Proceedings WARMICE-2012
Sudhir Kumar, et al. (eds)
I.A.H., 2012

III-2

Web GIS Application for Flood in Upper Assam

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Abstract : Large tract of the Brahmaputra basin in Assam is prone to floods. The flooding is caused mainly due to breaches in the embankment of the Brahmaputra. In Upper Assam, Dhemaji district is one of the most frequently flooded area. The district lies north of the Brahmaputra River. Often the right bank embankment of the river is breached causing flooding in Dhemaji. In this study, the Brahmaputra, other tributaries and embankments in the vicinity of Dhemaji district are mapped. The flood inundation map prepared from satellite data is processed and converted into Vector map. Main river in the district is Gai (earlier known as Sisi). Various maps prepared are available in native GIS format requiring GIS software to handle them. A new technology viz Web GIS in which GIS is combined with Internet has since emerged. In Web GIS, spatial information is disseminated on Web and may be accessed through a web browser. Operations namely display, navigation, query etc. may be performed on the spatial data. However, a Web GIS application requires dedicated software. These are available in both open source and commercial domain. Open source Web GIS software has several advantages, like it is simple to use, it costs nothing except hardware, in it complex application may also be developed etc. In this work, an open source Web GIS software Mapserver is used for dissemination of information on floods in Upper Assam, particularly in Dhemaji and Lakhimpur districts. In the application, vector layers of flood inundation, river course and embankments are displayed. Flood inundation map was prepared from IRS LISS-III data of August 1998. The inundation occurred mostly in the floodplains of the rivers. Large area is inundated adjacent to the embankment breach site. For visible and near infrared satellite data, the cloud cover hinders the mapping of inundation area. Thus, the inundation map depicted in Web GIS application shows part of the inundated area only. Full application may contain inundation maps of several years and other layers e.g. administrative regions etc.

INTRODUCTION

Large tract of land in India gets inundated each year causing damages to crops, land, human and cattle etc. Yearly average and maximum area affected from floods are nearly 8 and 18 million ha (Rao et al. 1998, Mahto and Patil 2005). Annual flood affected mean and maximum crop area are nearly 3.5 and 10 million ha (Rao et al. 1998). Maximum affected population has increased to 50 million (Mahto and Patil 2005). Assam is one amongst highly flood prone states in India. For flood mitigation various measured e.g. embankment construction etc. are taken up. Nearly 28 % of these were added in Assam constituting nearly 12 % of protected area in India (Mahto and Patil 2005). In spite of the measures adopted, flood continues to cause damages. Information of past inundation may be useful in flood mitigation. This may be obtained from remotely sensed data. The data are processed using image processing and GIS techniques.

Geographical Information System (GIS) has emerged as a very important tool for water resource applications. GIS provides a tool for effective and efficient storage and manipulation of spatial data. Traditional GIS are mainly desktop based systems and require computer hardware infrastructure in organizations. This requires investment in hardware and software, training etc. limiting the wider reach of the technology. Some of these limitations of traditional GIS technology are overcome by a new technology called Web GIS.

This is an application that utilizes the web and other networking systems to facilitate the access, processing, and dissemination of spatial information. It allows the users to store, analyze, and communicate the results of analysis to a broad audience. Information may be accessed through any web browser and does not require costly GIS software to be installed on the client's machines. Web browsers are available nearly on all computers. In Web GIS, need for learning of complex interfaces of traditional GIS systems is avoided. Use of Web GIS in dissemination of spatial information on flood inundation, drainage network and embankments in demonstrated here.

WEB GIS

A typical system consists of servers for Web, GIS and database. Information flow consists of an access request generated from the user's web browser forwarded to Web server over internet or intranet. The Web server provides the necessary information, namely the GIS data location, extents of areas etc. to the GIS server. The GIS server extracts the GIS data and uploads to the Web server in the form of images. The data may sometimes reside in a database server. The data in that case will be fetched from the database by the GIS servers. A GIS server also creates on request, images for map elements, namely scale bar, reference map and legend. In Web GIS applications, Web pages also contain static elements, such as a selection list, radio button, refresh button and text etc. The images provided by the GIS server are embedded by GIS server dynamically in these pages. These hypertext file are then sent to the user's browser. Several GIS data formats e.g. shape, geodatabases etc. are supported by GIS servers. A Web GIS software may be a commercial or an open source software. For large and complex systems, fast deployment needs and availability of huge budget, commercial software may be preferred. For research purposes, the open source software may be best options as these cost nothing except hardware. With sufficient input, it may possible to create complex applications with these systems. Examples of commercial systems are ArcGIS server, ERDAS Apollo, MapExtreme and ThinkGeo. Examples of open source software are Mapserver, Geoserver and MapGuide.

MAPSERVER

Mapserver software was developed by the University of Minnesota in cooperation with NASA and the Minnesota Department of Natural Resources. Mapserver use Common Gateway Interface (CGI) scripts residing on the web server. It supports shape file format (The Mapserver Team 2010). Map elements, namely thematic map, legend, scalebar, reference are created by the software. The input to the Mapserver program are made available in two ways, namely in Map file and in the query string of the HTTP request. Map file is a text file with Mapserver specific syntax. Map file also provide location and format of data files. The Map files may be either created manually in a text editor or automatically created using desktop GIS systems e.g. Quantum GIS, MapWindows etc. It should be ensured that the automatically generated Map file possess the desired version of Mapserver. Automatically generated Map files may need editing. The HTML documents used with Mapserver are Templates. Mapserver replaces variables, objects etc. in the template file with their values to convert them to a usable HTML document. Mapserver application may be developed in variety of ways e.g. writing applications afresh, modifying available Tutorials etc. Itasca is one of the available tutorials. The tutorial contains HTML files, Java script libraries, map files and data etc. The html files are modified and map file and data are replaced with that of user's own application. The tutorial based approach is followed here. The application requires exposure to both Web and GIS technologies. The application's front end consists of map with scale bar and north arrow etc., controls for navigation and layers and query frame. Navigation controls consists of zoom in, zoom out and pan. In layer control, one or more layer may be selected. The map is refreshed using refresh button. Box zoom is provided for the map using Java scripts libraries. Querying allows the user to select data appearing on the map, either at a specific location, or within a bounding box drawn using the mouse.

STUDY AREA

In Upper Assam, the Brahmaputra River flows from north to south. Near Tezpur, Brahmaputra River turns towards west. Dhemaji and Lakhimpur districts lie on north of the Brahmaputra. These are amongst most flood prone districts in Assam. The tributaries of Brahmaputra in these districts are Gai, Jiadhal and Subansiri. These rivers flow from north to south. Gai and Jiadhal emerge from lower Himalaya and flows in the piedmont area before reaching the plain area. Well defined channels do not occur at the foot of piedmonts. The rivers mostly occupy old river courses in the plain area. Gai and Jiadhal confluence with Subansiri at latter's left bank. Subansiri meets Brahmaputra on its right bank. In Gai catchment, elevation ranges from 1480 to 110 m. Mean annual rainfall ranges from 1362 to 3661 mm. Relative humidity varies from 73- 90 %. Temperature varies from 5.9- 39.9°C. Paddy is the principal crop with varieties namely, Sali, Ahu, Boro and Bao. Cropping system followed are Sali- Ahu- Toria, paddy- vegetation and paddy- fallow. Sugarcane, mustered and pulses are also sown. Sowing is done in November for Rabi. People are also engaged in pisciculture. Industries are very few and electrification is low. Bridges are mostly wooden. Floods cause damages to crop, agriculture land, fishponds, livestock, mulberry, forests etc. Main cause of flood in plains is diversion from Brahmaputra due to embankments breaches. Farmlands are sand casted affecting their fertility. There is a shift in occupation from agriculture to horticulture. The rivers in the area flow in north- south direction. Earthquake also causes avulsion in the river system. Prior to 1941, Sisi flowed southwards and joined Tangani, which then joined Burhi Suti, a tributary of Brahmaputra. Sisi was, then a tributary of Brahmaputra. Later avulsion occurred at the apex of alluvial cone. In this avulsion, the river shifted by 3 to 7 km westward. Devastating earthquake of 1950 might have caused this avulsion. In the satellite data of year 1998, two paleao channels in west of the current channel of Gai in the piedmont region are seen.

DATA

Landsat-5 and IRS satellite data are used. The path and row number for the Landsat ETM+, IRS LISS-II and IRS LISS-III data are respectively 135- 041, 14- 48 (Quadrant B2) and 113-052. Landsat data was obtained from Global Land Cover Facility (http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp). The format and projection of the data are Geotiff and UTM (Zone 46) with spheroid and datum WGS84 respectively. IRS data georeferenced to the same projection as that of Landsat data were available and used here. Flood inundation map based on August 1998 data of IRS LISS-III was also available (Rathore et al. 2004, 2008). The embankments and river courses were mapped using Landsat and IRS data of various years from 1998 to 2001

METHODOLOGY

The available flood inundation map was prepared through digital processing of the satellite data. Digitally processed maps contain inundation clumps of various sizes varying from single pixel to several pixels. Morphological processing could be used to eliminate small clumps and also to smoothen the boundary of large clumps in binary maps (http://www.mathworks.in/help/toolbox/images/f18-12508.html). Binary maps are the maps which contain only single land use class e.g. water (water depicted by '1' and non-water depicted by '0'). In morphological operations, central pixel in a window is changed based on values of pixels within the window. Window may be of a regular or irregular shape. In this study, rectangular 3 X 3 size window was used. Basic morphological operations are dilation and erosion, which smoothen the boundary as well as expands or shrinks a clump respectively. These operations were carried out through max and min filters respectively. Complex operation e.g. opening and closing comprise of series of these basic operations. Opening operation is accomplished through successive erosion and dilation. This removes small objects and preserves shape and size of the objects. Closing is achieved through successive dilation and erosion operation. Closing and opening operation are also used successively for morphological cleaning. This operation was used here. Further, the image was clumped and sieved for clumps of size 36 ha to retain large flood inundation areas only. The image was inverted and clumped and sieved for 3.6 ha pixels to remove small holes (non flooded area within flooded extent). Subsequent to it, the map was converted to vector polygon in ILWIS. Rivers were delineated from satellite data. For wide river channels, namely Brahmaputra, Subansiri and part of Gai and Jiadhal in piedmont region, both banks were delineated. Flood channels were also delineated for these rivers. Other streams were delineated by single segments. The embankments were often visible in October 8, 1998 FCC and were delineated. Retirement embankments visible in subsequent date FCC were also mapped.

Map server software was installed using 'Express Web-GIS install' option of the 'OSGeo4W' installer (http://download.osgeo.org/osgeo4w/osgeo4w-setup.exe). 'apache-install.bat' script was run to install Apache web server. After the installation, the web applications were accessible at web address 'http://localhost/' or 'http://127.0.0.1/' (Rathore et al. 2011). URL aliases were set in the Apache Web Server's Web Configuration file (Rathore et al. 2000). GIS layers were displayed in Quantum GIS version 1.3-Mimas software. In the software, the 'Plugins- Mapserver Export' menu was used to create Mapfile. During export, Mapfile's parameters e.g. Map name and size, units, image type were specified. The Map extent in the Mapfile is that of canvas in Quantum GIS and was modified to depict the area of interest only. The export creates Projection, Legend, Outputformat, Web and Layer objects. Other Mapfile parameters may need to be entered/ edited are shapepath, imagepath, imageurl, layer's name, class name etc. shapepath gives absolute path of the parent directory of the shape files. Image path is where the temporary images created by Mapserver reside and are embedded in the html pages displayed in the user's browser. Class name is used in the legend.

RESULTS AND DISCUSSIONS

Thematic maps, namely flood inundation on August 6, 1998, Brahmaputra River, tributaries and embankment are put in Web GIS. One or more data may be displayed dynamically. Fig. 1 depicts all GIS maps displayed in Web GIS. Flood map is displayed in cyan color. Brahmaputra River and tributaries are displayed in blue color and embankments are displayed in red color. The flood map depicts flood inundation mapped from August 6, 1998 satellite data. This flood was caused due to embankment breach in higher reach of the Brahmaputra River. Due to this breach, the flood crossed the Burhi Suti River and flowed in the Tangani flood plain. Thereafter, the floodplains of two anabranch of Gai were flooded. The interfluves of Tangani and Burhi Suti were also flooded. Total inundation extent was 562 sq. km. The map depicts that at many places the embankments have successfully contained the flood water. The actual flooded area will be larger than the area depicted in the map as part of the area was clouded in the satellite data. The map indicates that the embankment breach in the higher reach of Brahmaputra caused extensive flooding in Dhemaji and Lakhimpur districts. The districts are more flood prone compared to districts

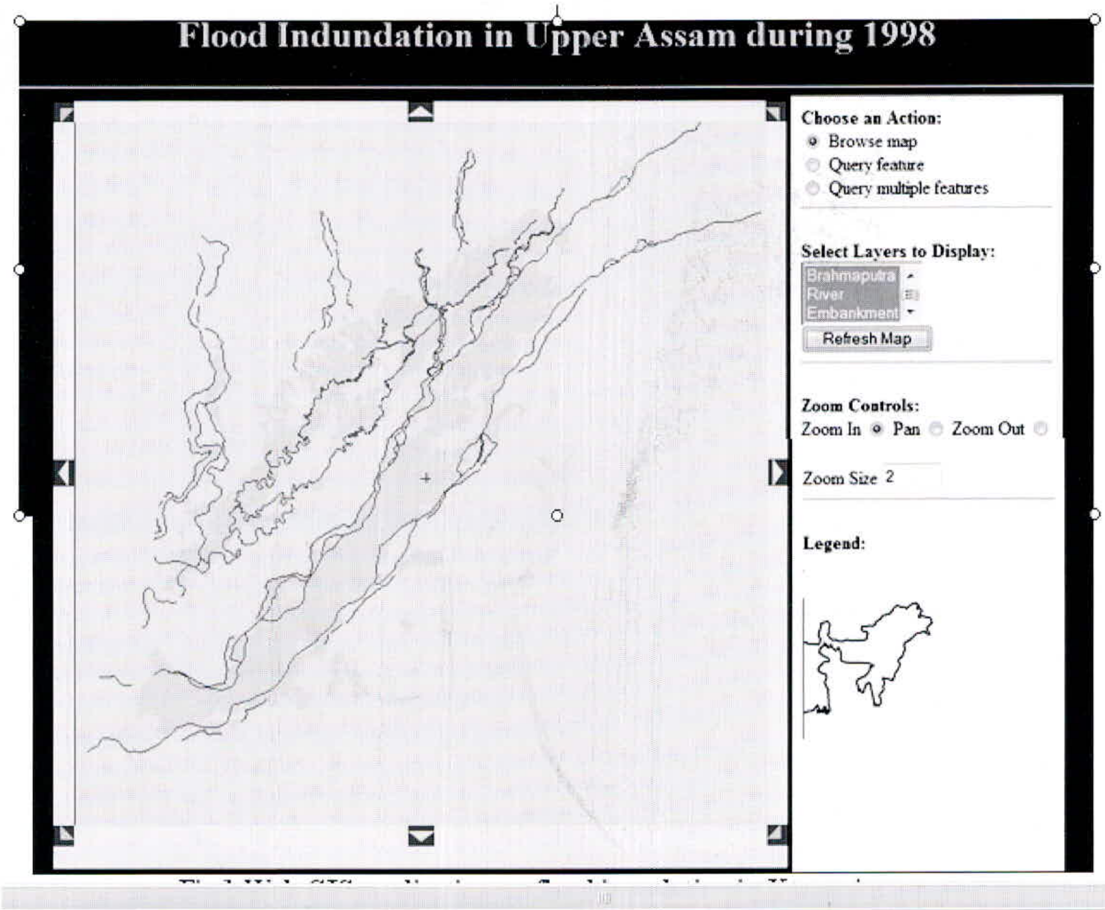

Fig. 1. Web GIS application on flood inundation in Upper Assam

in the east part. Thus, special effort will be needed to alleviate flood problem in these areas in the north of the Brahmaputra.

Embankments breaches

Brahmaputra carries large discharge and sediment load. Its embankments are frequently breached. Following the breaches, flood water enters in to the floodplain of Brahmaputra River and its tributaries. This is the principal cause of flooding in Gai plain area. Several breaches of the right embankment of Brahmaputra River were observed in the satellite images between years 1997 and 2000. These were located in the upper and lower parts of the Burhi Suti and between confluence of Burhi Suti with Brahmaputra River and Majuli Island. The interfluves between Tangani and Burhi Suti in the lower part of Burhi Suti get flooded in most of the years. At several of the locations, retirement embankments were seen in post flood images and which restricted flooding in those years.

DISCUSSION

In this study, thematic layers of flood inundations, main and tributary rivers and embankment are included in Web GIS. These maps in general provide synoptic view of inundation in the area. Maps may be zoomed and panned to get closer view. However, utility of the application may be enhanced by including other layers, namely administrative boundaries, especially village boundary, transportation network, breach locations, flood inundations of other years etc. Query and annotation may also be added. This will improve the information content and will be useful in planning of amelioration measures and flood management. Due to cloud cover, complete area inundated due to particular flood is not depicted and thus field input may be needed for getting correct picture of complete inundation extent. More breaches occurred in the right embankment of the Brahmaputra River and thus more emphasis on structural flood control may be given to this side of the river.

CONCLUSIONS

In the piedmont area, avulsion and migration of Gai River is significant due to various reasons and requires suitable amelioration measures. In the plain area, flood inundation is mainly caused due to flood flow from Brahmaputra River through breached embankments or un-embanked portions of the River. Various measures may be needed which may include strengthening of embankments, construction of flood basins etc. Web GIS application is useful in dissemination of information on flood inundation. It is possible to map past floods and put the inundation maps on web. Various thematic maps of administrative, transportation and stream network may also be put up on the Web. It will be possible in the Web GIS application to display all or selected layers to get idea regarding flood proneness of a particular administrative region. It will help decision makers in planning amelioration measures and flood management.

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