



## A Web-Based Spatial Data Visualization Tool for Yantra River Basin Area

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**Abstract:** The rapid progress in web mapping technologies has enabled generation of vast amount of spatial data worldwide. The extraction of appropriate information is a big challenge. Spatial data visualization, dissemination and sharing could be accomplished through the use of web-based GIS applications, giving also the opportunity to perform a number of analyses of the data.

The main goal of the current work is to provide a comprehensive user-friendly visualization tool of available spatial data for the case study area of Yantra River Basin. The application enables users to view natural resources data. The approach integrates open source technologies for development of web GIS applications and tools serving to disseminate the data through the web. Flexibility, extensibility and interoperability of the open source software solution have stimulated the development of the tool. The spatial data-viewer allows users to visualize and interact with the spatial data.

**Keywords:** web-based GIS, open source software, geovisualization.

### INTRODUCTION

Geospatial information redundancy in the last decades has led to a rapid development of great variety of geospatial approaches, tools and applications used in a wide range of different fields. Information and Communication Technologies (ICTs) play a critical role in this development and affect business, industry and people's daily lives. The vast amount of generated data through the advanced ICTs as remote sensing - satellite-borne observations and measurements, Global Positioning Systems (GPS), digital photogrammetry, internet-based sensors etc. has reflected in growing social impacts and benefits in knowledge, management and decision making processes. The technical advances in hardware, software and data management have been fundamental for the geovisualization development. The geovisualization combines the strengths of the human creativity and general knowledge with the computational power to explore knowledge from large geospatial datasets. A driving force for geovisualization progress is the rapid development of internet-based applications and the use of Internet as a medium for dissemination of geospatial data and maps. In general the Web paradigm shifted from passive to intelligent web respectively, influencing the web services and content in order to fit the users' demands.

The study of different aspects of visualization requires a multidisciplinary and multidimensional analysis. In fact the revolutionary innovation in geovisualization has been made by the interactive maps design, which leads to users deeper involvement and expands data sharing processes, developing also the collaborative dimension of data visualization.

The collaborative effort to share data resources and development experience has been greatly increased through the Open Source paradigm. Two main organizations have been coordinating the development of the open specifications - the OpenGIS Consortium Inc. (OGC) [8] and the World Wide Web Consortium (W3C) [14]. In 1999, the Open Geospatial Consortium (OGC) has begun establishment of Web Map Services (WMS) standards. The OGC comprising hundreds of companies, universities and government agencies participating in the process of developing public standards supporting interoperable solutions for geo-web, location-based services and data flows. Strategic Goals of the OGC includes provision of free available standards, delivery and integration of geospatial content and services and support in creation of innovative applications for geospatial technologies [9].

The open standards approach coupled with open source software allows easier resource and experience sharing resulting in development of great number of customized applications. The Open-Source Systems have expanded in different directions covering the whole range of software applications and tools development.

Main driver for data standardization from a European perspective is the INSPIRE (Infrastructure for Spatial Information in Europe) directive (Directive 2007/2/EC) of the European Parliament and of the Council [6, 4]. The goal of INSPIRE is to build an infrastructure for provision of harmonized spatial information across the members of the European Union (EU), supporting European and national environmental policies or activities, which may have an impact on the environment [7].

The current research work represents a visualization tool for a middle range river basin in Bulgaria.

### STUDY AREA

The research area is located in the central northern part of Bulgaria, characterized by sloping alluvial basins. Yantra River is the second largest among the Bulgarian tributaries of the Danube river in terms of catchment area - 7 862 km<sup>2</sup> and with a length of 285 km (*Fig. 1*). The spring is at the foot of Hadji Dimitar (Buzludja) peak in Shipchenska Stara planina mountain and the river flows

into the Danube near the village of Krivina at an altitude of 18 m above the sea level (a.s.l.). The mean elevation of the river basin is 470 m and the altitude varies in a wide range [2].

The river has five major tributaries, which constitute one of the largest surface water drainages within the Danube Basin Directorate. The left tributaries are: Rositsa, Eliiska and Studena rivers, and the right ones - Dryanovska and Lefedzha [13].

Because of the low inclination (4,6 ‰) in the Danube Plain the main river meandering and has the highest tortuosity coefficient of 3,1 at the Bulgarian territory, especially in the region of Dolna Oriyanovitsa, Varbitsa and Draganovo villages. The density of the river network varies from 0.7 km/ km<sup>2</sup> for the main river to 1,5 km/km<sup>2</sup> for the upstream tributaries [3].

The water resources of Yantra river basin are characterized by a complexity of their use for water supply, irrigation, waterpower production and ecological purposes [1]. Yantra River high water occurs in March - May period when the snow melt and rainfalls over the catchment area are coupled, and the low water is during August- September period. The average discharge to the Danube River confluence point is evaluated at approximately 50 m<sup>3</sup>/s.

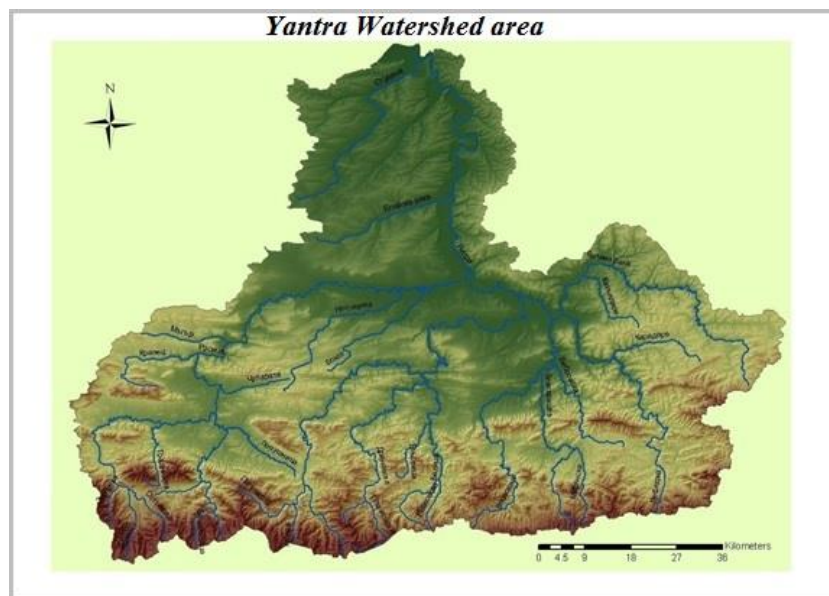


Fig. 1 Yantra River Basin

There are 16 hydrological stations over the whole catchment area - 3 along the main river, and the rest at the tributaries. Oak and beech trees cover 2250 km<sup>2</sup> of Yantra River drainage territory and the total forestation area is estimated at 28%.

## METHODOLOGY

The visualization is a complex process consisting of data processing phase (data selection, filtering, annotation, aggregation etc.), a phase of analysis (pattern detection, overlaying analysis, cluster analysis, index or indicators development, statistical or comparative analysis etc.) and finally the phase of visual data representations.

Web application architecture is fundamental in building a customized web tools for visualization or other purposes. It involves the infrastructure for the web development. Most Internet map servers consist of a three-tier architecture for the system implementation (Fig.2).

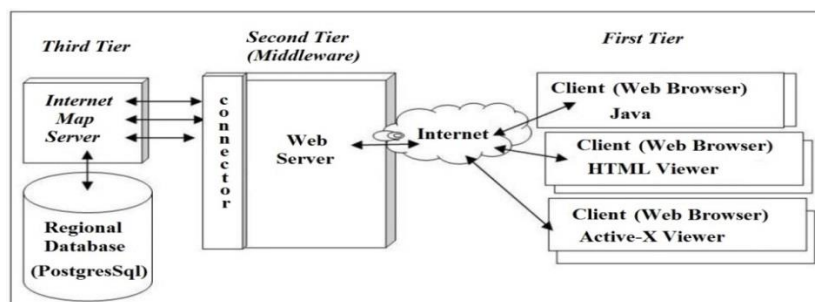


Fig. 2. System Architecture of a web-based Geoportal application [http://map.sdsu.edu]

The first tier is called “the client tier” and includes the user-side web browser and user HTML documents or Java applets. The client tier is used for making requests by the users and for viewing maps and remote sensing data. The second tier is the middleware tier that includes the Web Server and the Server to bridge the communication between clients and the map servers. The third tier is the data storage tier that includes the map server and the database server. The three-tier software architecture of web-based GIS provides customizable functions for different mapping applications and scalable implementation for different hardware [10].

## RESULTS

A preliminary research has been done in order to choose a proper open source solution for the development of the web application. The abundance of the approaches makes the choice complicated. The open source software configuration that has been chosen for the data processing, database development, map server and the framework, with the respective libraries is the following:

- **QGIS** for data processing
- **PostgreSQL** for the database
- **GeoServer** for a Map Server
- **GeoExt (JS toolkit)** for the Web Mapping Application
- **OpenLayers, Leaflet, jQuery etc.** – libraries.

The geospatial data are obtained from wide range of data sources - JICA project, NATURA 2000, DIVA-GIS, WorldClim - Global Climate Data, and some additional projects [5, 11, 12, 15].

The proposed viewer has been developed for displaying mainly water related data. It contains also datasets with social-economic and environmental information. The architecture of the application consists of three subcomponents: RDBMS (Relational Database Management System), web-based mapping component and a website. The various datasets are preprocessed in **QuantumGIS** open source GIS software (Fig.3) and transferred to a database in **PostgreSQL** open source geospatial database [18, 19].

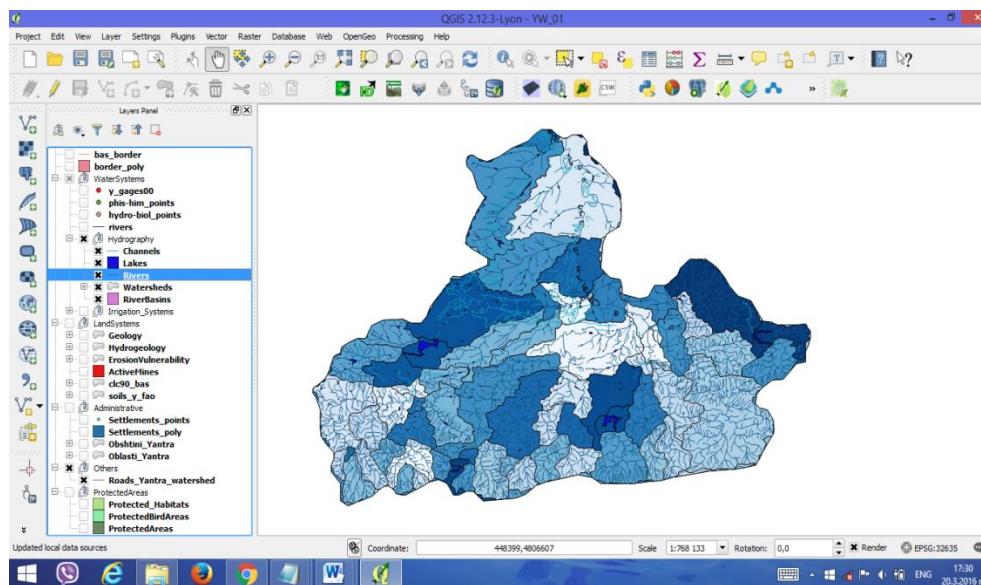


Fig. 3. Processed layers of Yantra River Basin Area in QuantumGIS

The datasets include vector and raster data. The visualization gives the opportunity to compare the various features of the watershed. The datasets are organized in thematic groups – Hydrography, Irrigation systems, Land Systems, Administrative etc.

The data are the heart of the hydrological modeling process. The inconsistencies or data gaps may lead to misleading or poor results. The geodatabase combines the geospatial data with the data repository to create a central data repository for spatial data storage and management. For the case study area a geodatabase of Yantra river basin and its tributaries was developed. The geodatabase offers storage of rich collections of spatial datasets into a centralized location with respective data relationships and defined rules (topologies).

The geodatabase supports different types of GIS data, such as geographic features, attribute data, satellite images (raster data), GPS coordinates, survey measurements etc.

The data are in WGS 84 UTM Zone 35N projection (EPSG: 32635)

The data-layers from the database have been uploaded to the GeoServer – a java-based server providing a number of open standard services such as *Web Feature Service (WFS)*, *Web Map Service (WMS)* and *Web Coverage Service (WCS)* used in

geospatial data processing [20]. The WMS service was used for the data-layers included in the viewer. The styling of the layers was accomplished using the Styled Layer Descriptor (SLD). uDig open source software was used for the processing of the SLD – files before uploading them on the GeoServer. The SLD-files generated in QGIS do not support the labeling function.

For building the framework different types of mapping libraries were used. The main library was **OpenLayers** JavaScript library which is used as an API for development of web-based geographic application. The OpenLayers is a client-side web mapping framework for integration of various data sources, among them Google Maps, Bing Maps, Yahoo Maps, OGC services, and some others [17]. OpenLayers is one of the most popular web mapping clients, used in both open-source and proprietary web mapping solutions.

The external portal is the public section of the portal used in the interaction with the public. It can be accessed from outside. The functionalities on the site are available for general public (without authentication) at the external portal. The application allows data access, visualization of a range of layers on the map, zooming and moving the maps, allows distance measuring, resources grouping and some functionality through a navigation bar. The base map could be changed into a satellite one or other type open source map (Fig. 4).

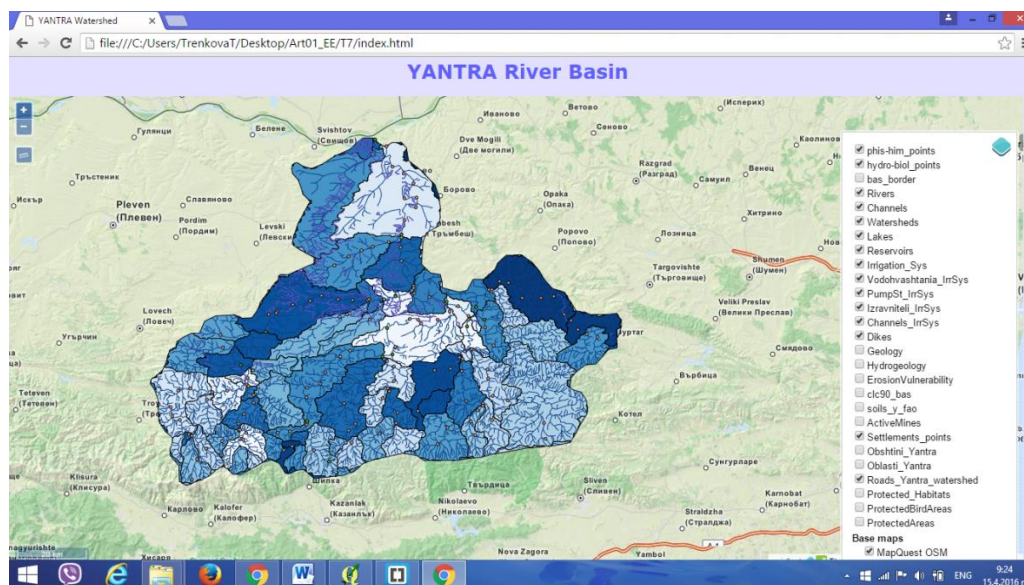


Fig. 4. A snapshot of the interface of the Geoportal with several activated layers

The JavaScript Toolkit GeoExt, which combines the geospatial functionality of the OpenLayers library and the user interface of Ext JS was used to build the GIS Web Mapping Application viewer on the web [16].

## CONCLUSION

Data heterogeneity requires strict standardization rules for the available geospatial data in order to improve the interoperability between the various applications and the spatial data platforms. The OGC standards are applied to solve this issue.

The proposed prototype of the spatial data web-viewer is not a final version, some additional functionalities will be added in order to make it more useful for wider range of users with specific needs. It could be a part from a broader web-platform for Yantra River Basin case study area. It could be used for assessment of the natural resources, evaluation of some environmental patterns, understanding of the environment, geology, topography etc. The next steps are directed to development of additional modules adding interactive functionalities. The final version is expected to be hosted next year.

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