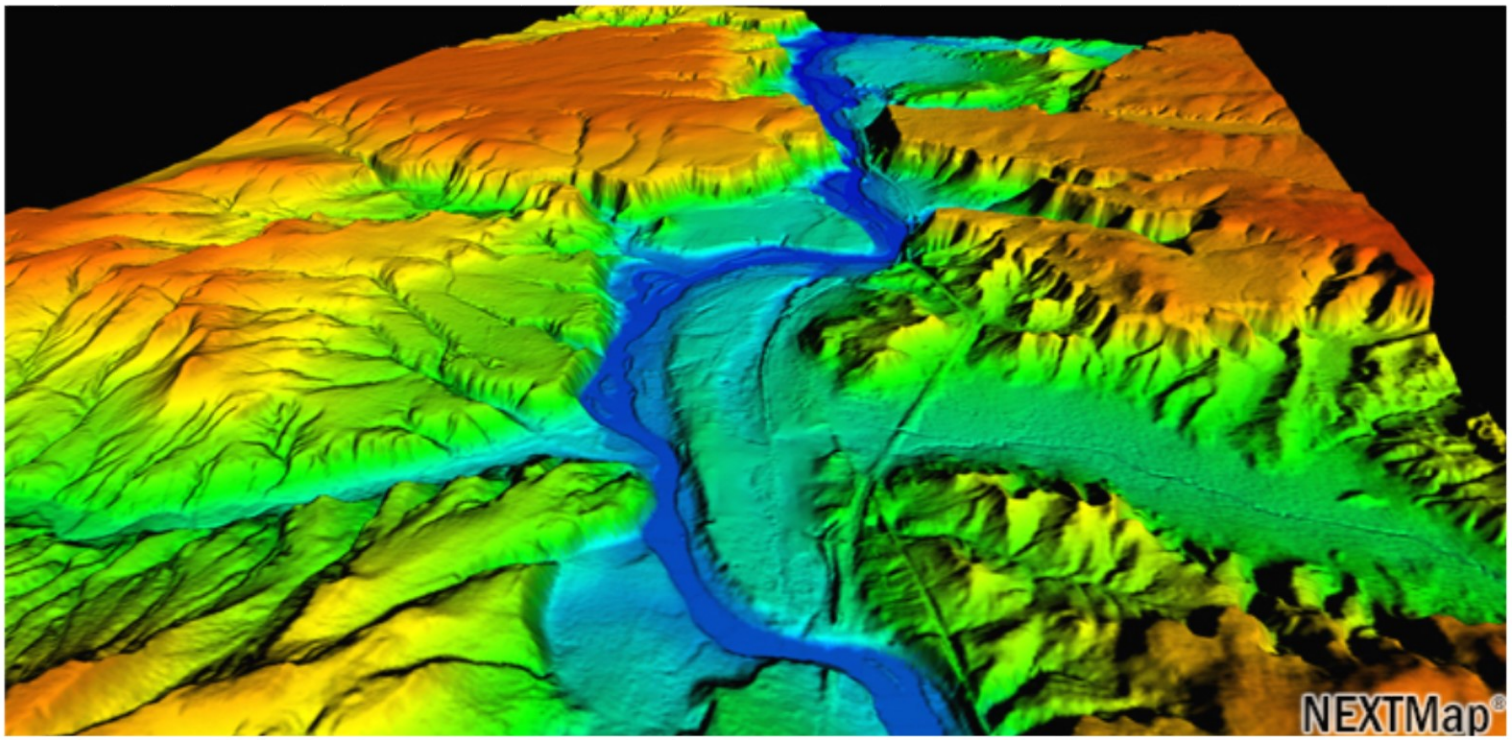
WATERSHED DELINEATION FROM DEM

(TUTORIAL SUPPLIMENTS)



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DEPT. OF GEOGRAPHY

BHATTADEV UNIVERSITY, BAJALI

MA/MSc Fourth Semester
Course No. GGY 4214 (3)
Course Name: Fluvial Geomorphology
Unit II: Practical Works (65 Marks)
7. Application of computer and software in fluvial geomorphology
(i) Watershed Delineation from DEM
A Syllabus for CBCS Based PG Corse in Geography, 2017
Department of geography
Gauhati University

Course Objectives:

1. To familiarize the students with the emerging modern technologies such as computers and software,
2. To make the students understand about the application of computers, various software such as GIS, GPS etc. and
3. To acquainted the students with the 2D & 3D data such as satellite image and digital elevation model respectively.

Course Outcomes:

1. The students will enrich themselves with the concept of emerging field of computer technology.
2. The students will learn to apply the GIS techniques in hydrological and fluvio-geomorphologic analysis.
3. The students will be able to handle the 3D data in a GIS environment with the help of computer.

ISSN 2277-2995

An integrated approach for catchment delineation and mapping of the Puthimari River by using Geospatial Technology

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Abstract

The shortfall of methodological narratives on drainage basin or catchment mapping results less awareness or lacking of this most essential skill of map making in the fields of Fluvial Geomorphology, Cartography or Geography as a whole in broader perspective, especially among the young scholars those who have recently stepped into the field. The unestablished or very poorly established methodology in the literature preludes the scientific society to arrive in a common consensus or standardisation of this vital task of map making. Survey of India Topographical sheets, Landsat ETM+ images, Bhuvan and SRTM Digital Elevation Models (DEM) have been used for this study. The 200m contour and hill shade have been generated from the Bhuvan DEM and overlaid with the DEM for better identification of water divide of the basin. The article presents a clear cut step-by-step methodology of drainage basin delineation and its mapping by using Geospatial Technology with an expectation that it will set a benchmark for methodological development of the discipline for future research.

Keywords: *1.Digital Elevation Model (DEM), 2.Drainage basin, 3.Geographic Information System (GIS), 4.Google Earth, 5.Water divide.*

Introduction

Drainage basin or catchment is an important geomorphic unit on the earth surface where gradational processes are most active. The identification, delineation and mapping of catchment are fundamental works for many activities such as drainage basin planning and management (Shee and Maiti 2012), land use and land cover mapping (Biswas 2012; Chandrasekhar, et al., 2009), engineering activities, recreation and construction, geomorphological research (Biswas 2012; G., et al., 2012; Nath and Bora 2012; Asthana and Pal 2009; Babar 2009; Chandrasekhar, et al., 2009) and development etc. After the advent of Geospatial Technology, geographers find it making things happen and getting things done faster than before and in a convenient way and more precisely (Roy 2014). The precise delineation and perfect mapping of catchment is a primary work for researchers who are working in drainage basin or catchment base activities such as catchment hydrology, fluvio-geomorphic analysis, water and sediment discharge dynamics, river bank erosion and deposition etc. as the basin parameter viz. shape, size

and area are determinants of many successive investigations which cannot be ignored. Maps are used to show locations, distances, directions and the size of study areas (Chandran and Roy 2014; Roy and Sarkar 2015). Moreover, maps also display geographic relationships, differences, clusters and patterns (Roy 2014). Many studies have been carried out in India (Chakraborty and Mukhopadhyay 2015; Devi and Goswami 2015; Chakraborty and Datta 2013; Agnihotri 2012; Babar 2012; Bharali and Sarma 2012; Bhattacharji 2012; Biswas 2012; Chaudhuri 2012; Das 2012; Nath and Bora 2012; Sarkar, et al., 2012; Sarma and Acharjee 2012; Shee and Maiti 2012; Dutta, et al., 2010; Kumar, et al., 2010; Agnihotri, et al., 2009; Babar 2009; Hire and Kale 2009; Joshi and Gaikhe 2009; Koul and Ganjoo 2009; Sharma and Asthana 2009; Bhutiyani, et al., 2008; Sarma, et al., 2007; Kotoky, et al., 2006; Bhakal, et al., 2005; Rajaguru, et al., 1995) and other parts of the world by different scholars (Grove, et al., 2013; Jones, et al., 2012; Ahmed and Fawzi 2011; Darby, et al., 2010; Lu, et al., 2007; Hung and Tanaka 2006; Leopold and Wolman 1956) especially in the field of fluvial geomorphology but, there is dearth of clear cut methodological narratives of delineating the catchment or drainage basin considered to show either the location of study area map or as an geomorphic unit of analysis; even some scholars (Abderrezzak, et al., 2014; Sharma 2012; Chandrasekhar, et al., 2009; Pizzuto 2009; Lawler, et al., 1999) ignored to show the basin map for their studies if the investigations have been carried out only in some selected reaches of the river. Although, some concerned scholars (Roy & De, 2016; Roy and Husain 2014; Pal 2012; G., et al., 2012; Sarkar and Patel 2009; Sharma, 2009) have tried to give an account on it in recent times but, a general observation is that those scholars also fail to give detail and clear cut narratives on how they delineated the drainage basins. The lack of methodological narratives on how to delineate and to prepare a basin map precludes the researchers to make a common consensus or standardisation of this basic task though it is assumed that most of the researcher adopt the process of catchment mapping by identifying and delineating the water divide of the basin following the basic definition of catchment. The article mainly deals with the methodology part of mapping a catchment or drainage basin or watershed as the fundamental objective is to develop a drainage basin map of the Puthimari River Basin (PRB) for further work.

Database and Methodology

Database

The study has been carried out based on mostly two types of data such as topographical sheets and Digital Elevation Model (DEM). Apart from these, the Landsat ETM+ and LISS III images have been taken for references of the study region. The topographical sheets (78N/10, 11, 12, 13, 14) at the scale of 1:50,000 have been collected from Survey of India (SoI) offices. The Carto DEM version 3 R1 (Carto DEM v3 R1), IRS P6 LISS III images and SRTM DEM version 4 (SRTM DEM v4) have been downloaded in GIS Lab of Department of Geography, North-Eastern Hill University from the Bhuvan Geoportal of National Remote Sensing Centre (ISRO), India and CGIAR-CSI respectively. The Landsat ETM+ images have been downloaded from Earth Explorer of USGS Geo Archive. The topographical sheets have been used mostly for downstream part where

Carto DEM has been used for the entire part of the basin. The SRTM DEM has been used for the location map. The data type, scale/resolution, publication or access year and sources have been mentioned in the Table 1.

Table 1: Various data used for the catchment delineation of the Puthimari River

Type of Data	Year	Scale/Resolution	Sources
Topographical Sheet	1961, 1973	1:50,000 78N/(10,11,12, 13, 14)	Survey of India
LISS III	2012	23.5m/4 Bands	Bhuvan (NRSC/ISRO)
LandSat ETM+	1990	30m/8 Bands	USGS
DEM	2015	30m Carto DEM v3 R1	Bhuvan (NRSC/ISRO)
	2015	90m SRTM v4	CGIAR-CSI

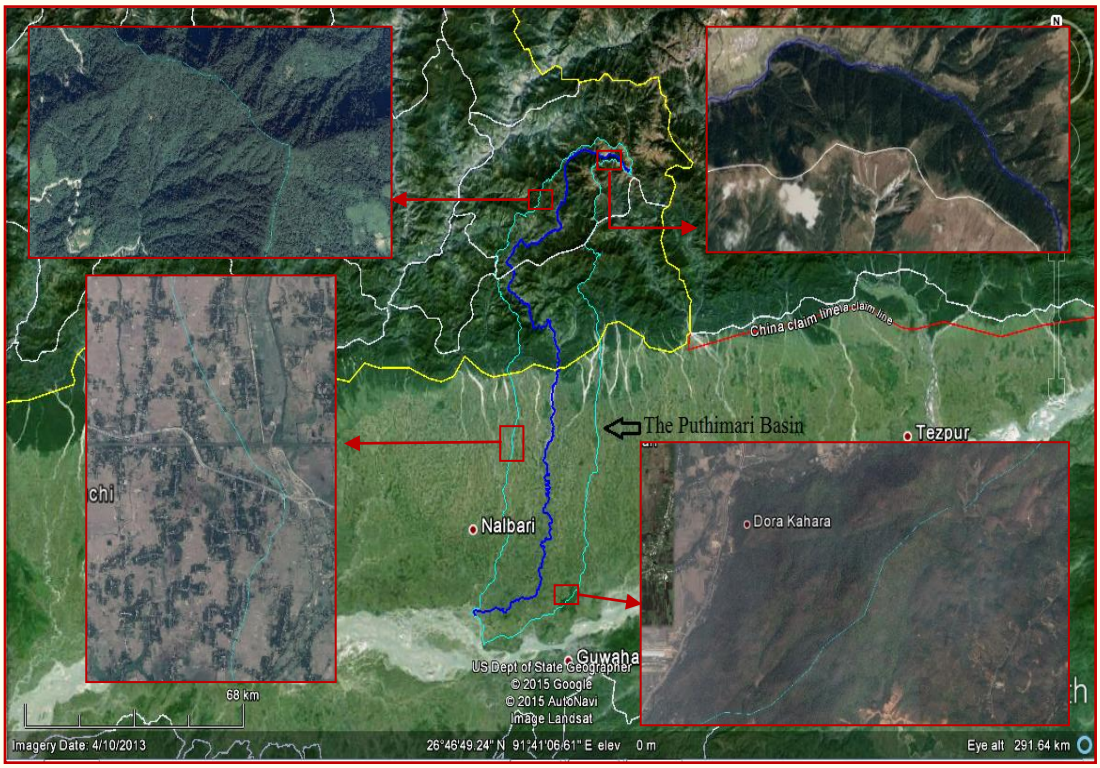

Figure.1: The overlaid KML file of the Puthimari River Basin in Google Earth Pro.

Methodology

The Puthimari River has been identified from Survey of India (SoI) topographical sheets. The three dimensional (3D) data of larger than the study region has been downloaded from Bhuvan Geoportal (NRSC, ISRO) and coordinate transformation has been done from geographic to Universal Transverse Mercator (UTM) projection with World Geodetic System 1984 (WGS84) datum. The SoI topographical sheets of the region have Polyconic Projection with Everest datum which bears the properties of neither conformal nor equal area. It has rolling fit with adjacent topographical sheets in east-west direction. Serious errors are introduced if the adjoining sheets are joined together. Instead, UTM projection is a conformal projection which is suitable for topographical mapping (Nag 2009). Hence, each sheet has been georeferenced to UTM grid system using WGS84 datum separately so that a seamless database can be produced with a common coordinate system along with topographical sheets and Digital Elevation Model (DEM). Then, a sharp DEM has been developed by performing standard deviation stretching considering the default values. The hillshade and two hundred meter contours have been generated based on the DEM. The hillshade and contour layer have been superimposed on DEM which helped to find out the water divide especially in the upstream part of PRB. The manual digitisation of the basin boundary along the water divide has been done based on the superimposed model since it provided pinpoint identification of water divide conveniently by using ArcGIS after creating a Shapefile. The Shapefile has been created in ArcCatalog to store the vector data which has been generated by the process of manual digitisation. The upper part of the PRB has been digitised first as the water divide had been clearly visible from DEM and hillshaded (Figure 2-A). But, the catchment or drainage basin delineation of the downstream part has been really challenging as to find water divide had not at all possible. The downstream part of PRB (Figure 2-B) is very flat especially after debouching from the Bhutan Himalaya. The identification of water divide is very difficult in such a flat surface especially when low resolution DEMs are used. The SoI topographical sheets with a RF of 1:50,000 have been used to develop the basin area for the remaining part. Though there are no water divide present in any topographical sheets the justification is that, these topographical sheets provide facilities to digitise in finer details with greater convenience (Asthana and Pal 2009; Moharana and Kar 2009; Sarkar and Patel 2009; Sharma 2009) where high resolution (<30m) 3D data are not available or can't be generated due to lack of financial sponsorship or special funding for the research and the research work is self-funded. Another challenging task here is that most of the contours are transverse to the river and to sparse too consider for drainage divide. In such cases, the digitisation has been carried on assuming the intermediate points of two adjacent basins ignoring the cultural features such as railway lines, roads etc. Care had been taken so that no smaller or larger water outlet or stream has crossed during digitisation. Once the digitisation of the entire basin has been over, the generated Shapefile has been uploaded to Google Earth Pro explorer (Figure 1). After uploading the Shapefile, it had been verified zooming to a maximum extent as an additional reference and modified wherever needed creating a new Keyhole Markup Language (KML) file as

the editing of Shapefile is not possible in Google Earth. The newly created KML file of the PRB has been converted to a layer file and stored in an already created Geodatabase for further use. This KML file has been converted again to a Shapefile by using Conversion Tools of Arc Toolbox in ArcGIS and used for final compilation of the basin map. The downloaded Landsat ETM+ image has been clipped for better representation and to give final layout of the PRB.

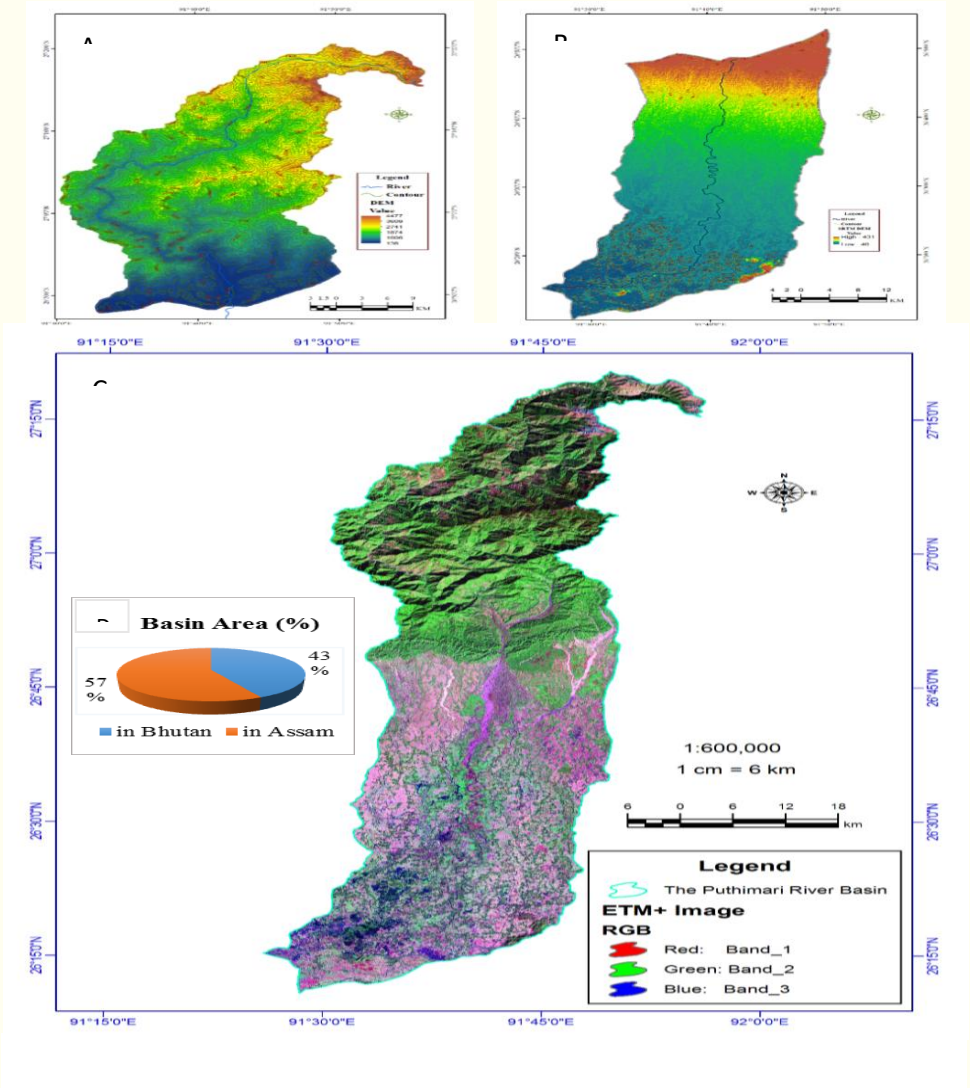

Figure.2: The upstream part of the Puthimari River Basin in Bhutan (A) and the downstream part in Assam (B) have been overlaid by 200m contour on Carto DEM v3 to delineate the basin and the whole Basin has been represented by Landsat ETM+ image (C) after delineation.

ISSN 2277-2995

Discussion

The Puthimari River is one of the tributaries of the river Brahmaputra (Figure 1 and 2). The river has come across various geographic and geologically complex regions from the source at (27°26′55″ N latitudes and 91°55′34″ E longitudes) Tethyan Himalaya, a part of Eastern Himalaya in Bhutan to mouth at (26°14′52″ N latitudes and 91°26′55″ E longitudes) the Brahmaputra River near Barsulia village, 7.6 km downstream from Hajo in Assam, India (Roy & De, 2016). The Puthimari River Basin (PRB) is a transnational river basin located within political boundaries of Bhutan and the state of Assam in India. The latitudinal and longitudinal extent of the PRB falls between 26°10′50″ N to 27°20′27″ N and 91 °25′57″ E to 91°56′12″ E (Figure 2). The basin is extended in north-south direction from the high Tethyan Himalayas to flat flood plains of the River Brahmaputra in the state of Assam in India. The shape of the basin is elongated. The basin is fat in the middle tapering at the source and mouth resembling with a leaf of Olive tree (Figure 2-C). The total area of the basin has been found calculating the value in attribute tables. The PRB covers an area of 3,090.11 sq. km; out of which, 1,315.87 sq. km (43%) (Figure 2-D) lies in Bhutan and 1,774.24 sq. km (57%) (Figure 2-D) in Assam (India) (Roy, 2017).

Conclusion

The identification of water divide and delineation of basin from DEM at 30m resolution or finer and topographical sheets at a scale 1:50,000 or larger are helpful for mapping the catchment of any river. These methods of catchment delineation and mapping demonstrates and sets a benchmark on common methodology for researcher especially for fluvial geomorphologists to prepare drainage basin map even though the location is in highly complex topographical areas. It will be helpful not only for the fluvial geomorphologists but also for researcher in different fields, especially when such mapping is needed as base map for further investigation in future.

Acknowledgement:

The author acknowledges Prof. Sunil Kr. De and late Prof. Zahid Husain who critically evaluated the manuscript, helped and suggested during the preparation. The author is deeply indebted to Prof. Husain who passed away midway before seeing it in published form.

ISSN 2277-2995

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