Groups.

- It is working on a high level in society and focuses on strategic and effective means for river basin management.
- The result of ICPDR to a large degree depend on non binding and voluntary contributions from member countries.

Management philosophy and style

- The degree of delegation is high.
- Personal contributions are crucial due to few forcing regulations.

The culture or cultures of the organisation (political and technical)

- Many different cultures are present in the organisation due to the specific and large geographical area covered, due to the multi disciplinary focus and working methods and due to the multi level societal relevance of organisation outcomes.

Driving force for GIS

- Requirements of the EU Water Framework Directive
- A strong will from professionals within the organisation to promote GIS as an effective tool for river basin management

Technology maturity

- The technological maturity is generally high, there exists an advanced information service already (DANUBIS) used by many professionals cooperating with ICPDR but few outside the organisation.
- IT infrastructure is strong in some parts of the region but weaker in others

Available resources

- Monetary resources: there is a low will to finance resource intensive technology and personnel beyond the already existing financial commitments of the secretariat.
- Human resources: Relevant human resources are abundant in the organisation, primarily represented by the various experts being members of the Expert Groups, but they are available on a “voluntary” basis.

The complexity of business functions of the organisation

- The complexity is high and so is the fraction well educated professionals.

Success or failure within the organisation?

How can one reach a *successful implementation* of GIS in ICPDR?

- We need to work pragmatically with the implementation. Costs needs to be low, needs must be prioritised and we need to make use of existing data and infrastructure rather than constructing yet another set of measurement programs and improvement of technical infrastructure.
- Kraemer et al (1989) point out that an organisation in a strategic state such as ICPDR a GIS project implementation is most likely to succeed if an organisation wide perspective of the technology and the implication of it is taken into account. For ICPDR that would mean including all user groups outlined in the user needs assessment and try to look to the needs with a broad user definition rather than looking to the needs from ICPDR only.

Implementation of GIS within ICPDR may well fail if some important aspects are not considered. We need first to define what a failure is concerning the DRB GIS implementation in general and the GIS database construction in particular. A failure is apparent when:

- The GIS database is being close to a data graveyard type of database with low usage rate. The developed GIS remain an expert tool only.
- The GIS database is being used for WFD reporting only and not as a basis for relevant transboundary analysis

What are the reasons for such a failure?

- Lack of clearly specified and jointly agreed upon aim and objectives concerning purposes, users, contents, and distribution policies
- Sub-optimal ‘design’ or ‘decision’ of the body that will be responsible to carry out the work
- Far too many water managers and decision-makers involved in River Basin Management leading to:
 - Low awareness in the potential of GIS
 - Low priority of GIS
 - Low willingness to reallocate funding from current environmental information activities focussing upon State and Impact indicators/variables
- Conflicts between bureaucrats, ivory tower scientists and applied scientists
- GIS work focussed on technology while knowledge of existing GIS data sources, spatial information policy, diplomacy, political science and project oriented management skills are given lower priority.
- Copyright restrictions hindering a wide use of the GIS database.

2.4.1.2 Permanent Secretariat

The permanent secretariat of ICPDR has twelve members. Members have an overview of the organisation and work with the transboundary matters of ICPDR. Their tasks are to support the ICPDR sessions, Expert Groups and project development and implementation, coordinate the work programme and maintain the ICPDR information system.

Phone interview with Ms. Ms. Ursula Schmedtje, Technical Expert on River Basin Management at the ICPDR permanent secretariat, Mr. Károly Futaki, Information Management & Admin Officer and Ms. Mihaela Popovici, Technical Expert on Water Management (Pollution Control)

Concerning *GIS data and information* needs, all interviewees stated that the Danube GIS should not be a tool for WFD reporting only but should be extended to include other relevant data and information. Map-making was seen as a basic feature but more important was transboundary analysis. Mentioned and prioritised applications mentioned were: planning of action programs, integration of existing databases, links to other databases, forecasting and vulnerability mapping.

Concerning *systems development* Mr. Futaki suggested that the development should be outsourced but that the hardware probably need to be placed at the ICPDR. It would ensure security of the system and the data. It was stated that the GIS should be finished within a three or four year period.

Public access was said to be of high importance by both Mr. Futaki and Ms. Schmedtje. It was pointed out that public users might not need analytical tools, rather good thematic maps and graphs presenting the problems or results. User friendliness was seen as important.

2.4.1.3 River Basin Management Expert Group (RBM EG)

The needs of this group have been identified through analysis of its terms of reference, other RBM documents, the WFD guidance documents and through phone interviews with Ms. Ursula Schmedtje, Technical Expert on River Basin Management at the ICPDR permanent secretariat and member of the RBM EG, Ms. Visnja Omerbegovic, chairman of the RBM/GIS ESG and Mr. Ulrich Schwartz, technical support to the RBM/GIS ESG.

The RBM EG has a large responsibility within ICPDR to carry out a large part of the work required by the WFD. RBM EG is given the task to develop a concept for reporting and cartography, including a Danube GIS. Responsibilities relevant for GIS usage include:

- identification of the River Danube Basin District
- coordinate the river basin characterisation
- review of human pressures and impacts
- co-ordinate all activities to set up a River Basin Management Plan

- prepare appropriate information for dissemination to interested bodies and the public.

GIS guidance document

The guidance document on implementing the GIS Elements of the WFD (GIS GD) is of high importance for the Danube GIS development. The document is clear in its recommendations and the links to the text in the WFD are comprehensive. It is important to keep in mind that the GIS GD is exclusively focussed towards the reporting requirements. The document specifies what maps and data are required for the reporting obligations in the WFD. It can thus be seen as a first core of a river basin GIS that must be established if their intention is to fulfil the WFD requirements. ICPDR has that intention and the data and maps specified in the GIS guidance document should therefore be taken as a first goal in a short time perspective of the Danube GIS. For river basin management purposes (with GIS implications) beyond the reporting parts it is important to take the other guidance documents into consideration e.g. on pressure and impact analysis and on public participation.

The WFD requires that Member States report a considerable amount of information in the form of maps. There is no real alternative to GIS to collect, handle and disseminate the data needed for the reporting obligation. Concerning the first point the question is therefore not whether or not to use GIS to construct the maps or what to include as this is specified in the Directive itself, in annexes and in guidance documents. The question is rather how and when to do it. Deadlines for the reporting of “GIS-maps” start already in 2003 and by the end of 2004 several maps are required on the roof-report level. For a general overview, the time schedule for reporting Table 2 and 3 specifying contents and reporting date can be used, but for a more detailed overview, the tables in Appendix 2 of the GIS GD should be consulted. In the Appendix all attributes for the required maps are listed along side with definitions of data, scale and reporting dates.

Pressure and impact analysis guidance document

In the guidance document “Guidance for the analysis of Pressures and Impacts in accordance with the Water Framework Directive” (IMPRESS) information needs for pressure and impact analysis are examined. The guidance document indicates what types of data may be useful in the analysis of impacts and pressures, why the data may be useful, and suggests a European-scale data source, if available. Section five provides extensive tables of data and information relevant to carry out the requested analysis in the WFD. It must be stressed that the data are by no means required from member states as is the case in the GIS guidance document but mostly a recommendation to what data and information that may be useful for the analysis work. The guidance document recommends that, where possible, data is collected in digital form and used within a GIS.

Key stakeholders that could be involved in the IMPRESS analysis are in the GD (section 5.1.2) identified as being:

- Experts from Ministries (agriculture, transport, planning, economy)
- Water Service Suppliers, Water using sectors & stakeholders (farmers, industrialists, etc.)
- Environmental NGOs
- Stakeholders/civil society/public
- Researchers/Experts (usually as consultants of the mentioned stakeholders)

Clearly there is a broad definition of who might be providing useful input to the pressure and impact analysis. All these stakeholder groups need to be fed by information for making good and integrated decisions. In fulfilling the WFD there is likely a strong interest from the RBM EG to involve most of these groups in the development of river basin management. The stakeholder groups and the RBM EG would therefore benefit from an information system enabling interaction.

The public participation approach is outlined in the issue paper “Public participation for implementing the Water Framework Directive in the Danube River Basin”. In the paper it is clear that public participation is an important objective of the RBM EG and that it is seen as cost efficient in the long run to work with outreaching activities. Public participation with GIS should therefore be seen as a means for such activities, and a Danube GIS should be amended to suite public participation.

Public participation guidance document

Public outreach is important for the RBM EG in their work towards sustainable management of Danubian waters. The guidance document on public participation aims at assisting competent authorities in the Member States and Accession Countries with the implementation of Article 14 of the Water Framework Directive about Public Participation. The guidance document on actively mentions Web-GIS tools as being one of thirteen most important public participation techniques.

Map Name	Layer Code	Layer Name	Feature Type	Availability and Reporting Dates ¹
1: RBD-Overview				
	SW1	River basin district (RBD)	polygon	12/2003 (RBD) 06/2004 (CEC)
	SW2	River basin, sub-basin	polygon	
	SW3	Main Rivers ²	line	
2: Competent Authorities				
	D7	District of competent authorities	polygon	12/2003 (RBD) 06/2004 (CEC)
3: Surface Water Bodies (SWB) – categories -				
	SW4	Surface water bodies - Rivers - Lakes - Transitional waters - Coastal waters if applicable, indicated as artificial SWB or heavily modified SWB	line polygon polygon	12/2004 (RBD) 12/2009 (CEC)*
4: Surface Water Bodies (SWB) – types -				
	SW4a	Types of Surface Waterbodies	attribute of SW4	12/2004 (RBD) 12/2004 (CEC)* 12/2009 (CEC)*
	D6	Ecoregions	polygon	
5: Groundwater Bodies				
	GW1	Bodies of groundwater	polygon	12/2004 (RBD) 12/2009 (CEC)*
6: Monitoring Network for Surface Water Bodies				
	SW5a	Operational monitoring sites. Inclusive monitoring sites for habitat and species protected areas	point	12/2006 (RBD) 12/2009 (CEC)
	SW5b	Surveillance monitoring sites	point	
	SW5c	Monitoring sites drinking water abstraction points from surface water	point	
	SW5d	Investigative monitoring sites	point	
	SW5e	Reference monitoring sites	point	

(1) RBD: The date when the map or layer needs to be available within the River Basin District.

Map Name	Layer Code	Layer Name	Feature Type	Availability and Reporting Dates ¹
7: Ecological Status and Ecological Potential of Surface Water Bodies				
	SW4b	Ecological status	attribute of SW4	12/2009 (RBD) 12/2009 (CEC)
	SW4c	Ecological potential	attribute of SW4	
	SW4d	Bad status or potential causes by (non-) synthetic pollutants.	attribute of SW4	
8: Chemical Status of Surface Water Bodies				
	SW4e	Chemical status	attribute of SW4	12/2009 (RBD) 12/2009 (CEC)
9: Groundwater Status				
	GW1a	Quantative status of groundwater bodies	attribute of GW1	12/2009 (RBD) 12/2009 (CEC)
	GW1b	Chemical status of groundwater bodies	attribute of GW1	
	GW1c	Pollutant trend	attribute of GW1	
10: Groundwater Monitoring Network				
	GW2a	Groundwater level monitoring network	point	12/2006 (RBD) 12/2009 (CEC)
	GW2b	Operational monitoring network chemical	point	
	GW2c	Surveillance monitoring network chemical	point	
11: Protected Areas				
	PA1	Drinking water protection areas	polygon	12/2004 (RBD) 12/2009 (CEC)
	PA2	Economically significant aquatic species protection areas	polygon	
	PA3	Recreational waters	point	
	PA4	Nutrition-sensitive areas	polygon	
	PA5	Habitat protection areas (FFH)	polygon	
	PA6	Bird protection areas	polygon	
12: Status of Protected Areas				
	PA7	Status of protected areas	attribute of PA1-PA6	12/2009 (RBD) 12/2009 (CEC)

(1) RBD: The date when the map or layer needs to be available within the River Basin District.

CEC: The date when the maps need to be reported to the European Commission. Note: The date of Fredrik Hannerz and Sindre Langaas, KTH Royal Institute of Technology

Phone interviews

Phone interviews were carried out with Ms. Ursula Schmedtje, Technical Expert on River Basin Management at the ICPDR permanent secretariat and member of the RBM EG Ms. Visnja Omerbegovic, chairman of the RBM/GIS ESG and Mr. Ulrich Schwarz, technical support to the RBM/GIS ESG.

Concerning the *final usage* of the GIS database Ms. Omerbegovic and Ms. Schmedtje pointed out that reporting is not the most important. Data analysis such as modelling related to pressure and impact analysis and planning for action programs was said to be more important.

Concerning *public dissemination* of data Ms. Omerbegovic thought that data in a Danube GIS should be publicly available. This opinion was not stressed by Mr. Schwarz who expressed that the question of public accessibility to GIS data is sub-ordinate at the moment. Ms. Schmedtje meant that public access is important but that it might be difficult in the beginning but that with time member states will probably become more positive to open access.

Concerning *web-mapping* approaches (similar to the Wasserblick application) Ms. Omerbegovic was very positive and thought that all stakeholder group would benefit from having that. Mr. Schwarz on the other hand was more doubtful about web mapping as a solution for Danube GIS. He thought that web mapping is too ambitious and not needed now.

Concerning *scale and approach to database construction*, Ms. Omerbegovic and Mr. Schwarz expressed similar opinions. They both thought that a combined approach would be beneficial. Combined here means a combination of a top-down (cut out from Danube, European wide or global data) and a bottom-up (national data) approach. Both expressed the need for data on the overview scale, meaning that very high-resolution data is not important at the moment.

Mr. Schwarz strongly expressed the need for having a *GIS person* only doing GIS work. This person should, be placed at ICPDR or at an institution close to ICPDR capable of carrying out the work. Ms. Schmedtje shared

2.4.1.4 Cartography and Geographical Information Expert Sub-Group of the River Basin Management Expert Group (GIS ESG)

The role of the GIS ESG is to support the implementation of GIS in ICPDR. The group doesn't really have any own needs for GIS analysis but instead a need for information to support the coordination. Such information is e.g. boundaries of administrative regions, crucial for data harmonisation issues. The GIS ESG are responsible for the development of data models transfer of data and metadata and therefore has a large need to a functioning communication model.

2.4.1.5 Economics Expert Sub-Group of the River Basin Management Expert Group

Guidance document

No interview was carried out with members of the ECON ESG. Instead GIS needs were analysed by reading the WFD Guidance document on Economics and the Environment (Wateco WG 2002). In the guidance document the economical elements of the WFD are described in a circular flowchart (Figure 6)

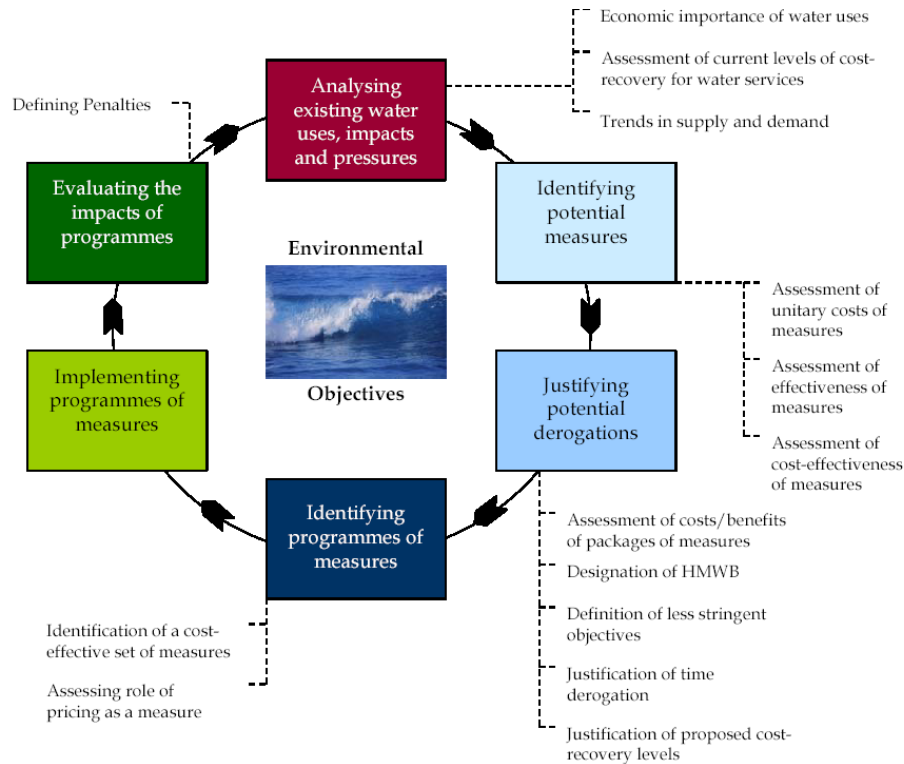


Figure 6. Flowchart showing the work plan of economical work within the WFD

The economical analysis is tightly bundled with the results from other activities such as identification of pressures on water quality, biological biodiversity, hydrological fluxes etc. Nothing is said in the guidance document about the use of GIS or maps other than that the result should be prepared in consistency with the maps prepared for Article 7 (of the WFD). A list should be compiled of economically significant aquatic species as an input to the register of protected areas. As this is one of the “GIS-maps” required by the WFD the ECON ESG have at least some needs for GIS.

As the GD indicates it is important to include not only indicators from natural science in the drainage basin characterisation but also economical variables that will differ from place to place in the drainage basin. Examples of such variables or indicators are GNP, trade balances, income, employment, water supply, water demand, investments in water quality improving measures etc. Such data are very well suited for a GIS system.

2.4.1.6 Case study: MARE NEST decision support system

Cost-effect optimisation of pollution abatement strategies is a large issue in many drainage basins, also in the Danube RB. Pollution abatement options are compared with associated costs for a particular option and with other options to maximise what will yield the best overall result. Via a modelling approach cost optimisation can then be carried out on the catchment scale. One example of such an approach is the MARE NEST decision support system⁵ focusing on cost effective nutrient pollution abatement in the Baltic Sea drainage basin. MARE NEST is described in Wullf et al (2001). The main questions to answer within the decision support systems are:

- How should reductions in nutrient load be allocated between measures and countries in order to minimize total cost?
- How are costs and distribution of payments affected by changes in Baltic Sea targets?
- How would costs and policy instruments change if we, instead of expressing the targets in deterministic terms, formulate probabilistic targets?

⁵ MARE NEST can be found at the MARE research programme web: <http://www.mare.su.se/english/index.html> or <http://data.ecology.su.se/Models/BEDonWeb/next/>

The Danube river basin have many similarities to the Baltic Sea Drainage Basin and questions regarding optimisation of costs for pollution abatements are probably very similar in the two regions. GIS based modelling crossing over into economics is an interesting field and could probably be very useful in the Danube River Basin. Regional economical analysis of pollution abatements strategies could be substantially improved with a GIS-integration.

2.4.1.7 Accident Prevention and Control Expert Group

E-mail questionnaire results Mr. Anatoliy Shmurak (Ministry for Environmental Protection and Nuclear Safety, Ukraine), GIS facilitator of the APC Expert Group

Answers from Mr. Shmurak yielded the following conclusions concerning the APC EG:

The APC EG use GIS for creation of thematic maps and analysis of inventory data

The APC EG has needs for *maps and GIS layers* to support their activities, e.g. a network model of Danube basin and a watershed model of Danube basin. That would improve the DBAM (Danube Basin Alarm Model). The DBAM model-system covers the whole river system of the Danube Basin and provides fast information at selected locations and selected time on the simulated characteristics of an accidental polluting spill, like travel time, concentration profile, shape of pollutant plume.

The EG think that parts of the data need to be in the *public domain* but not all. Some of the data will need to be in the internal working area of DANUBIS.

Concerning *scale* the EG would benefit from a database with lower spatial precision but higher degree of harmonisation and more freedom of use.

A *web-GIS* approach where all users have access to a common GIS database via a web interface appeals the group.

Terms of Reference:

One of the objectives of the APC EG is to address the operational, organisational, and development aspects relating to: coordinated, basin-wide communication of alarm/warning and information messages; accident risk assessment, pollution prevention and precautionary control. The work of the AEPWS/EG is expected to result in improved response to emergency situations with potential transboundary effects.

The APC EG has made two inventories for the Danube River Basin:

- Inventory of Potential Accidental Risk Spots
- Inventory of Contaminated Sites

These inventories could be transformed into GIS format and be the basis for risk assessments and scenario based pollution transport modelling hopefully leading to increased understanding of accidental prevention priorities.

The group is acting in a short time scale. If an accident occurs transboundary prognoses and action plans may need to be compiled rapidly. The group could need a lot of map-material to be able to quickly assess potential actions. The group could further develop a GIS based modelling tool for assessment of potential impact areas from accidental risk spots.

2.4.1.8 Ecological Expert Group

Some of the major responsibilities of the Ecological EG are to gather information about protected areas and to disseminate information and support activities concerning conservation, restoration and sustainable management of wetlands, especially floodplains. “GIS –maps” on protected areas required by the WFD and outlined in the GIS guidance document are:

- Drinking water protection areas
- Economically significant aquatic species protection areas
- Recreational waters
- Nutrient-sensitive areas

- Habitat protection areas
- Bird protection areas

This is the minimum requirement of “GIS–map” deliverables from the ECO EG.

Phone interviews with Mr. Ulrich Schwarz, Technical Experts to the Ecological Expert Group and technical support to the RBM/GIS ESG

Concerning scale issues of *GIS data* Mr Schwarz stated the need to data on an overview scale and meant that the ECO EG cannot collect all national data, it must be relevant on the Danube scale. He pointed out that the national level should be separated from the ICPDR activities, concerning WFD the countries will deliver the data to Brussels but ICPDR are not able to involve all that data. Concerning publicity of data Mr. Schwarz expressed a concern about copyright restrictions. He said that the national data providers need to decide if the information can be made available and that ICPDR is not the only owner of the data.

Concerning *systems solution* Mr Schwarz stated the need for a final database and meant that ICPDR should not construct a database where core data changes every year. He pointed out that if changes are to be done to the database they should be of high importance.

2.4.1.9 Emission Expert Group

The overall objective of the EMIS EG is to identify and agree measures that will reduce polluting emissions to the Danube River Basin. Today, the EMIS EG have an emission database of municipal and industrial pollution available via DANUBIS.

Phone interview with Mr. Franz Überwimmer, member of the Emission Expert Group

Mr. Überwimmer said that the EMIS EG made some maps from emission tables in order to *visualise* the sources. He stated that it was very effective and that the EMIS EG had changed their decisions and recommendations due to the maps.

Concerning *GIS derived maps* Mr Überwimmer said that the EMIS EG would like to create maps of:

- 1 Present situation.
- 2 How it could be in the future depending on different decision and scenarios

Mr Überwimmer summarised the *GIS data needs* of the EMIS EG as being more harmonised data on:

- | | |
|---|--|
| ▪ Diffuse pollution | ▪ Cities |
| ▪ Differentiation between background and human impact | ▪ Meteorological data as rainfall, evaporation |
| ▪ Driving forces, pressure and impact | ▪ Animals |
| ▪ Priority substances | ▪ Fertilisers |
| ▪ Common river names | ▪ Pesticides |
| ▪ Land use | ▪ Population |

Concerning *systems solutions and scale* Mr Überwimmer said that the EMIS EG would prefer a centralised approach rather than a national and that this would require a person with GIS skills in order to support the work within the EGs.

2.4.1.10 Flood Protection Expert Group

The Flood Protection EG is a new group and the work plan is still under elaboration. The role and ambitions of the group is therefore still uncertain, so are the needs for GIS related data and information. The major task for the group will be to develop a flood forecasting system and to make recommendation on how to prevent damages from flooding events. The flood forecasting system will build on the GIS-integrated LISFLOOD model that defines a large part of the needs for GIS in the EG today.

Phone interview with Mr. Gabor Balint, member of the Flood Protection EG, chief scientific researcher at Vituki Consult Rt

Concerning *scale* of GIS data Mr. Gabor said that the FP EG needs a scale similar to the GISCO data. That would serve most needs for core data in the EG. For some applications e.g. delineation of floodplains the EG needs more detailed maps. Concerning *systems solutions* Mr Balint stated that the FP EG initially needs a centralised effort that works for the whole basin. Mr. Gabor expressed a fear that the database otherwise will never be finished.

Current GIS data needs in the FP EG are data on:

- Hydrometeorological observation.
- Stream length as a attribute besides geographical coordinate
- Crosssections of river channels
- Flooding areas and potentially flooded areas.
- Flooding monitoring sites.
- Structures alongside with the river/streams (flood embankments, dykes, longitudinal structures)
- Dam constructions.
- Snow coverage and depth
- High-resolution elevation model

Description of LISFLOOD

The flood forecasting system will build upon the LISFLOOD model (De Roo 1999), a distributed and dynamic GIS integrated hydrological routing model. GIS maps are the basis for model calculation (Figure 7) and output is also in form of maps alternatively time series of e.g. runoff and flow accumulation.

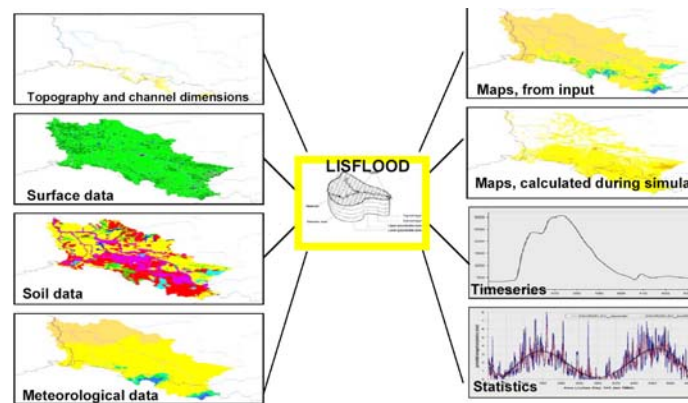


Figure 7. LISFLOOD input and output examples

The flood-forecasting model requires a harmonised multi-layer GIS database covering the whole river basin. Output from the model is partly in GIS format and could therefore easily be added to a Danube GIS as modelled data layer describing some distributed variables. Relevant input datasets is presented in Figure 8. The figure also indicates where the GIS data might be taken from both European wide sources (DEM, Flow network, Land use, Soils) and data from national data providers (on river cross sections, reservoir data, polder data, discharge data and meteorological data).

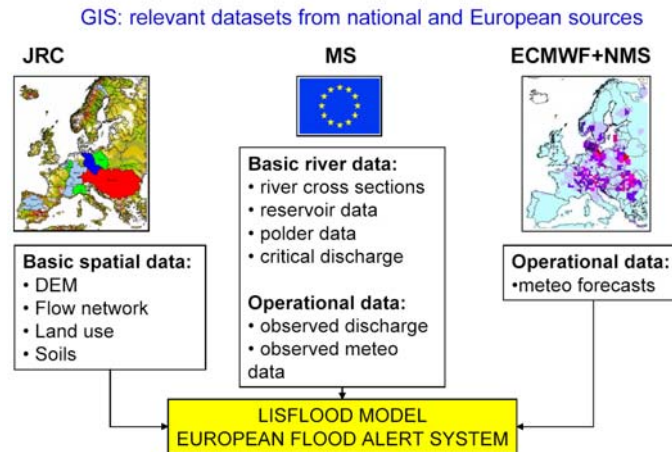


Figure 8. GIS data input to the LISFLOOD model. From Schmuck et al 2002

Other data necessary for LISFLOOD modelling:

- Division Rainfall/Snow
- Interception
- Evapotranspiration
- Leaf drainage
- Snow melt
- Glacier melt
- Soil freezing
- Infiltration
- Vertical soil moisture redistribution
- Sub-surface lateral flow
- Groundwater recharge
- Groundwater flow
- Infiltration excess overland flow
- Saturation excess overland flow
- River channel flow (kinematic and dynamic wave)
- Reservoir operations
- Retention storage

For carrying out the flood-forecasting modelling the FP EG and JRC will jointly need to construct a GIS database with a considerable amount of data for the entire drainage basin. The data and model results from this modelling would probably be very useful to include in a Danube GIS for other purposes outside the group as well.

2.4.1.11 Monitoring, Laboratory and Information Management Expert Group

Today, the EG have three databases (accessible with DANUBIS): the recent TNMN database, the older Bucharest Declaration Database and the database from the Joint Danube Survey. MLIM EG communicates information via the annual reports (year book) and via DANUBIS. The yearbooks contain a small number of maps constructed with GIS. "GIS-maps" required by the WFD, under the responsibility of the MLIM EG are, as stated by the GIS guidance document:

Surface waters

- Operational monitoring sites
- Surveillance monitoring sites
- Monitoring sites drinking water abstraction points
- Investigative monitoring sites
- Reference monitoring sites

Ground waters

- Groundwater level monitoring network
- Operational monitoring network chemical
- Surveillance monitoring network chemical

The MLIM EG with its current databases seems to have covered much of the required monitoring data concerning surface waters but not ground waters.

Mail answer by Ms. Juliana Adamkova, member of the MLIM EG, Slovak Hydrometeorological Institute

Concerning *GIS data, map and information* material the EG would prefer a GIS based system as it would ease visualisation of monitoring data and enhance map-making.

Concerning *public dissemination and systems solutions* Ms Adamkova expressed her opinion that all data should and could be publicly accessible and that a web-based GIS system where data could be uploaded, downloaded and distributed would be beneficial to the group.

Concerning *needs for additional GIS data* the MLIM group would need:

- Data on “pressures” put on surface water status for interpretation of monitoring data.
- Data on sources of pollution in river basin – both point and diffuse.
- Data on morphological alterations and alterations of hydrological regime

2.4.2 UNDP/GEF

UNDP/GEF has a strong interest in transboundary processes in the Danube river basin. One of their aims is to make reinforcements of monitoring, evaluation and information systems to control transboundary pollution. UNDP/GEF does not have an equally strong focus on the WFD as ICPDR.

Phone interview with Mr. Andy Garner, Environmental Specialist, UNDP/GEF

Concerning *current and forthcoming data holdings* of the UNDP/GEF project:

- Wetland management activities generate information.
- UNDP/GEF will generate data on water quality parameters.
- Some economical data exists
- The joint Danube and Black Sea project will provide a lot of data and information.

Concerning *GIS data and information* needs today, Mr. Garner outlined the following needs for the UNDP/GEF project:

- Ready made maps of different scales (Danube, sub basins, national and sub-national)
- Various maps made on ad-hoc basis.
- Linkage between available data sources
- Data, information and maps on pressures and impact

Concerning *systems solution* Mr. Garner stated the need for:

- Public access to GIS databases and derived information
- A centralised approach due to many countries that needs to be coordinated and the present large and multi-disciplinary knowledge at ICPDR about the whole Danube River Basin that would probably be very beneficial for the GIS work.
- A GIS resource person at the ICPDR secretariat or externally skilled in map-making

2.4.3 NGO

2.4.3.1 WWF Aueninstitut

WWF-Aueninstitut is among other things working with flooding areas mapping in the Danube River Basin. Within a project, a combination of historical maps and current topographical maps resulted in GIS data showing current and former floodplains. The relevance of such data for a Danube GIS is naturally high.

Phone interview with Mr. Detlef Günter-Diringer at WWF-Aueninstitut

Current relevant *data holdings* at WWF-Aueninstitut:

- Current and recent floodplains

- Restoration relevant data on the Danube Delta and lower Danube

Needs for GIS data and related information stated by Mr. Günter-Diringer:

- More detailed forest data/information. The three forest classes in Corine are not enough.
- A detailed and harmonised linear data set (e.g. EGM) including river network.
- One base data source in order to discard many of the harmonisation problems
- Detailed DEM (about 1 meter altitude correctness)

Concerning the *systems solution* Mr. Günter-Diringer strongly stated the need for a centralised approach and meant that with a decentralised approach it would be very difficult to get harmonised data. He also stated the need for overview *scale* data in the database.

2.4.4 Science Community

2.4.4.1 DANUBS

DANUBS is a EU 5th framework research programme assessing the nutrient load problems in the Danube river basin. Among other tasks, the project develops quantitative models for calculation of nutrient transport in the basin and the transport to the Black Sea. One of the models, the MONERIS model uses GIS maps to derive inputs to the model. GIS maps covering the model input parameters are thus crucial for the modelling work. The outcomes from MONERIS modelling are maps on sub-catchment level for important nutrient transport parameters. Nutrient transport, including scenario and cost analysis are in DANUBS calculated for approximately 390 sub-catchments in the Danube River Basin.

Phone interview with Ms. Heide Schreiber, PhD student, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin

During recent two years an extensive GIS database covering the Danube drainage basin has been built up within the Danubs project in order to support MONERIS modelling. The contents of the GIS database are summarised in Table 4.

Table 4. List of input maps to MONERIS modelling in the Danube River basin

Theme	Scale	Source data
Administration	1:1 Million	Bartholomew, Macon
Catchments	1 km grid	Derived on the basis of the TNMN, monitoring station list for each of the Danube countries and the DEM
CORINE landuse	250 m grid	<i>European Centre on Land Cover</i> , Kiruna, Sweden, 1997
Landuse IGBP	1 km grid	IGBP
Landuse USGS	1 km grid	USGS
Waterbodies	1:1 Million	DCW and others
River network	1:1 Million	DCW
Soil FAO	1:5 Million	Digital Soil Map of the World and Derived Soil Properties (CD ROM), 1998
Geology	1:10 Million	derived from the Hydrogeological map of Europe, RIVM, Netherlands)
Nitrogen deposition	50 km grid	map from the EMEP, 1996
Monitoring stations*		TNMN and chosen stations for each country (corresponding to sub-catchments)
Climate	From 200 m grid	Based on "Atlas der Donauländer"(1970-1989)
Elevation	1 km grid	GTOPO30, USGS
Aspect	1 km grid	GTOPO30, USGS
Topographic index	1 km grid	GTOPO30, USGS
Slope	1 km grid	GTOPO30, USGS
Erosion	5 km grid	<i>Fraunhofer Institute of Ecotoxicology</i>

In addition to the GIS maps (Table 4) the DANUBS have collected considerable amount of GIS formatted statistics, required by the MONERIS model (e.g. agricultural statistics, population, land use, sewage water connectivity). Further, a vector data map of geology will be compiled within the project by digitising of paper maps.

Main problems with existing GIS data and information in the Danube region as outlined by Ms. Schreiber:

- Availability of digital data
- Accessibility to available regional and sub-regional data.

Ms. Schreiber summarised further data and information needs for MONERIS modelling within DANUBS:

- Better resolution of soils and geology.
- Erosion maps.
- Data on nutrients in tile drainage and ground water.
- Climate and evapotranspiration data.
- Data on the rate of WWTP-connected people, types of systems and exact locations.

Concerning *scale* Ms. Schreiber stated the need for overview scale data, homogenous for the whole basin.

2.4.5 Media

Information needs from media should not be underestimated; especially not as effective public communication is a goal for ICPDR implementation of the WFD. The media is very skilled in communicating information, even difficult information related to water management. The media thus play an important role in RBM and should be served useful information. Media will unlikely use the GIS data itself, as it requires too much time and skills. Statistics is neither a plausible source for the

media unless it is very information rich. Instead they will use derived maps and well formulated information.

Phone interview with Ms. Jasmine Bachmann, project manager Danube Watch.

Concerning current needs for GIS related information Ms. Bachmann stated the need for:

- Appealing maps on overview scale for visualisation and for building a common river basin identity.
- Information products
- Basis statistics on relevant indicators (e.g. water use, population, income) on national level. The statistic should be more easy to use than today.

Ms. Bachmann pointed out two information services from the Baltic region, the Baltic Sea Region GIS, Maps and Statistical Database⁶ and the Lake Peipsi GIS database⁷ as being an information models very useful for her purposes as they contain information on different levels and nice looking publishable maps

2.5 Conclusions

Stakeholders (all groups identified for the user needs assessment) have different needs for data and information products. Phone interviews with key persons inside and outside the ICPDR organisation revealed that some needs and wishes upon a DANUBE GIS are similar within most of the groups. Four common needs were identified from the majority of the groups:

- 1) We need maps
- 2) We need a system on the overview scale
- 3) We need a centrally initiated and developed GIS database
- 4) We need public access

“We need maps”

The needs for maps are stated by almost everybody. There seems to be a clear lack of maps of the region. Some state the need for nice looking cartographics for publication in papers, reports and via the Internet while others point out the need for informative maps for planning and management. The latter group would probably need some function for making maps on an ad hoc basis. A primary need is to cover the 15 maps required by the WFD for reporting purposes (Table 2 and Table 3)

“We need a system on the overview scale”

All interviewees stated the need for a system on the overview scale while nobody stated the need for very detailed data and information in the Danube GIS, at least not in an initial database. In map terms such an overview scale should probably not be larger than 1:1 000 000.

“We need a centrally initiated and developed database”

All interviewees said that a centralised approach would be better, at least initially, than a decentralised. After the initial phase, some said we might go further and develop a more decentralised system. Some of the interviewees said that there are so many countries that will make a decentralised approach to database building very difficult. The EMIS group has some experience and said that without a centrally placed person taking care of present and occurring tasks there would not be any emissions inventory today.

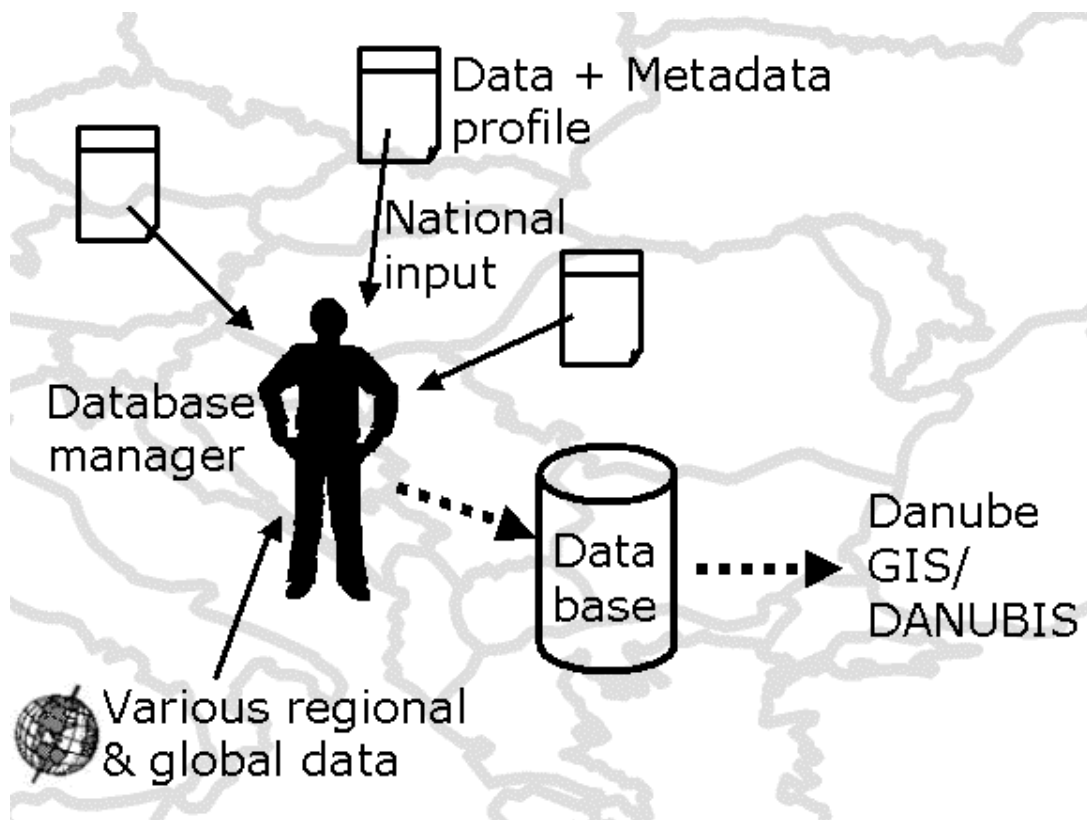
“We need public access”

⁶ Baltic Sea Region GIS, Maps and Statistical Database - <http://www.grida.no/baltic/index.htm>

⁷ Lake Peipsi GIS database - <http://www.mantraeast.org/gis/>

The importance of having a system with public access functionality is important to most interviewees. Some groups need data that will likely be difficult to disseminate and therefore stated the importance of some restrictions.

3 A conceptual design



3.1 Introduction

The user needs assessment for a Danube River Basin GIS, primarily conducted by reviewing various relevant ICPDR and WFD documents and by interviewing selected representatives of various ICPDR groups, the GEF/Danube Project and some other major stakeholders, forms the basis for the conceptual design. Phone interviews revealed that many needs and expectations upon a Danube RB GIS are similar between most user groups. A majority of the groups stated following needs:

- We need maps
- We need a system on the overview scale
- We need a centrally initiated and developed GIS database
- We need public access

The user needs assessment enabled us to identify the following primary needs according to the following needs categories:

- Needs for a multi-thematic GIS database and a series of derived maps and statistical tables based upon the GIS database featuring the key characteristics of the Danube River Basin. These needs reflect those for WFD reporting, as well as numerous other purposes.
- Needs for ‘GIS system solutions’ to enable the various ICDPR groups and other stakeholder groups to access, use, exploit, and disseminate the GIS database and thereby facilitate the development of derived and new spatial information upon demand and according to needs as they will evolve over time.

Furthermore, the needs assessment enabled us to identify the primary and secondary users and beneficiaries.

Based upon this we suggest a multi-component development approach to meet the needs of the various users and beneficiaries.

- Component 1: Development of a multi-thematic GIS database covering the Danube River basin. We have further suggested two different ambition levels for this component, termed Option 1 and Option 2.
- Component 2: A flexible ‘systems solution’ based upon a combination of stand-alone GIS software, Internet MapServer software and Web server software to exploit and disseminate GIS data, derived geographic information products, internally at ICPDR and externally

While interrelated, the suggested components can be looked upon as separate activities that can be considered as externally fundable or stand-alone projects or activities. Of the two proposed components, component 1 will most likely need considerable new financial resources beyond the ordinary ICPDR budget or national resource commitments of the Signatories of the Danube Convention. This component is typically one that can be defined as a time limited project, with reasonable clear inputs, outputs, resource requirements and a well-defined time schedule. Component 2 will also require substantive resource inputs, yet this activity can be seen as future internally funded and operated activities of the ICPDR. Obviously, as will be noted in the more detailed descriptions, each of these components can be further sub-divided into smaller components, activities or projects.

Based upon the consultants own experiences from the Baltic Sea region in developing, using, and disseminating GIS data and derived geographic information products, we have chosen to give most emphasis to the first component, the initial development of a multi-thematic GIS database covering the Danube River basin. This initial GIS database will be the core and heart of any ‘Danube GIS’, however defined

3.2 Component 1. Development of a multi-thematic GIS database covering the Danube River basin

3.2.1 Objective

The objective of this component is to develop a harmonized, multi-thematic GIS database covering the Danube drainage basin in support of:

- EU Water Framework Directive reporting
- Integrated River Basin Management within and outside the ICPDR
- Strategic decision-making
- Research
- Education
- Public outreach

The database should contain relevant river basin information with sufficient level of detail and other characteristics pertinent for the above purposes. To achieve maximum positive impact upon the Danube river basin environment the GIS database should, with as few exceptions as possible, be made publicly available. The database design should also encourage reuse and integration of existing data and GI infrastructure rather than encouraging another monitoring program and more GI hardware and software

3.2.2 Database contents

3.2.2.1 Time frame and thematic contents

Based upon the interviews with representatives of the various ICPDR Expert Groups and others, and reviews of WFD Guidance Documents, it appears that the wishes or needs for thematic maps and GIS layers are very comprehensive, possibly reaching beyond 40 layers. Thus, there is a clear need to prioritise within this comprehensive list of needs and wishes. The user needs assessment clearly showed that fulfilling WFD requirement now is highest priority. The database must reflect this priority and should therefore follow the WFD reporting deadlines. In order to be relevant on the transboundary scale it should also contain the most important additional layers supporting basin wide analysis of pressure, state and impact variables. Our proposal is based on three development periods, the short time frame until 2004, the medium time frame until 2006 and the long time frame until 2009 (Table 5). These periods are based on ICPDR relevant WFD reporting dates. Additionally we suggest two options for the contents of the Danube GIS, option 1 being what we consider the minimum requirement for a 'Danube GIS' (what is required by the WFD). Option 2 is an extended GIS database expanding upon option 1 and include other data that will be crucial for effective and transboundary use of the GIS database. A lot more layers could be included in the extended database but time constraints will limit what is possible to achieve.

Table 5. Suggestion for time frames and contents of the Danube GIS

Timeframe	Contents of minimum database (WFD requirements)	Contents of extended database
SHORT – 2004	WFD reporting Dec. 2004 Layers necessary for transboundary harmonisation	
MEDIUM – 2006	WFD reporting Dec. 2006	<ul style="list-style-type: none"> ▪ Most important layers for transboundary analysis e.g. pressure and impact data that will be accessible within two years ▪ A number of cartographic layer necessary for mapmaking ▪ A few additional key needs of some ICPDR Expert Groups.
LONG – 2009	WFD reporting Dec. 2009	<ul style="list-style-type: none"> ▪ Additional layers for more effective transboundary RBM ▪ More GIS data on pressure and impacts ▪ Some additional key needs of some ICPDR Expert Groups.

Short time frame, until December 2004

The minimum content requirements until 2004 corresponds to the most promptly needed maps for roof report obligations by end 2004. Thematic maps to be included in the roof report are listed in the ICPDR document “Time line for fulfilling the requirements of the WFD needed by the end of 2004...” as in Table 6.

Table 6. Thematic maps to be included in the 2004 roof report

Thematic maps⁸:	Responsible	Deadline
1. Preparation of map content		
<ul style="list-style-type: none"> Map SW4: Surface water bodies of the Danube incl. HMWB candidates 	GIS ESG/ RBM EG	Draft: Apr 04 Final: Sep 04
<ul style="list-style-type: none"> Map D6: Ecoregions 	GIS ESG/ MLIM EG	“
<ul style="list-style-type: none"> Map SW4A: Surface water body types of rivers and lakes in the overview map 	GIS ESG/ MLIM EG	“
<ul style="list-style-type: none"> Map of significant point pressures on the overview level Map of significant diffuse pressures on the overview level Map of significant hydromorphological pressures 	GIS ESG/ EMIS EG/ MLIM EG/ RBM EG	“
<ul style="list-style-type: none"> Map of significant impacts on the overview level (risk of failure to achieve good status) 	GIS ESG/ MLIM EG	“
<ul style="list-style-type: none"> Map of land use based on CORINE and data from JRC 	GIS ESG	“
<ul style="list-style-type: none"> <i>Map(s) on groundwater issues (to be specified)</i> 	GW experts/ RBM EG	“

All these maps will be reported by latest in December 2004. A final version of the maps must be finished in September 2004. As there is no real alternative to GIS to construct and handle the maps and underlying data the 2004 roof report requirement will constitute a good start for the Danube GIS. To our understanding the minimum data holdings in order to construct these maps are those listed in Table 7.

⁸ Number of maps refers to EU WFD Guidance document on GIS

Table 7. GIS data layer required to produce the maps for the 2004 roof report.

Layer	WFD Data map nr.	Data type	Most important attributes
Administration			
Administrative boundaries (Nuts 0 - 3)	-	Polygon	Code, Name
District of competent authority	D7	Polygon	Name, contact info
Danube River Basin District	SW1	Polygon	Name
Hydrology			
River basins	SW2	Polygon	Code, Name,
Surface water bodies	SW4	Line, polygon	Code, Name of waterbody, Type of surface water body (SW4a), Ecoregion (D6)
Main rivers	SW3	Line	Code, Name
Ground water bodies	GW1	Polygon	Code
Other River Basin characteristics			
Land Cover	-	polygon or raster	land cover class
Pollution			
Diffuse Nitrogen pollution	-	Raster or Polygon	Diffuse N inputs per area (per sub-basin)
Diffuse Phosphorous pollution	-	Raster or Polygon	Diffuse P inputs per area (per sub-basin)
Point pollution sources	-	Point	Type of point (industry, WWTP, town), amount and type of input
hydromorphological pressures	-	Raster or Polygon	

Medium time frame, until December 2006

Between 2004 and 2006 the Danube GIS should be developed into an operational system, integrated with the DANUBIS. The GIS should integrate the information sources already existing within ICPDR (EMIS inventories, JAP inventories, TNMN database etc), with new data. Such new data may or may not be required by the WFD depending on the ambition of ICPDR concerning the GIS. One possibility is to restrict the Danube GIS to include data and map information necessary for the WFD roof-reporting (minimum option) or to extend the database (extended option) to include useful data for other transboundary applications as well. The minimum option would be cheaper but less useful, the extended option more expensive but also more useful. The necessity to expand the Danube GIS beyond WFD reporting were strongly stressed by many potential users of the Danube GIS during the user needs assessment. This is also our recommendation.

The minimum content of the database at the end of 2006 is specified in Table 8 following recommendation in the WFD guidance document on GIS.

Table 8. Data required to produce WFD reporting maps by the end of 2006

Layer	WFD Data map nr. type		Most important attributes
Administration			
District of competent WFD authority	D7	Polygon	Name, contact info
Danube River Basin District	SW1	Polygon	Name
Hydrology			
River basins	SW2	Polygon	Code, Name, Population, land cover statistics,
Surface water bodies	SW4	Line, polygon	Code, Name of waterbody, Type of surface water body (SW4a), Ecoregion (D6)
Main rivers	SW3	Line	Code, Name
Bodies of ground water	GW1	Polygon	Code
Monitoring			
Monitoring network for Surface Water Bodies	SW5a-e	Point	Code, type of measurement point, measurements
Groundwater Monitoring Network	GW1a-c	Point	Code, type of measurement point, measurements
Protected areas			
Drinking water protection areas	PA1	Polygon	Code, Name, Status of protected area
Economically significant aquatic species protection areas	PA2	Polygon	Code, Name, Status of protected area
Recreational waters	PA3	Polygon	Code, Name, Status of protected area
Nutrition-sensitive areas	PA4	Polygon	Code, Name, Status of protected area
Habitat (Natura 2000) protection areas and equivalent	PA5	Polygon	Code, Name, Status of protected area
Bird Protection areas	PA6	Polygon	Code, Name, Status of protected area

The data in Table 8 are following the minimum WFD requirement. More data will become necessary for pressure and impact analysis as specified by the Directive and for other transboundary applications. A proposal for the extended database for 2006 can be found in Table 9. Data for the extended database was selected according to the following criteria:

- Layers necessary for transboundary harmonisation (e.g administrative boundaries)

- Layers possible to finish within two years
- Important pressure and impact data that are accessible or will be accessible within two years (e.g. diffuse N and P loads)
- A number of cartographic layer necessary for mapmaking, enabling of a future web-GIS and for identification of geographical features in the basin.
- A few additional key needs of some ICPDR Expert Groups.

Table 9. Contents of the extended database by end of 2006.

Layer	Data type	Most important attributes
Administration		
Administrative boundaries (Nuts 0 - 3)	Polygon	Code, Name
Settlements	Point	Name, population
Infrastructure		
Roads	Line	Type of road
Dam constructions	Line	
Other River Basin characteristics		
Soils	Polygon or raster	Type of soil
Population distribution	Raster	Population
Land Cover	polygon or raster	land cover class
Elevation data	Raster	Elevation
Pollution		
Diffuse Nitrogen pollution	Raster or Polygon	Diffuse N inputs per area (per sub-basin)
Diffuse Phosphorous pollution	Raster or Polygon	Diffuse P inputs per area (per sub-basin)
Point pollution sources	Point	Type of point (industry, WWTP, town), amount and type of input
hydromorphological pressures	Raster or Polygon	

Long time frame, until December 2009

After the launch of the Danube GIS in 2006 by latest the database should be updated and extended to cover more of the needed data. A minimum would be the required WFD data (Table).

Table 10. Additional data required by the WFD by the end of 2009

Layer	WFD map nr.	Datatype	Most important attributes
Ecological and chemical status and potential			
Ecological Status and ecological potential of surface water bodies	SW4b-d	Attribute of SW4	
Chemical status of surface water bodies	SW4e	Attribute of SW4	
Groundwater status	GW1a-c	Attribute of GW0	
Status of protected areas	PA7	Attribute of PA1-PA6	

A further extension of the non-WFD required data would be important in order to integrate existing data (e.g. data on accidental risk spots and older pollutant data) and to extend useful data for transboundary analysis (e.g. flooding areas and meteorological data). A suggestion for the contents of the extended part of the database can be found in Table 11.

Table 11. Suggested contents of the extended database, finished by latest by the end of 2009.

Layer	Data type	Most important attributes
Hydrology		
Flooding areas	Polygon	Recent floodplains, Former / historical floodplains
Infrastructure		
Railway lines	Line	
Other River Basin characteristics		
Temperature	Points	Monthly mean temperatures
Precipitation	Raster	Long-term precipitation
Hydrogeology	Raster or polygon	Aquifer type, capacity
Erosion	Raster or polygon	Erosion potential
Pollution		
Atmospherically N deposition	Raster	Deposition of NH4 and Nox
DABLAS project sites	Point	Type of site, status, investment amounts
Main contaminated Sites	Point	Site type, Status
Accidental Risk Spots	Point	Activity type
Bucharest Declaration Pollutant Data	Point	

3.2.2.2 Metadata – ISO 19115

Preparation of easy accessible metadata is one of several approaches to stimulate and increase the use of GIS data for various application areas. This should consequently be an important task of any GIS database development work aimed towards establishing transboundary river basin GIS databases. Both the minimum and extended database should be documented with at least two levels of metadata, namely metadata for discovery and metadata for use. These types of metadata are described in the GIS guidance document section 3.7. A new metadata standard, ISO 19115 have finally emerged and was published 2003-05-08. Below is a brief description of the ISO standard as formulated on the ISO Web site⁹.

⁹ ISO (International Organisation for Standards - <http://www.iso.org/>)

ISO 19115:2003 defines the schema required for describing geographic information and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data.

ISO 19115:2003 is applicable to:

- the cataloguing of datasets, clearinghouse activities, and the full description of datasets;
- geographic datasets, dataset series, and individual geographic features and feature properties.

ISO 19115:2003 defines:

- mandatory and conditional metadata sections, metadata entities, and metadata elements;
- the minimum set of metadata required to serve the full range of metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data);
- optional metadata elements - to allow for a more extensive standard description of geographic data, if required;
- a method for extending metadata to fit specialized needs.

Though ISO 19115:2003 is applicable to digital data, its principles can be extended to many other forms of geographic data such as maps, charts, and textual documents as well as non-geographic data.

A full description of the standard can be found in the recently published international standards text or in a summarised format in appendix VII of the GIS Guidance document (written when the standard was not yet formally published).

The standard contains a huge amount of metadata elements aimed to cover a wide range of purposes. Most of these elements are optional. There is a large need to develop a standard profile in the light of the WFD requirements and this is currently being done. A preliminary ISO 19115 profile is already submitted to the European Commission for comments (Alessandro Annoni, JRC, pers. comm.).

Vendors have tools that are already equipped to handle ISO metadata e.g. ESRI's ArcCatalog, Intergraph's SMMS and MapInfo being licensed and M3CAT and Enraemed being freely available tools.

Recommended actions:

- ICPDR should decide upon a metadata profile for all data input to the Danube GIS. It is recommended that the upcoming WFD standard profile of ISO 19115 is being used.
- Metadata should be stored centrally in a metadatabase together with the GIS database (Figure 9)
- Metadata should be documented in a single language (English) so that all users in connection with the Metadatabase can understand the data.
- ICPDR member states should be responsible for updating of the metadata for data originating from national sources while other data must be documented and updated by the constructor of the central database.

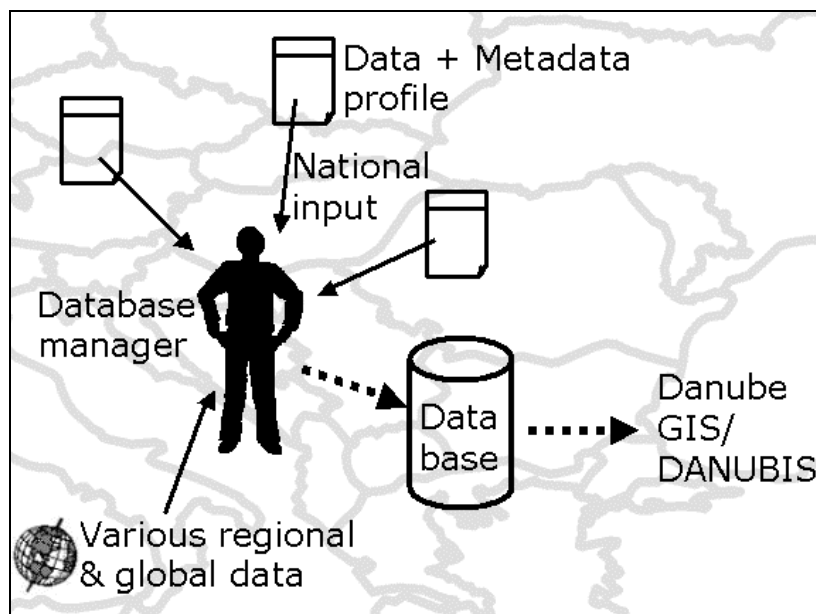


Figure 9. Data and metadata flow into the common Danube GIS database and DANUBIS.

3.2.2.3 Technical characteristics and data flow

During the interviews with various representatives of ICPDR Expert Groups and others it was obvious that most users were quite relaxed with respect to technical aspects like nominal scale and resolution, quality aspects like positional and thematic data accuracy. The dominating view was that ‘best available and accessible’ information should be used. The proposed database will contain data with variable scale. It is recommended to in this stage develop a database with a scale of 1:1 000 000 or smaller.

Considering the Guidance Document on GIS, it contains quite detailed recommendations not only on format, coding and reference systems. It is recommended to adopt the WFD guidelines on a geodetic framework.

Concerning exchange format ESRI standards are recommended (further discussed in the report on GIS hardware and software considerations)

A strict data model needs to be followed for the exchange of data (Figure 9). The model needs to be developed early in the Danube GIS process, by latest in the initial phase of the 2004 – 2006 development period. Our recommendation is to:

- Use the data model outlined in the WFD guidance on GIS for WFD where applicable
- Develop new common data models for other data

For data with no WFD reporting obligations it can be generally recommended to use harmonised interstate data sources, if available, instead of a combination of national data.

3.2.3 Development of the GIS database

The database development should include the steps outlined below:



- Identify user needs
- Develop standards together with the GIS ESG
- Inventory & acquisition of data
- Harmonisation of data
- Documentation and management of metadatabase
- Dissemination

A number of meetings will be of high importance to support the development. These meetings are plotted in the time chart and further explained in Appendix 4.

Concerning the responsibility for development of the GIS database there are some options. The GIS database construction could be carried out by:

- A consultant (Proposal 1)
- A GIS resource person at the ICPDR permanent secretariat (Proposal 2)
- An institute or authority at member state level (Proposal 3)
- A research institute involved in GIS (Proposal 4)

Considering the contents of the database the technical outcome from the five options would probably not be very different from each other as long as personnel with relevant GIS skills are contracted and adequately coordinated by the GIS ESG. No matter who will do the work it should be done under supervision of the GIS ESG that will see to that the interests of ICPDR are properly taken into account during the whole process.

3.2.3.1 Proposal 1 – Consultant

A consultant situated close to or far from Vienna could be hired to do the job.

Advantages

The consultant will not be involved in other ICPDR activities and will therefore not be able to carry out upcoming tasks such as mapmaking and data collection (that could well be for a person at the secretariat). The database will thereby more likely be finished in time.

Drawbacks:

- The consultant will leave the database at the ICPDR but not the knowledge about how to construct databases, how to work with it etc. Updating and further development of the database might therefore be more difficult at a later stage.
- A consultant cannot offer the same continuity of services as e.g. a national institute.

3.2.3.2 Proposal 2 – GIS developer at ICPDR permanent secretariat

Hiring a GIS developer skilled in GIS database and applications development is the option that will bring the GIS database closest to the ICPDR, at least during the development.

Advantages:

- Knowledge will be close to the secretariat and integrated into the organisation
- ICPDR will increase its know-how about how to work with GIS
- GIS database and future applications derived will be influenced by the transboundary focus at the secretariat and the wide range of expert fields present there.
- Long-term continuity

Disadvantages:

- There is a larger possibility that a GIS resource person situated at ICPDR will be given other tasks than the pure GIS database development. There is a large need for maps and other information

products that will likely delay the development of the database and thereby all derived product of the final database.

- The GIS developer will be alone in the field at the secretariat. The broad GIS knowledge and support present in a larger organisation working with GIS will therefore not be present.

3.2.3.3 Proposal 3 – a member state institute or authority

A relevant institute or authority on national level could be an option, it has been done in other river basins e.g. in the Rhine and Elbe river basin

In the Rhine river basin the database development is entrusted to a BfG in Germany, (Bundesanstalt für Gewässerkunde). The Federal Environmental Agency in Vienna was mentioned during the user needs assessment as another possible partner. Several of the national hydrometeorological institutes would probably be well suited as well.

Advantages:

- Continuity of service
- Variety of experiences in the GIS field will probably solve most technical problems
- Experience with land and water management related GIS activities

Drawbacks:

- Little knowledge of GIS database construction will be transferred to ICPDR

3.2.3.4 Proposal 4 – a research institute

A research institute with background in development of transboundary GIS databases and derived applications could be an option for the development of the Database. The user needs assessment present some research institutes involved in GIS activities in the Danube River Basin:

- The EC Joint Research Centre having a long tradition of development GIS and remote sensing applications for natural resources management
- Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IBG) in Berlin.

Both these institutes are involved in transboundary modelling (flood forecasting and nutrient transport modelling) with GIS for the whole Danube River Basin. They thus have a good understanding of what type of information is needed for transboundary analysis. As they are actively involved in the management on the Danube RB already they have good knowledge of the area, a contact network and colleagues in various fields in the river basin already. The research background in these institutes would probably give a very positive input to new RBM applications based on the GIS database.

Drawbacks of this alternative are:

- Research institutes are meant to do research and are generally not that positive to commit themselves to provide permanent services.
- Knowledge of developing transboundary GIS databases is not necessarily transferred to the organisation

3.2.3.5 Recommendations

In our recommendations, we would like to distinguish the period until end of 2004 from the time after. Considering the short time frame until end of 2004 and the amount of work that needs to be done very soon we would recommend ICPDR to contract a consultant/consultancy company to develop the necessary GIS data and maps with a deadline in September 2004. It will be difficult to arrange a more long-term solution before this date and at the same time produce the requested data and maps.

A long-term solution should be developed from 2004 and onwards. ICPDR would then need a solution with more continuity in service than the one of a consultant. We believe that such continuity in service, required skills and suitable professional background will be provided by either a national institute/authority (such as a hydrometeorological institute) or by a research institute.

3.2.4 Estimated resource needs

Development of harmonised transboundary GIS databases takes time and will thereby need some quite substantial resources.

A rough estimate of the resources needed to develop the database is found in Table 12.

Table 12. Resource needs for database development, measured in man months

Timeframe	Task	Minimum database (WFD requirements)	Extended database
SHORT – 2004	Development of database	6 man months	
	of maps	2 man months	
MEDIUM – 2006	Development of a data and metadata model	5 man months	
	Development of database	18 man months	6 man months
	Direct costs		
	Data	10 000 Euro	5 000 Euro
LONG – 2009	Development of database	7 man months	7 man months
	Data	5 000 Euro	5 000 Euro

Costs for GIS hardware and software are not included in the above listed resource needs. Such costs will depend on choices concerning system solution, where to place hardware and database development. A rough estimate of yearly costs for a modest GIS could be approximately some 12 000 Euro. This covers one licence of ArcIMS, ArcSDE and ArcInfo (source: ESRI Sweden). It does not cover the whole cost of purchase of the software but only the yearly licences. Neither does it include the cost of hardware costs. An initial purchase of hardware and software for such a modest GIS could be approximately 50 000 Euro¹⁰.

3.2.4.1 Deliverables

The GIS database should be made available on the DANUBIS and on CD for public dissemination. If by strong reasons the data cannot be published on the public part of DANUBIS it should be available on the internal part and on a separate set of CDs. A description at the public site is recommended explaining what data are restricted, together with an explanation to why it is restricted and where to possibly get the data via a licensing procedure.

Metadata and documentation should be made available in HTML format and published on DANUBIS together with download facilities of the GIS data.

3.3 Component 2. Systems solution to exploit and disseminate GIS data, derived information products and information services

¹⁰ Hardware cost 11 000, software cost 39 000 Euro

3.3.1 Aim

To set up the database information environment so that it can be maximally exploited internally at ICPDR and externally by various stakeholders inside and outside the Danube river basin.

3.3.2 Contents of the information environment

3.3.2.1 Development of an information package with derived digital maps and statistics

The GIS database will be the base for any derived geographical information in the basin. All data is in the database, still somebody needs to extract useful information from it. Many users have stated the need for maps and statistics at several scales. The usability of nice looking graphics, more specifically directed informative maps and selected statistics is hard to overestimate. No matter if this work is to be carried out by the proposed resource person at ICPDR or by a consultant the person should have a strong profile in map making. For an example of good practice map making for transboundary river basins have a look at: <http://www.grida.no/baltic/htmls/maps.htm> where nice and informative maps of the Baltic can be downloaded.

Resource needs: 4 man months + 2 000 Euro in direct costs

3.3.2.2 GIS resource person at the ICPDR secretariat

Several interviewees stated during the user needs assessment the need for a GIS resource person situated at the secretariat. Duties for a GIS resource person would be:

- Maintenance and updating of the Danube GIS and the link to DANUBIS
- Ad-hoc preparation of derived material
- GIS knowledge resource for the ICPDR secretariat, expert groups and member states

Having such a resource person would yield a quick response to upcoming needs for important updates, changes in the information system and for derived products. He or she would further help the secretariat and expert groups to develop useful GIS applications and to enhance the usability and user friendliness of the database and information system.

Resource needs: a 50% duty

3.3.2.3 Web-GIS solution

GIS services bundled with the Internet is an effective means to communicate spatial information within and outside the organisation. The key added benefit of linking up with the Internet lies in the ability to provide distributed access to GIS derived data and information and simple analytical and map-making services to anyone connected to the Internet and equipped with a web browser. If comparing the Danube River Basin with the Baltic Sea Drainage Basin several useful web-GIS services can immediately be identified:

- A driving forces, pressures, state, impact and response web site with comprehensive information on causes and effects of pollution loads in the catchment. For an example see: <http://boing.fimr.fi/index.html>
- An easily used map making facility with base data such as land cover, administrative units, cities, lakes etc. For an example see: <http://maps.grida.no/baltic/>
- A service with pollution loads, investment programmes and pollution loads follow up. For an example see: <http://maps.grida.no/scripts/esrimap.dll?name=hotspots&cmd=map>

To connect GIS software to web servers so-called Internet Map Servers have been developed by most commercial GIS developers. Freeware alternatives exist as well. These map servers act as communication bridges between stand-alone GIS software and databases and web servers. While in principle they allow for full GIS analysis functionality, they are often tailored towards the simpler functionalities offered by stand-alone GIS, such as zooming (in and out), panning, selection of specific features.

Resource needs: 4-6 man months depending on ambition. In addition to the web-server an Internet maps server will be required. One alternative would be ArcIMS from ESRI priced at 14 000 Euro and 2 700 Euro per year in addition for maintenance, support and updates, starting from second year (source: ESRI Sweden).

3.3.2.4 Optimisation of hardware and software

Optimisation of hardware and software will in the future be needed in some parts of the region. Some collaborating institutions to ICPDR which would be of importance for filling the database with national contents and which could be identified as potential important users of the database would benefit from an upgrade of GIS hardware:

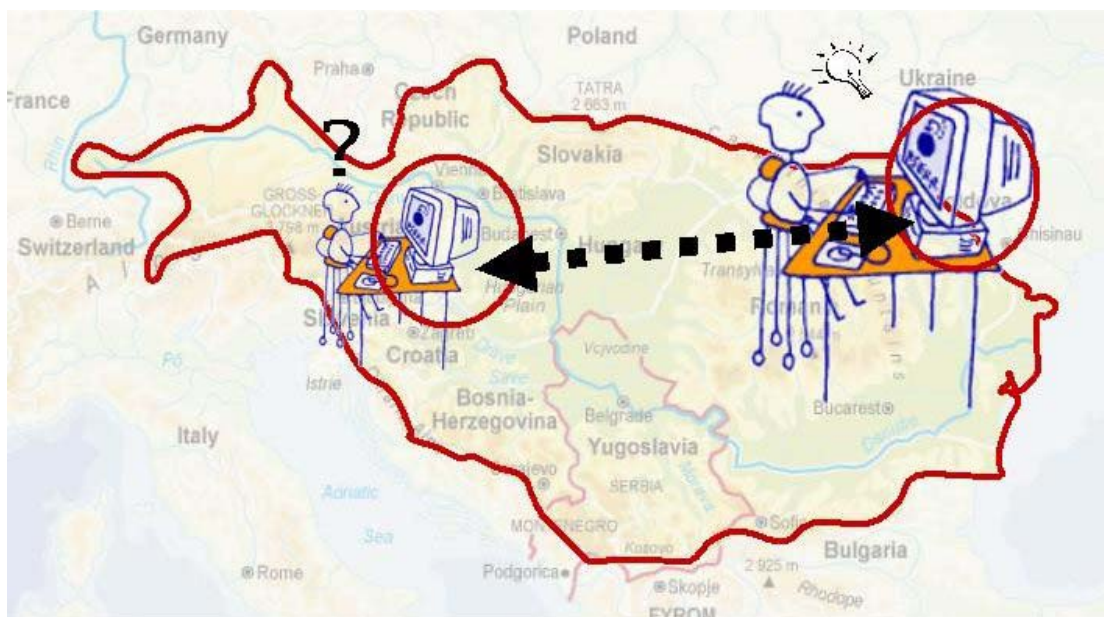
- Computers
- Digitising equipment
- Storage capacity

Additionally some suitable software might be necessary:

- Software package suitable for GIS data analysis, digitising and data communication. It should of course be compatible with the agreed format for communication of data within the Danube GIS.

Resource needs: 0 - 150 000 Euro depending on ambition. An investigation on optimisation would need to be done when further experiences with data collection, data creation and harmonisation within the Danube GIS are gathered.

4 GIS hardware and software considerations



4.1 Hardware and software considerations introduction

In this chapter we try to identify existing technical structure concerning GIS hardware and software and try to make some recommendations on those aspects for the Danube River Basin GIS.

Current software and hardware were assessed mainly with help of two existing questionnaires sent out and analyses during 2002, namely the survey on the ICPDR information system (DRP 2002) and data exchange and data inventory questionnaire (GIS ESG 2002).

4.2 Hardware

Hardware technology changes constantly. Computer power is enhanced, storage capacity grows and it also gets cheaper with time. Any recommendations on GIS hardware are bound to be outdated before the organisational set-up required for a large GIS initiative is in place. As hardware becomes cheaper the issue becomes less important to emphasize on during the design phase of a GIS. Therefore we will in this report not go deep in this issue.

A minimum hardware requirement for an organisation working with GIS analysis, GIS data input and GIS data dissemination could be:

- A server for sharing and storage of data
- Desktop computers
- Colour and/or monochrome printer
- Digitiser
- Scanner
- GPS unit
- A stable and fast internet connection

Are these requirements generally fulfilled in the Danube region? In 2002 the Danube Regional Project carried out a survey about the DANUBIS and the user experiences of the system, availability of hardware and software and the Internet connection at user institutions. 60% of the active users of the Information System answered the survey. It did not specifically assess relevant GIS hardware and software but the survey answers some important questions concerning relevant equipment and Internet connections. The survey has resulted in an improvement of hardware at some of the institutions participating in the survey. Some countries/institutions were identified as having too poor hardware infrastructure and some resources were therefore used for the improvement of that. Below statements were made before current hardware improvement were carried out.

Concerning hardware it was concluded that

- the average user has exclusive access to a Desktop PC, which is equipped with a 500 MHz processor, 128 MB memory, 10 GB hard disk, a 17" monitor with a screen resolution of 800x600 pixels, as well as a b/w laser printer.

and concerning Internet connection:

- 85 % of the users connect to the internet via a Local Area Network.
- Download rates vary widely, not only from country to country, but also within the countries. 20% of the users only achieve download-rates of up to 5 KB/s and 40% of more than 30 KB/s, the rest is in-between.

The average hardware as outlined by the survey will not really boost the functionality of the GIS system nor will it be the bottleneck for a well functioning GIS system (as outlined in the report on conceptual design of the Danube River Basin GIS). Internet connections are probably a more serious problem for the effective communication needed for a well functioning Danube GIS. Low Internet connection speeds in parts of the drainage basin call for information and data exchange based on CDs as an alternative to web-based dissemination.

4.3 Software

Current use of GIS software was analysed in the questionnaire “Inventory of GIS and Cartographic Presentation of Spatial Information” part “GIS and database”. Distributed by the GIS ESG in 2002. The questionnaire tries to assess what kind of GIS software (for analysis, storage and distribution) that is used in ICPDR member countries. The questionnaire is not supposed to cover the use in the whole member countries but only what is used at authorities linked to the members of the GIS ESG.

Answers are not yet analysed and does not cover all countries in the Danube Drainage Basin. As the answers of the questionnaires do not cover all countries of institutions/authorities involved in the Danube GIS work extracted information on the use of GIS software is only a good indicator of the real usage. Relevant information from available answers included in table 13 below.

Table 13. Results from questionnaire “Inventory of GIS and Cartographic Presentation of Spatial Information” part “GIS and database”

Country	What is your main GIS-system?	Do you use other GIS-programs?	Database	Data formats
Austria	Intergraph MGE	ArcView, Geomedia	Intergraph Oracle, MS-Access	Shape, Designfiles, Dxf...
Bulgaria	Arc/Info	ArcView, MapInfo		Arc/Info ArcView, MapInfo
Bulgaria	Arcinfo, Arcview			Arcview and Arcinfo exportfiles
Croatia	Arcinfo	ArcView	No	E00, Shapefile, coverage
Czech Republic	Bentley's	ArcView	Oracle	DXF, ASCII, Shapefile
Germany	ArcView	ArcInfo, ArcView, GeoCad	IMS, Oracle, Access	ArcInfo coverage, Shapefile, SICAD-SQD, DXF,DGN
Hungary	Arcinfo, Arcview	Microstation, system, Magguide	CAD Oracle, access	DGN, DXF, coverages, shapefile
Romania	Idrisi,	Geo-Media, MicroStation	Geo-Media, Access	DXF, TRC/GPS data, DWG
Slovak Republic	Arcinfo, Arcview		INGRES, SYBASE	.dbf .txt .xls
Slovenia	Arcinfo, Arcview		Oracle	E00, Shapefile, DXF

The dominance of ESRI based software packages (ArcGIS, Arc/Info and ArcView) is not total but large. With one exception only, being Romania, institutions either use ESRI software or state that they regularly export files using ESRI specific file formats. Romania using mainly Idrisi will not have any problems in exporting and importing ESRI file formats.

Some of the most frequently used and relevant software in the region as outlined by the survey are described below.

4.3.1 ESRI products

Recognized as the leader in GIS software, it's been estimated that about seventy percent of GIS users use ESRI¹¹ products. ESRI overhauled their software packages into an interoperable model called ArcGIS. The three main GIS software packages available from ESRI are: ArcInfo/ArcView 8.x, ArcView 3.x and ArcIMS.

- ArcInfo was the first software product available from ESRI and is also the most comprehensive analytical and mapping software offered by ESRI.
- ArcView 3.x is the original desktop solution offered by ESRI as an out-of-the box desktop mapping software product for the end user. More user friendly than ArcInfo, ArcView's editing

¹¹ ESRI - www.esri.com

and data manipulation capabilities are extended with each update. In addition, ESRI has developed plug-ins called extensions which add to the functionality of ArcView.

- ArcIMS is a relatively young product from ESRI designed to create out-of-the-box web mapping but also allowing developers to create more involved, custom browser-based mapping applications.

4.3.2 Idrisi32

Idrisi32¹² is a popular desktop raster GIS and Image Processing system. It is developed and distributed on a non-profit basis by the Clark Labs, a project within the Graduate School of Geography at Clark University in Worcester.

4.3.3 Intergraph

Intergraph¹³ makes several GIS applications. Most of the GIS packages are designed with an Open GIS in mind and therefore can work with a variety of other GIS software formats. Currently in Version 4.0 the GeoMedia family is made up of following four components:

- GeoMedia is the information integrator, serving as a visualization and analysis tool and as an open platform for custom GIS solution development.
- GeoMedia Professional is a product specifically designed to collect and manage spatial data using standard databases.
- GeoMedia WebMap is a Web-based map visualization tool with real-time links to one or more GIS data warehouses.
- GeoMedia WebEnterprise creates dynamic, custom web-mapping applications that can analyse and manipulate geographic data.

4.3.4 MapInfo

A leading competitor is MapInfo which produces a suite of GIS software. MapInfo Professional is their leading GIS product containing the most advanced analytical tools. MapInfo also offers plug-ins called add-ons to enhance the functionality of MapInfo Professional. For the development side, MapInfo offers Map-X. Through an Active X component, developers can embed mapping applications into other applications such as Excel.

4.3.5 Pricing of GIS software

The pricing of GIS software varies widely from country to country (personal communication Karina Nylin, ESRI Sweden) depending on the general price situation in respective country. The largest price difference however is between research and educational institutions contra commercial actors and authorities. The discount on ESRI products for research and educational institutions is in the range 80 – 90 %. A full (including all components) single user licence of ESRI's flagship ArcGIS would cost about 50 000 Euro in Sweden, while an institution involved in education or research would pay only 10 % of that amount. ArcView, ESRI's most widespread software is more modestly priced at about 2400 and 400 Euros respectively (Arcview 8.1).

4.4 Conclusions and recommendations

Some general conclusions can be made based on the information in this report:

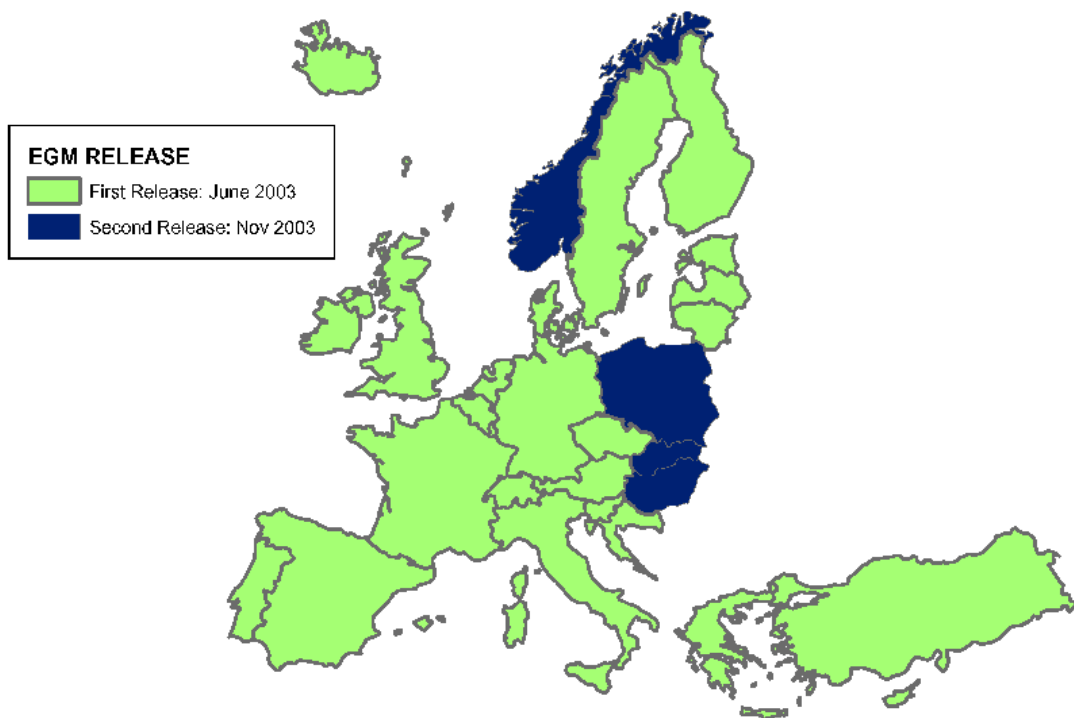
- Hardware and software issues should not be viewed upon as the bottlenecks of a Danube GIS. Problems are today generally solved at low costs compared to other costs of the information system (e.g. salary, office rental, meetings, database development etc.)
- Needs for hardware and software will become visible during the implementation phase. In this early stage it is difficult to know exactly who will be the most suitable organisation or person to carry out parts of the work and to assess the needs from all these partners is even more difficult.

¹² IDRISI32 is described at Clarklabs' web page - www.clarklabs.org

¹³ Intergraph - <http://imgs.intergraph.com/>

- The choice of software is important to the user rather than the system, most important being the user's experience with the software on beforehand. As long as the software enables communication with others users of Danube GIS and include basic functionality common in most modern GIS software there is really no problem in choosing whatever appeals the user/host institution the most.
- Considering the dominance of ESRI produced GIS software in the region we would recommend the use of ESRI standards for communication between users of the Danube GIS. Practically shapefiles, coverages, ESRI interchange files, alongside with ESRI grids could be used.

5 Evaluation of EuroGlobalMap



Picture source: EuroGeographics

5.1 Evaluation of EuroGlobalMap introduction

EuroGlobalMap (EGM) is an initiative from EuroGeographics¹⁴ with objective to compile a European base map on the scale 1:1 000 000. The project runs in parallel with an attempt to also construct a base map on the 1:250 000 scale, EuroRegionalMap. ICPDR have now signed an evaluation licence of EGM for the coming two years. In the light of the evaluation it is of importance to point out some positive and negative features of the data and the use of it.

Most important for the understanding of the EGM data is to understand how the data was created and what usage rights possible users have. EGM is a composite data set, compiled using a "bottom-up" approach. National Mapping Agencies in every covered country is required to contribute with their part of the covered area. This is a reasonable approach as it to some degree ensures the user that the most reliable and up-dated background data is used for the database. However, data on the national scale used to construct something at the larger scale will inevitable result in a patchwork of data with more or less varying characteristics. Every mapping agency have their own definition of large and small roads, rivers contra streams, city contra village etc and these definition are the reason for the varying characteristics in the data that also have implication on the use of the data and the results of analysis based on the data.

When analysing the suitability of the EGM we choose to distinguish between needs stated in the user needs assessment and data needs for GIS-based large scale analysis. We also try to assess the possible hindrances for making EGM publicly available since the data have strict user right attached to it.

5.2 Contents and relevance of EGM

Table 14 display the contents of the EGM data. It also contain information on whether the specific data layers are required for WFD reporting, if it is suggested to be included in the Danube River Basin GIS (both option 1 and option 2 in the conceptual design paper) and possible other data sources. The point of making such a simple table is to assess whether the data covers many or few of the reporting needs, if those needs can be covered by other sources and whether the data is more or less relevant for the Danube GIS considering other needs than the reporting needs.

Table 14 show that only few layers in EGM are recommended to be included in a Danube GIS. There are some very important layers, particularly the administrative boundaries, river network and named locations but most of the layers are of lower importance for river basin management purposes.

¹⁴ EuroGeographics - <http://www.eurogeographics.org/>

Coverage	Layer	Required by WFD?	Suggested for Danube GIS?	Other possible data sources
ADMINISTRATIVE BOUNDARIES				
ADMIN	Administrative boundary	Yes	Yes	Eurostat, DCW, Bartholomew
HYDROGRAPHY				
WATER	Sea coastline	Yes	Yes	World Vector shoreline, DCW, Bartholomew
	Inland shoreline	No	No	
	River/Stream	Yes	Yes	Eurostat, DCW, Bartholomew
	Canal	No	Yes	Bartholomew
	Ditch	No	No	
	Sea water	No	No	
	Foreshore	No	No	
	Island	No	No	WVS, DCW
	Lake	Yes	Yes	Bartholomew, DCW
	Reservoir	If large enough	If large enough	
	River/Stream, polygon	No	Yes	Bartholomew
DAMWE	Dam/weir	No ?	Yes	
SPRIN	Spring/waterhole	No	No	
GLACI	Borderline of an ice feature	No	No	Corine LC
	Help Line	No	No	
	Glacier	No	No	Corine LC
	Ice peak	No	No	
	Ice shelf	No	No	
	Snow field / Ice field	No	No	Corine LC
FICRI	River / Stream (fictious)	No	No	
TRANSPORTATION				
	Railway	No	Yes	Bartholomew and possibly DCW
	Road	No	Yes	Bartholomew and possibly DCW
	Ferry route	No	No	
	Railway station	No	No	
	Border crossing point	No	No	
AIRPO	Airport / airfield	No	No	DCW, Bartholomew
			No	
BUILT-UP AREAS				
SETTP	Buit-up areas as a point	No	Yes	
CITYA	Buit-up areas as an area	No	No	Corine Land Cover
ELEVATION				
ELEVP	Height point	No	No	
ELEVA	Relief portrayals	No	No	USGS, Hydro1K
NAMED LOCATIONS				
NAMES				

5.3 Evaluation of EGM based on stated needs in the user needs assessment

“We need maps”

Concerning mapmaking EGM is probably a good choice. Discrete and well-defined data are relatively harmonised, there are a lot of named locations in several languages and the data will be updated with time. There will be no copyright problems with publishing and dissemination of paper maps with EGM data as long as the source is acknowledged.

“We need a system on the overview scale”

In the user needs assessment intended users of the GIS database stressed the importance of a Danube GIS on the overview scale, at least initially. The scale of EGM is 1:1 000 000, which likely correspond to the overview scale mentioned by the users. This scale is probably suitable for a Danube GIS. In section 1.4 of the technical documentation of EGM it is acknowledged that the positional accuracy of the data depends on the accuracy of the source data, recommended position accuracy is 1000 meters or at least better than 2000 meter according to the technical documentation. Some people might think that 1000 - 2000 meters is a large error but for management of the huge Danube drainage basin this accuracy is enough for most applications.

“We need a centrally initiated and developed GIS database”

The choice between EGM and other available data sources, e.g. the GISCO database will not make a big difference regarding this need. EGM, GISCO, Digital Chart of the World are all relatively harmonised and are thus suitable for a centrally initiated database as very little time will need to be spent on data harmonisation related work.

“We need public access”

There are strict user rights attached to EGM. The user, ICPDR, will by no means be able to disseminate the vector data freely to third part. ICPDR will however according to the EGM licence be able to give user rights to cooperative bodies in the region such as national institutions, consultants and even research programs cooperating with the ICPDR and having a need for working with the EGM data. Groups with less obvious links to ICPDR such as groups within education, media, NGOs and the public will have difficulties accessing the data. Why is that a drawback?

- Promotion of easily accessible and relevant data leads to an increased use of GI technology, which will affect the future success of drainage basin management.
- Groups not accessing the data will inevitably start working with other data sources leading to some double work being done and several geographical definitions used for the same features

Users not accessing the data as such and/or users not having enough GIS skills will likely benefit from having various web-GIS services as described in “towards a Danube River Basin GIS: A conceptual design”. It is not fully clear if the EGM licence will allow ICPDR to publish the data via web-GIS. Usually such a licence would cost a lot more in addition to a traditional multi-user licence. The licence however allows publication of pixel-based graphics, e.g. raster maps. If this is true and with no exceptions the data could in theory be rasterised to a very high resolution raster data set and disseminated. For most users somewhat skilled in GIS it would not make a bit difference weather the data is in vector or raster format as the conversion between the formats is a relatively simple task. Attribute files can be made available separately and can then be linked to downloaded data by the user after vectorisation. Such actions would however not likely be actively supported by EuroGeographics.

The discussion lead to two important questions that ICPDR need to sort out with EuroGeographics:

- What rules apply to the use of EGM for web-GIS applications? Are all kinds of web-GIS application already supported by the evaluation licence and will they be after the evaluation period has expired? If not, what will the costs be?
- Very specifically, what types of graphical formats and raster formats of the data can be placed in the public domain and what is, if any, the maximum resolution of such graphics or raster files?

5.4 EGM for spatial analysis

EGM is a bottom-up approach data set and is therefore somewhat of a patchwork of data with more or less varying characteristics. Every mapping agency have their own definition of large and small roads, rivers contra streams, city contra village etc and these definition are the reason for the varying characteristics in the data that also have implication on the use of the data and the results of analysis based on the data. In this section we choose to distinguish between discrete and well defined geographical objects such as administrative boundaries and coastlines and more vaguely defined objects/data such as a river, soil data, population data etc. that depend very much on different definitions and classification procedures.

A river is an example of a vaguely defined object; their characteristics are generally not of high interest to the general public. No international standards have been elaborated for the mapping of streams and rivers. Therefore no real effort has been put into harmonised mapping of these objects. Differences between rivers, streams, ditches etc are by no means clearly defined. On a national level definitions may be present but not always and there are clear differences in how these objects are defined in different countries. These differences may create problems for a regional analysis based on the data.

A study from the Baltic Sea Region (Hannerz 2002) assessed the implications of these vaguely defined objects on river basin management. The study clearly showed that these ill-defined objects could mislead a potential user if used on the aggregated scale such as the Baltic or Danube scale. It was shown that the bottom-up approach datasets (EGM) were highly unsuitable for some applications due to its low degree of harmonisation.

The aim of the study was to assess if different definitions of streams and rivers within and between GIS data can give implications on important indicators derived from the GIS data. Drainage density, defined as the sum of lengths of all rivers divided by area, was chosen as an example of such an indicator. Drainage density has become an important landscape characterisation indicator now widely used in hydrological, geomorphological and soil science applications. It can be derived using standard GIS, which is likely the reason for the increase in usage of the indicator. The density of streams can be seen as an indicator of how easily nutrients will be transported from a point in the landscape to the sea. The higher density there is the faster a particle will be transported via the streams downstream towards the sea. Measuring drainage density is therefore a tool for diffuse and point source apportionment.

For the study MapBSR¹⁵ (a sub-set of EGM for the Baltic states) was used as an example of a non-harmonised bottom-up approach data set while Digital Chart of the World¹⁶ was used as an example of a harmonised top-down approach data set. Results were compared and analysed using expert knowledge about the physical characteristics of the region. The results were very different from each other. Analysis based on the MapBSR (EGM) gave high drainage densities in flat areas of the southeastern part of the basin while it gave very low densities in the northwestern part. Expert knowledge concluded that the actual drainage density was rather the contrary. DCW on the other hand gave results on drainage densities very similar to the results from expert knowledge. If the two sources had been used simultaneously in management situation for e.g. an assessment of nutrient, metal or other important fluxes with a substance flow model using drainage density as an input parameter they would probably have yielded very different outputs. One can thus conclude that it is very important for some applications at this scale to use harmonised input data.

Why is this important for the ICPDR? Many applications on the Danube scale for example flood forecasting, modelling of nutrients, metals and other substances etc need harmonised data covering the whole drainage basin rather than more detailed non-harmonised data from national data providers. This problem does not only apply to river network but many other important data for analysis of pressure and impact such as soils data, hydrogeology, Canals, ditches, lakes etc, all being subject to differing classification schemes and definitions.

¹⁵ MapBSR - <http://www.mapbsr.nls.fi/>

¹⁶ Digital Chart of the World - <http://www.maproom.psu.edu/dcw/>

5.5 Conclusions EGM

One cannot simply say that EGM is suitable or not for a Danube GIS. It is highly suitable for some purposes and definitely not suitable for some others. Different users will likely have varying needs for harmonised data. For well defined features such as administrative boundaries the data set will be suitable (considering only the quality of data) but for less well defined data it will be important to include more homogenous data sources in the Danube GIS as an alternative.

A large benefit with EGM is that the data content is “official” data coming from national data sources. ICPDR thereby leaves responsibility for the data content to EuroGeographics in for example disputable land areas, which might otherwise be sensitive.

Spatial analysis - Using EGM for analysis will probably be okay as long as the analysis is based on discrete and well-defined features of EGM such as the administrative boundaries. In other cases one should bear in mind that EGM is not thematically harmonised.

Public dissemination – If dissemination of raster files is allowed with the present EGM licence we see no large drawbacks regarding EGM and the possibilities to disseminate the data alongside the information to a general public. Some questions regarding dissemination to third part and web-GIS publication still need answers since there is a large possibility that such publication might cost large sums on top of the already available licence. This is important since ICPDR in the future very likely is going to request some web-GIS services for map display via the web and other more interactive information services via DANUBIS.

We would like to recommend ICPDR to work further with EGM but first: make very clear what actually concerns dissemination of data to third part both via web and other media.

EGM benefits

- Include some very important base data
- “Official” data on administrative boundaries
- Include updating

EGM drawbacks

- It is a composition of national data and therefore not thematically harmonised
- Only a few of the included GIS layers are relevant for RBM purposes
- It is not a public domain dataset and will thereby have strict user rights. Public dissemination of the data will probably be impossible.

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Appendix 1-Letter of introduction - Danube GIS needs assessment

River basin information in the form of maps or GIS data has an important role to play in Integrated River Basin Management. The EU Water Framework Directive explicitly requests Member States to create maps using GIS technology in their reporting to the European Commission, as well in the development of River Basin Management Plans. Some tasks that can be strongly supported by GIS beyond the mandatory reporting is the river basin characterisation, pressure and impact analysis and in conjunction with the Internet for public outreach and consultation purposes.

For the transboundary Danube River Basin District, all countries cooperating under the DRPC have stated their firm political commitment to support the implementation of the WFD in their countries and to cooperate in the framework of the ICPDR to achieve a single, basin-wide coordinated Danube River Basin Management Plan. Consequently, the ICPDR made *inter alia* the following resolutions at its 3rd Plenary Session on November 27-28, 2000 in Sofia:

- The implementation of the EC Water Framework Directive is considered as being the highest priority for the ICPDR
- The ICPDR will provide the platform for the coordination necessary to develop and establish the River Basin Management Plan for the Danube River Basin.
- The Contracting Parties ensure to make all efforts to arrive at a coordinated international River Basin Management Plan for the Danube River Basin.

In response to the need for GIS tools in preparing a Danube River Basin Management Plan under the WFD, the potential need for GIS in other ICPDR tasks, as well as other WFD requirements, the ICPDR has established a GIS Expert Sub-Group (GIS ESG) within the frame of its River Basin Management Expert Group. The GIS ESG is currently developing an issues paper "Development of a Danube GIS for WFD Implementation" that describes the strategy and the implementation steps for the development of a Danube GIS. In order to support the development of this paper the GIS ESG, with financial support from the UNDP/GEF Danube Regional Project, has assigned us, a team from the KTH – Royal Institute of Technology, Stockholm, to *inter alia* carry out a needs assessment for a GIS database and information system in the Danube river basin. The purpose of this assignment is to gain a clear understanding of the ICPDR's needs for a Danube River Basin GIS database and system, and thereby facilitate the development of an implementation proposal. At this preliminary stage we envisage an implementation proposal that will focus upon four aspects:

1. A technical proposal for the initial development of a harmonised multi-thematic GIS database primarily to meet the WFD implementation requirements and other ICPDR needs including public outreach.
2. A organisational proposal for how this GIS database best can be updated and managed in a sustainable way over time
3. An organisational and technical proposal for how the GIS database best can be exploited by the various expert groups, other groups and stakeholders to produce management and decision-support relevant information. Likely alternatives are either as a centralised GIS solution at the ICPDR PS or elsewhere, or as a decentralised solution, or as a combination of both.
4. Assuming a decentralised solution; a proposal for capacity building efforts for specific groups and Contracting Parties with limited GIS capacity so that they be able to exploit the GIS database for their ICPDR related purposes.

Objectives for the needs assessment

The objectives are to assess the needs of the ICPDR for the development of a Danube GIS in cooperation with the GIS ESG, the ICPDR PS as well as other ICPDR Expert Groups.

The assessment should identify GIS needs:

- of the ICPDR for meeting WFD requirements
- for other RBM tasks
- for other ICPDR activities

Why do we contact you?

Besides reviewing various relevant documents such as WFD Guidance Documents and various ICPDR documents, we would like to conduct semi-structured interviews with relevant representatives of various ICPDR Expert Groups, the ICPDR Secretariat and some other key actors supporting the work of ICPDR that may have constructive ideas on the GIS data and information needs in light of the above objectives. In the enclosed list below you will see whom we plan to interview as representatives from the various groups. You are identified as a relevant representative for your group for one or more of the following reasons:

- You are one of the key persons in the ICPDR organisational structure
- You are identified as having insight into GIS information needs in your expertise area
- You represent an NGO, research group or other external group likely to show high interest in Danube wide environmental information.

How and when do we want to conduct the semi-structured interview with you?

We would like to contact you by phone sometime in the period 8th of April – 15th of April for the interview. We expect that the interview will take around 30 minutes to conduct. For you to be prepared, we attach a set of questions that will guide the interview and allow you to reflect on beforehand. In an attached excel sheet you will find a suggestion for the GIS database contents. The list will be central during the interview, so if you have the possibility to read it though on beforehand we would be very happy. As there are many interviewees on the list, we will simply proceed by phoning you during the above period until we catch you at a time that suits you. If you are away on missions for longer periods, we welcome an email (hannerz@kth.se) specifying when you cannot be reached. If you would rather answer the enclosed questions via e-mail, please send the answers within the same time period as assigned for the interviews alternatively as soon as possible to the same email address as above.

What will happen with the results?

The results from the interviews will be included in the user needs assessment report that later on will form the basis for the implementation proposal. These documents will become available through Danubis and can also be sent you directly, if you so wish.

Best regards,

Sindre Langaas and Fredrik Hannerz

Appendix 2 Interview questions

Information and data

GIS related information can consist of the GIS data but also of derived information such as maps, cartographics and statistical tables. The usability of these products differ depending on the users expertise field and the characteristics of the data (scale, thematic content etc).

GIS data

What types of GIS data does your group possess today?

How do you use it?

Does your group collect any data (not only GIS formatted data but also any kind tabulated data)?

If so, what data is collected and how?

Is the data, or could it be, made publicly available in some format?

Do you except GIS data also use maps, cartographics or statistical tables for your work?

If you were able to freely choose additional data and information, not considering if it is available or not, to support your group activities, what would that be?.

If such data was available, would that improve the results from your group and do you think it would contribute to good river basin management?

Attached to the mail is a list with suggestions of with data layers could be included in a Danube GIS. Do you miss any layer?

Do you have other comments to the list?

Information Systems

A GIS can be set up in different ways. Traditionally the "stand-alone" GIS is used where data and software is stored locally on a computer and used by the GIS expert. An alternative is to use a webGIS approach where all users have access to a common GIS database via a web interface.

Would your group benefit from having a central web based GIS were data could be uploaded, downloaded and distributed?

Do you think that the data and information contained in such a GIS should be publicly available?

One alternative to the "bottom-up" approach for constructing a database, i.e. putting together a patchwork of national datasets into a Danube wide database is to use more coarse, but hopefully more homogenous data for the whole region in.

How would your group benefit from having?

- a) A database with high spatial precision but low degree of harmonised data and possibly data with a lot of user restrictions on it?
- b) A database with lower spatial precision but higher degree of harmonisation and more freedom of use.

GIS training

In order to successfully work with a Danube River Basin GIS the users need to have enough GIS skills. Skills required would include data handling (e.g. data editing, data harmonisation) meta data compilation, data transformation and data analysis.

Considering the above stated requirements, do you think training is needed in your group?

If so, what kind of training and to what extent?

Considering your group, do you think some of the country representatives in the group have larger training needs than others in order to fulfil the requirements from a Danube GIS?

Appendix 3: List of interviewees, user needs assessment

Following persons were interviewed concerning their respective groups GIS user needs.

Ms. **Juliana Adamkova**, Slovak Hydrometeorological Institute, member of the MLIM EG

Ms. **Jasmine Bachmann**, project manager Danube Watch.

Mr. **Gabor Balint**, chief scientific researcher at Vituki Consult Rt, member of the Flood Protection EG,

Mr. **Károly Futaki**, Information Management & Admin Officer, ICPDR permanent secretariat.

Mr. **Andy Garner**, Environmental Specialist, UNDP/GEF

Mr. **Detlef Günter-Diringer**, WWF-Aueninstitut

Ms. **Visnja Omerbegovic**, chairman of the RBM/GIS ESG

Ms. **Mihaela Popovici**, Technical Expert on Water Management (Pollution Control), ICPDR permanent secretariat.

Ms. **Ursula Schmedtje**, Technical Expert on River Basin Management at the ICPDR permanent secretariat and member of the RBM EG

Mr. **Anatoliy Shmurak**, Ministry for Environmental Protection and Nuclear Safety, Ukraine, GIS facilitator of the APC Expert Group

Ms. **Heide Schreiber**, PhD student, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, co-worker in the Danubs research project

Mr. **Ulrich Schwarz**, FLUVIUS, technical support to the RBM/GIS ESG

Mr. **Franz Überwimmer**, Amt der Oberoesterreichischen Landesregierung, Linz, member of the Emission Expert Group

Appendix 4: Some important next steps

Development of the Danube River Basin GIS 2003 - 2006

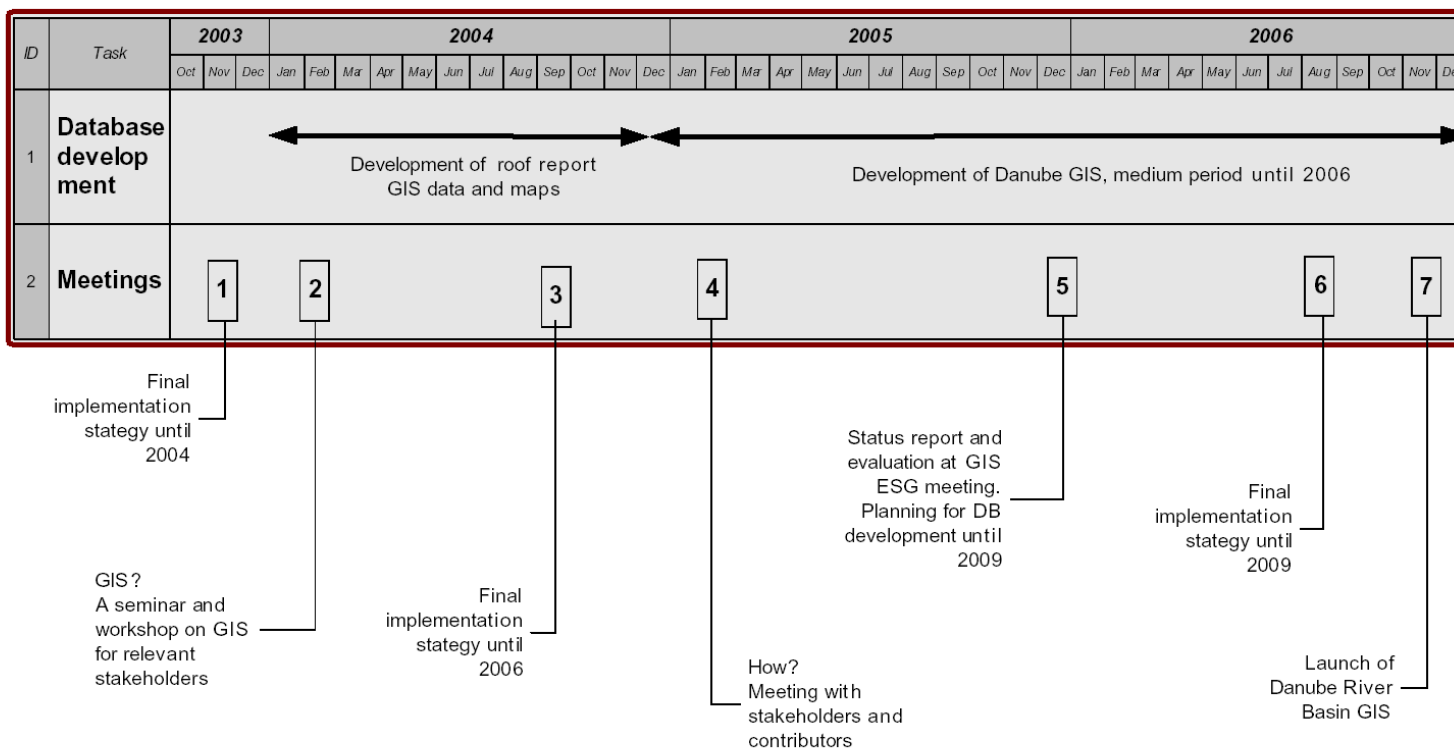


Figure 10. Time chart for GIS database development until 2006.

Meeting number	What?	Purpose	Contents:	Comments:
1	Final implementation strategy meeting for the period until end of 2004.	Elaborate a final implementation strategy for the DRB GIS until end of 2004 in order to produce necessary GIS data and maps. Development of a terms of reference for consultant		
2	Seminar and workshop on the role and use of GIS for sustainable river basin management	To get a broad agreement on purpose and scope of a Danube GIS Visualise how GIS can be used for sustainable transboundary river basin management. as a tool for analysis, visualisation and outreach Via a workshop educate and inspire river basin managers to continue with GIS in the Danube RB.	2-4 best practice presentations by inspiring people actively using GIS as a tool for European transboundary river basin management Workshop on how the presented ideas and others can be applied to the Danube River Basin.	The seminar and workshop should be directed towards people involved in the transboundary aspects of river basin management. National and Expert Group Facilitators could be the target group. Especially Expert Group Facilitators are in the position to know the needs/tasks within the EGs.
3	Final implementation strategy meeting for the period until end of 2006	To elaborate a final implementation strategy for the DRB GIS until end of 2006 based on results from workshop, WFD requirements and proposed extensions of the Danube GIS.		
4	A planning meeting and workshop for a few stakeholders and contributors to the Danube BD GIS.	Gain experience from existing transboundary GIS database initiatives in the Danube River Basin To assess how existing DRB wide GIS data can be integrated into the DRB GIS. To integrate knowledge from applied GIS modelling projects in the region		A lot of relevant transboundary and DRB wide GIS data already exists developed for various purposes. It is of highest importance to integrate available data sources into the Danube GIS. Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin involved in the Danubs project have developed a harmonised multi-thematic GIS database for the Danube River Basin already that is of very high relevance for the proposed database. Joint Research Centre in Italy are involved in GIS integrated modelling for the Danube and have a lot relevant data covering the area as well. Another example is WWF Aueninstitut where relevant floodplains data have been

			derive for the Danube. GIS database developer/developers, a few people from GIS ESG and RBM EG, relevant representatives from the Danubs project, JRC, WWF Aueninstitut should be invited to this meeting.
5	GIS ESG meeting with a status report on and evaluation of the development of the Danube RB GIS so far.	<p>To check the status of the GIS database development</p> <p>To discuss activities and applications to be developed after the initial database development</p> <p>To discuss upcoming questions concerning data exchange, data access and WFD reporting</p> <p>To outline the continuation of the GIS database until 2009.</p> <p>To plan the Danube RB GIS launch.</p>	
6	Final implementation strategy meeting for the period until end of 2009	To elaborate a final implementation strategy for the DRB GIS until end of 2006 based on results from workshop, WFD requirements and proposed extensions of the Danube GIS.	
7	Launch of the Danube River Basin GIS	<p>To present the GIS database to the ICPDR EGs</p> <p>To get publicity for the dissemination of the database via DANUBIS</p> <p>Media attention</p>	GIS database developer, ICPDR EG representatives, ICPDR PS, UNDP/GEF, relevant NGOs, database contributors.
