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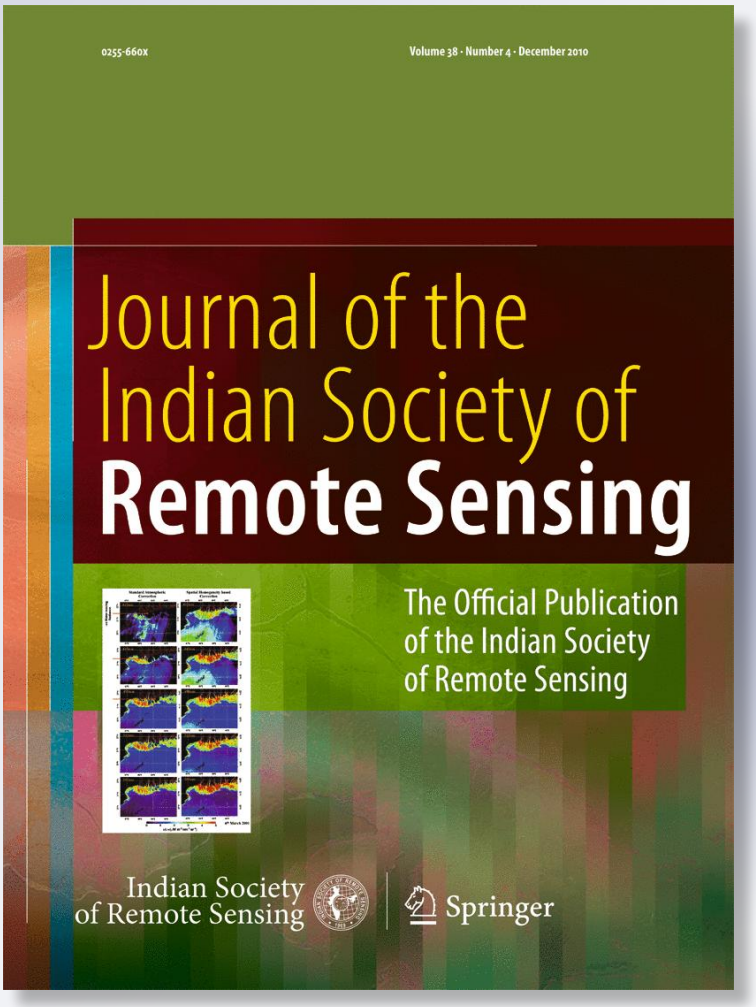

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RESEARCH ARTICLE

A Web GIS Application for Dams and Drought in India

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Abstract Dams and diversion are built in India for meeting needs of water and energy. Due to variability of monsoon in space and time, precipitation falls short or exceeds causing in extreme cases drought and floods respectively. Water resource planners and engineers need information on dams and diversion. Drought information is needed in disaster management. For dissemination of these spatial data, Web GIS technology can be utilized, which is amalgamation of several information technologies. For Web GIS application, a high end, powerful and open source software, namely Mapserver is available. The software is CGI technology based. An application on dams and drought information for India is conceptualized using Mapserver. It is planned to write the application by modifying available tutorial. This will require writing DHTML pages, writing logic, using available libraries etc. Separate DHTML pages will be written for dam and drought applications. For dam application pages will be written for storage, hydropower and all dams. The drought application will provide maps of rainfall over districts for different SPI and time scales.

Keywords Web GIS · Dams · Drought · SPI · India · Mapserver

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Introduction

Due to seasonal nature of monsoon precipitation in India, nearly 75–90% rainfall occurs in monsoon months. Other months receive scanty rainfall. There is also an inter annual variability in rainfall. Since surface water is quickly drained from the river basins, the availability of water in the rivers deplete in non monsoon months. The water demand will need to be met from surface water storages and groundwater. Since groundwater storages are limited compared to the surface water, large demand is met from surface storages. To meet increasing demand in the country, surface water storage and diversion projects were completed. Many projects are still on going and under planning stage. Information of projects can be useful of planning and operation of the projects. Up to X plan 442 major and 1,230 medium projects were taken up. Out of these 276 and 1,008 were completed (anticipated figures). Thus, total major and medium projects taken up and completed are 1,672 and 1,284 respectively. In the XI plan period the ongoing major and medium projects in the country are 166 and 222 respectively. Thus, total 388 major and medium projects are ongoing. Major and medium projects proposed are 78 and 145 respectively. Projects targeted for completion during the plan are 72 and 133 (Anon 2006).

Drought and floods are major natural disasters affecting agriculture, industry, power generation and domestic water supply in the world. The disasters occur due to abnormal summer monsoon in India. South-west

monsoon occurs in four months, namely from June to September. Due to global climatic factors, rainfall varies from its normals. Significant deficit in rainfall results in drought. About one third of the total geographical area of the country is recognized as drought prone. There are 99 districts in 14 states identified as drought prone districts. These districts have cultivable area of about 77 Mha which is about 42% of the country's total cultivable area of 184 Mha. Among the States, Gujarat and Rajasthan are the most droughts prone followed by Karnataka and Maharashtra.

To monitor the drought, indices play an important role. Several indices are available from simple percentage deviation from normal to complex indices based on water balance concepts. Indian Meteorological Department (IMD) uses a simple index, namely percent deviation from normals. Standarized Precipitation Index (SPI) was devised by McKee and others (1993) (vide Hayes 2006; Anon 2005). SPI is used in USA and many other places. IMD gives two categories for droughts, namely moderate and severe, for meteorological sub divisions in India based on the percent deviation from normal. For a given period a rainfall deficiency between 26% and 50% from mean results in moderate drought. A deficiency of more than 50% results in severe drought. SPI utilizes probability distribution for the rainfall data. Rainfall time series have negatively skewed distribution with smaller rainfall magnitudes occurring with larger frequencies. Gamma probability distribution function provides better fit for the data. For a cumulative probability for a rainfall total, the value of standard normal variate is SPI. The classes of dryness and wetness for SPI are given in Table 1. The class limits have fixed probability of occurrence.

Table 1 Classifications of SPI

SPI	Drought/Wetness condition
2 and above	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
−0.99 to 0.99	Near normal
−1.0 to −1.49	Moderately dry
−1.5 to −1.99	Severely dry
−2.0 and less	Extremely dry

Materials and Methods

The proposed application requires thematic maps and tabular data related to dams and drought in India. The information can be obtained from standard publications, GIS/tabular/spreadsheet data sources or through processing of data. Information of dams and diversions can be obtained from several sources, e.g. reports of central and state agencies, books, atlases etc. Publications of Central Board of Irrigation and Power, Centre Water Commission are in particular comprehensive publications providing salient features of the projects. Several state agencies have developed Internet sites providing information on the projects. For location information, atlases, books, reports, index maps etc. are useful. Atlases by Central Board of Irrigation and Power, All India Soil and Land Use Survey, Ministry of Water Resources, National Thematic Mapping Organization provide thematic maps with river, basins, dam and diversion etc. The thematic maps in GIS formats prepared from these sources are available. The salient features are available in RDBMS formats. District wise monthly precipitation data, available on Internet for period 1901 to 2002 (Anon 2010a), can be utilized for deriving drought related information. The data is based on Climate Research Unit (CRU) TS2.1 dataset, of the Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia in Norwich, UK. These were processed in GRASS GIS on linux OS to obtain district wide rainfall by CRU. The data is useful in creating rainfall maps for SPI at time scales and an average rainfall map. India's district GIS layer available from Survey of India as a licensed digital data product can be used for creating thematic maps of the rainfall for various SPI.

Mapserver

Mapserver was developed in the mid-1990's by the University of Minnesota with the assistance of NASA and the Minnesota Department of Natural Resources (MNDNR) (Anon 2010b). Currently, the software is being managed by the Open Source Geospatial Foundation (OSGeo). The server can be run on several operating systems, e.g. Windows, Linux, Mac OS X etc. The software was developed in C programming language. It supports shape file format. Map elements, namely thematic map, legend, scalebar, reference can be created. The software is based

Table 2 Layers used for storage dams application in Mapserver

Map	Status
India	Default
Basin	On
Sub basin	Off
Major river	On
River	Off
Dams capacity >1,000 Mcum	On
<1,000 & >500 Mcum	Off
<100 & >500 Mcum	Off
<100 Mcum	Off
Major river—Annotation	On
Dams capacity >1,000 Mcum—Annotation	On

on CGI technology. HTML pages calls the software. The variables are passed through query string to the program. The program in most cases uses a Map file, which is a text file. File defines several objects, variables, paths etc. These are utilized by Mapserver during the program run to create map elements. Template HTML file are often utilized. The template files are special HTML documents. These files contain names of variable, objects etc., which Mapserver recognizes. Mapserver replaces these variables, objects etc. with their values and creates an HTML file. The values for these variables are obtained from query strings, Map files or both. The HTML files are passed to the web server.

Table 3 Layers used for hydropower dams application in Mapserver

Map	Status
India	Default
Basin	On
Sub basin	Off
Major river	On
River	Off
Hydropower >500 MW	On
<500 & >100 MW	Off
<100 & >30 MW	Off
<30 MW	Off
Major river—Annotation	On
Dams capacity >500 MW—Annotation	On

Table 4 Layers used for all dams application in Mapserver

Map	Status
India	Default
Basin	On
Sub basin	Off
Major river	On
River	Off
Dams—All	Off
Major river—Annotation	On
Dams capacity >1,000 Mcum—Annotation	On

A tutorial application of Mapserver is also available for download. The tutorial contains HTML files, Java scripts, Map file and data. The tutorial can be downloaded from Internet. The tutorial illustrates various stages in development of Mapserver application. Index page contains introductory text and 'select' control for applications. The 'imagepath', 'imageurl', 'map', 'program' and 'root' variables for directory paths, program name etc. are modified. 'Imagepath' and 'imageurl' give path and url of directory storing the temporary images created by the Mapserver. Variables 'Map' and 'program' give path of map file and url of Mapserver program respectively. The 'root' variable gives path of the tutorial directory. The urls are the aliases defined in the web server configuration file. The application uses Cross-Browser Java script reference library.

The application involves creating of the DHTML document, Map file and obtaining input data. The DHTML document, Map files may be created afresh or may be created by modifying available documents/files. Latter approach is selected here for DHTML files. The Map files can be created automatically from GIS software or created by modifying the Map file available with the tutorial. The data for dams are available. Data for drought application will be prepared by processing the available precipitation time series. The DHTML pages provided with the tutorial will be modified and new pages, logic will be written. Typically, following changes may be made in the example DHTML application:

- The index page of the example may be modified to suite the present application.
- Main index page may open index page for another application, if more context are needed.

- Typically HTML table layouts are used in the application. Cascading Style Sheets may be used for layout.
- The tutorial utilizes inline styles. The application may utilize Cascading Style Sheets (CSS1 and CSS2) to separate presentation and structure of the HTML document.

Results and Discussion

For application on dams, information on storage dams, hydropower dam etc. can be separately disseminated. Thus, a main index page is needed for this application. This index will open separate Mapserver templates for storage dams, hydropower dams and all dams. Along with dam layers, other layers will also be displayed (Tables 2, 3 and 4). Annotation will also be done. Multiple layers will be selected interactively. Query results will be displayed for single or multiple layers. For 'All dam' case, the query will return only name of the dam. This sub application was specifically planned to disseminate only the name of the dams, as database does not yet have salient features recorded for all dams. For other pages, the salient features will be displayed. The 'default' status indicates that layer is always displayed and can not be toggled to off status. The 'on' status indicates that the layer is displayed at the start of the application. Certain layers are required to be put as default or 'on', for frequently needed information.

In drought application, rainfall map is displayed for average value and zero or negative SPI at various time scales. Only one layer can be selected. The query results displays average rainfall and rainfall for different SPI for a given time scale. Same query result will be obtained irrespective of the average or particular SPI map displayed for a given time scale. Time scales of 1, 3, 4, 6, 12, 24 and 48 months will be available.

Conclusion

Mapserver is a high end open source Internet GIS server. It is possible to develop Internet GIS application using this software with ease. Further, with the availability of a tutorial application, any application can be built quickly. An application conceptualized here will provide many functionalities of a modern Internet GIS application for water resources in India. Further work involves database preparation, DHTML coding and testing of the application.

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