Web based Geo-Spatial and Village Level Information Extraction System using FOSS

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Abstract— Increase in the number of commercial and open source tools for geospatial applications have resulted in confusing environment among students / researchers, institutions and consultants while selecting software tools. Also geospatial software applications require more time and money in design and development. To demonstrate the use of free open source software (FOSS) for geospatial data management, a system was designed for extracting geospatial information content from spatial database and practical issues during development are described in this paper.

Index Terms— FOSS, GIS, Data extraction, Village information system.

I. INTRODUCTION

In a developing country like India, the 73% of the population resides in rural area and cannot subscribe commercial software. Though number of tools are available for web based spatial information system, each one of them have some restrictions, such as cost, license, internet connectivity, availability of skilled person, etc. To overcome such problems, open source tools are better solutions. Open source geospatial tools provide facilities such as cost effectiveness and it can be customized according to user needs. Also, various spatial queries can be made for better decision making. They are helpful in monitoring various rural development schemes run by government [2].

The GIS provides a systematic spatial and attribute database, which is prerequisite for implementing development and research projects, for drawing development strategies that are sustainable, area specific and take into account the local needs; and to facilitate the process of decentralized (to smaller unit i.e. district or below) planning and for more timely response to promote effective administration, planning, decision making and development process. Study aims at understanding basics of open source software and further focusing on need and capabilities those software tools by taking case of web based information system.

II. OPEN SOURCE GEO-SPATIAL TOOLS

Geospatial Data: Almost all information to support rural development has a strong geographical context. Geospatial data include geographic coordinates (e.g., latitude and longitude) that identify a specific location on the Earth; and data that are linked to geographic locations or have a geospatial component (e.g., socio-economic data, land records, land surveys, homeland security information and environmental analyses).

FOSS are those software that have licenses that allow users to freely run the program for any purpose, modify the program as they want and also to freely distribute copies of either the original version or their own modified version.

A. Need for Open Source Geospatial Software Tools

The last 20 years have seen dramatic developments in GIS technology and geographical information science. High competition and growing user demand has resulted in a number of high-quality solutions, which are largely responsible for the vast increase in the GIS marketplace [1]. But the commercial software are not so much popular in small development projects because:

- Inadequate funds for uniform software setup.
- Poor support for commercial software packages.
- Diverging needs within one organization.
- There are a lot of restrictions for access to source code.
- Installation cost is too high, hence not economical for small project.
- User should have deep knowledge of the software.
- Inadequacy of standardized format for results (i.e., varying file and data formats).

B. Advantages of Open-source Geospatial Tools

- Access to source.
- Enables development of highly customized applications based on client’s needs.
- Development priorities are driven by end-user needs.
- No licensing fees.
• Resources are allocated for building the applications.
  No licensing multiple machines.
• Interoperability, adoption of open specifications.
• Developers listening to users directly.
• Issues can be resolved in-house.
• Affordable and high quality.
• Open source software has fewer defects, because if defects are present, they get repaired faster.
• Free as in freedom.

FOSS guarantees four fundamental freedoms, (i) To run the program for any purpose. (ii) To study how the program works, and adapt it to your needs. (iii) To redistribute copies. (iv) To improve the program and release your improvements to the public, so that the whole community benefits [3].

III. DESKTOP AND WEB APPLICATIONS OF OPEN SOURCE GEOSPATIAL TOOLS

A web service can discover and invoke any service anywhere on the Web, independently of the language, location, machine, or other implementation details. The goal of Semantic Web Services is the use of richer, more declarative descriptions of the elements of dynamic distributed computation including services, processes, message-based conversations, transactions, etc. [21].

A. Natural Resource Data Base (NRDB)

NRDB Pro is a GIS tool for developing and distributing environmental databases. Its aim is to provide people in developing countries with a powerful yet simple tool to assist in managing their own resources.

The natural resources database software was originally developed for the Bohol Environment Management office, provincial government of Bohol, Philippines, by Richard D. Alexander, with the assistance of voluntary service overseas. This was supported through the skills for community-based resource utilization and management (SCRUM) program. SCRUM was a four-year project partly funded by the European Union (EU) and the British Embassy. The goal of the project was to promote effective resource management by communities so as to ensure food security and well-being, alleviate poverty and prevent further depletion of valuable natural resource in which their livelihoods depend [12].

B. Quantum GIS (QGIS)

Quantum GIS is a Geographic Information System that runs on Linux, Unix, Mac OS X, and Windows. The QGIS supports vector, raster, and database formats. It can access databases like PostGIS, in addition to the dozens of other vector and raster formats. It supports feature labeling and has a great user community. Extensibility is provided through a plugin environment [16].

C. Integrated Land and Water Information System (ILWIS)

The ILWIS is desktop GIS & Remote Sensing software, developed in the Netherlands by ITC up to its last release (version 3.3) in 2005. ILWIS software is available as open source software under the 52° North initiative (GPL license). Its powerful image processing functions make it a highly useful tool for natural resources management and for organizations that need to process orthophotos or satellite imagery for base mapping [9].

D. GeoServer

GeoServer is an open source software server written in Java that allows users to share and edit geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards. Being a community-driven project, GeoServer is developed, tested, and supported by a diverse group of individuals and organizations from around the world. GeoServer is the reference implementation of the Open Geospatial Consortium (OGC), Web Feature Service (WFS) and Web Coverage Service (WCS) standards, as well as a high performance certified compliant Web Map Service (WMS). GeoServer forms a core component of the Geospatial Web [5].

E. POSTGRESQL

PostgreSQL is an object-relational database management system (ORDBMS) based on POSTGRES, Version 4.2, developed at the University of California at Berkeley Computer Science Department. POSTGRES pioneered many concepts that became available only in some commercial database systems much later. PostgreSQL is an open-source descendant of this original Berkeley code. It supports a large part of the SQL standard and offers many modern features: complex queries, foreign keys, triggers, views, transactional integrity, multiversion concurrency control [15].

F. PostGIS

PostGIS adds support for geographic objects to the PostgreSQL object-relational database. In effect, PostGIS "spatially enables" the PostgreSQL server, allowing it to be used as a backend spatial database for geographic information systems (GIS), much like ESRI's SDE or Oracle's Spatial extension. PostGIS follows the OpenGIS "Simple Features Specification for SQL" and has been certified as compliant with the "Types and Functions" profile [14].

IV. HOW OPEN SOURCE GEOSPATIAL TOOLS CAN BE USED FOR RURAL DEVELOPMENT?

Recent advances in the domain of spatial technology are making considerable impact in planning activities. This type of planning is more important in countries like India where rural population is more and is having variations in geographic patterns, cultural activities, etc. One of the strongest points in favor of open source geospatial tools is that they are cost effective. By using open source geospatial tools, planning work can become simpler and cost effective. It is helpful in monitoring the rural development schemes and various spatial queries that can be run for analyzing the problem.
Various maps can be generated using open source geospatial tools, which provide an added dimension to data analysis by Geo-visualization.

- Administrative Map, Village Location Map, State Highways Map, Major District Roads.
- Map of Village Roads, Light Vehicle Roads (Matelled, Un-matelled), Roads Under construction, Prime Minister Roads Under Construction.
- Map showing Child and Maternity Welfare Centres, Ayurvedic, Allopathic, Homeopathic Hospitals, Community Health Centres, Public Health Centres, Base Hospital, District Hospital, Civil Hospital, Women Hospital etc.
- Perennial Water bodies Non Perennial Water bodies of District, Forest Cover of District, Agriculture Land map, etc.
- Service area map, showing accessibility of service facility from villages or to villages.
- Map showing drought affected area, flood affected area can be prepared.

V. WEB BASED SPATIAL INFORMATION SYSTEM OF STUDY SITE

In order to demonstrate the use of open source tools for web based spatial information system was designed and tested on the stand alone platform and local area network. The state, district, taluka and village level data was obtained from Latur district spatial database. The NRDB (free open source software) is used to develop the spatial database.

A. Methodology

The tools selected were, NRDB for the geo-referencing and generating different outline layers from the maps. GeoServer for windows consists of set of Apache web server, etc. which were used for visualizing information over front end. POSTGIS is used to build spatial query module facilitating panning, zooming and selecting region to view the database in POSTGRESQL. Relational database management tool POSTGERSQL server was used to store data and PHP facilitated querying on database in the form of simple and complex non spatial queries. Open source content management system ‘QGIS’ was used to design the front end consisting of user account. The open source software used in this context are shown in Figure 1.

B. Structure of the Proposed Information System

The internal logical structure of proposed information system is shown in Figure 2, which also shows interactivity with different parts of the system, and figure 3 shows the front end information systems. The complete documentation of the system is done in order to facilitate the next user in future to develop the better system than available.

Figure 1. Process flow of spatial information system

Figure 2. Logical Structure of Proposed Information System

Figure 3. Front end of Information System

Figure 4. Web based Spatial Information System at http://localhost:8080
management through enabling or disabling of different loaded map layers like, village locations, digital elevation model (DEM), ASTER Satellite Imagery, Multicolored elevation contour line, etc. The layers are as shown in left panel (i.e. Map Layers) of Figure 4. Apart from these, a user can also use some more features of this system i.e. map navigation, zooming, scale manipulation, geolocation display, measuring distance, measuring area, etc.

C. Filter Map Attributes

Extraction of data with respect to user need is the key factor of this system. The above said system is designed for villages level information system, and allows users to extract any kind of village level information through filtering their attributes using common query language (CQL).

<table>
<thead>
<tr>
<th>Attribute1</th>
<th>Op</th>
<th>Attribute2</th>
<th>Logical Op</th>
</tr>
</thead>
<tbody>
<tr>
<td>Village Name</td>
<td>= =</td>
<td>X-(User defined value)</td>
<td>AND</td>
</tr>
<tr>
<td>House Holds</td>
<td>! =</td>
<td>Total Male- Population</td>
<td>OR</td>
</tr>
<tr>
<td>Total Population</td>
<td>&lt; &lt;=</td>
<td>Total Female- Population</td>
<td></td>
</tr>
<tr>
<td>Total Male- Population</td>
<td>&gt; &gt;=</td>
<td>Total Literates Total Male- Literates</td>
<td></td>
</tr>
<tr>
<td>Total Female- Population</td>
<td>LIKE</td>
<td>Total Female- Literates Total Male- Literates</td>
<td></td>
</tr>
<tr>
<td>Total Literates</td>
<td></td>
<td>Total Female- Literates Total Male- Literates</td>
<td></td>
</tr>
<tr>
<td>Total Male- Literates</td>
<td></td>
<td>Total Percent- Literates Total Male- Percent- Literates</td>
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</tr>
<tr>
<td>Total Female- Literates</td>
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<td>Total Female- Percent- Literates Total Female- Percent- Literates</td>
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<tr>
<td>Total Illiterates</td>
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<td>Total Illiterates Total Illiterates</td>
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<td>Total Male- Illiterates</td>
<td></td>
<td>Total Male- Illiterates Total Male- Illiterates</td>
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<td>Total Female- Illiterates</td>
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<td>Primary Schools</td>
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<td>High Schools</td>
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<td>Colleges</td>
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<td>Colleges Colleges</td>
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<tr>
<td>Primary Health- Centers</td>
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<td>Primary Health- Centers Primary Health- Centers</td>
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<tr>
<td>Sub Centers</td>
<td></td>
<td>Sub Centers Sub Centers</td>
<td></td>
</tr>
<tr>
<td>Sex Ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Village- Performance (%)</td>
<td>= =</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The server side CQL are written to execute queries automatically through selecting the villages level attributes and operators which are provided in different list boxes in the filter attribute module (top left corner in Figure 4). The list of all attributes and operators of filter attribute module are shown in Table 1. By combining or selecting different attributes and their appropriate operators, user can extract the useful information from this system. Following are the few examples demonstrated to showcase the use of filter attribute module.

VI. RESULTS AND DISCUSSIONS

With respect to the above discussed concepts, the followings are few examples and results extracted from the proposed system.

Example 1:
Consider, a user would like to extract the information with multiple conditional expressions like, which villages are having more illiterates than literates and their sex ratio is below 1:1 (male to female).

The attribute filtering using logical AND, OR are used to execute multiple conditional expressions, and they can be processed using the fields provided in the filter module. This example will execute the query with following CQL statement.

```
New_Map = SELECT * FROM VILLAGES1 WHERE Totillit > TotLit AND SexRatio < 1 ;
```

The above query will extract the spatial locations of all villages which are satisfy the above query conditions, and they are shown in the Figure 5.

Example 2:
Extract all villages in which their names either starts with character ‘S’ or ‘T’. Here the LIKE operator is used to complete this task. The following query is processed and the result is shown in Figure 6.

```
New_Map = SELECT * FROM VILLAGES1 WHERE Villages LIKE 'S%' OR Villages LIKE 'T%';
```

The above query will extract the spatial locations of all villages which are satisfying the above query conditions, and they are shown in the Figure 5.
Example 3:
The system can be used to extract/query information through clubbing more than one attributes at the same time. This example demonstrates that, one can extract village, elevation, river, taluka etc. information by executing a single query by clubbing multiple conditions of multiple attributes. The following are the few attributes used with different conditions within a single query to extract needful Geo-information.

- Show all villages, which are having PHCs.
- Show all rivers, whose name starts with ‘M’
- Show taluka area and location, whose name is ‘Udgir’
- Show all elevation contour poly lines, having greater than or equal to 550 AND less than or equal to 600 surface height.

The following query can be executed by selecting proper attribute 1, attribute 2 or user defined values and logical operators from filter attribute panel. The query will be

\[
\text{New\_Map} = \text{PHC}==1 \text{ OR Rivers LIKE 'M%' OR Talukas == 'Udgir' OR (ELEVATION >=550 AND ELEVATION<=600)}. 
\]

The Figure 7 shows the extracted information resulting from the above discussed query.

The main advantages of the system are:

- Centralized control over data & model resulting in lower costs for hardware, software, distribution, maintenance and training as well as more efficiency in model improvement and data update, particularly, for models with dynamic and real time information.
- The simple GUI and user friendly way to query/extract the village level information.
- Users do not need professional GIS knowledge, training or expensive and complex hardware and software as web based systems are platform independent.
- Allow public and stakeholders to access and participate in planning and decision making processes.
- Other facilities such as education, market changes, agriculture information and information of government schemes can be made available through the same system.

VII. CONCLUSION

In this paper, how one can design, develop and explore the spatial (geographical) information of a particular area, spread on internet in the form of web based spatial information system using open source geospatial tools. This chapter also deals with the following issues:

- Open source software can solve some of rural India's social, political, and administrative challenges and create a viable & cost effective technology for the provision of health, education, and other social services.
- Open source geospatial tools provide an added dimension to data analysis which helps in visualizing the real world complex problem.
- It’s easy to modify using source codes of software tool rather than building new which facilitates the conservation of financial resources.
- Voluntary organizations can get better software tools for spatial and non spatial study helping in planning and management of development work.
REFERENCES


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