J. Environ. Sci. & Natural Resources, 7(1): 169 - 175, 2014 ISSN 1999-7361

Identification and Delineation of Turag River Basin Boundary Using Remote Sensing Techniques

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Abstract: The objective of this study was to identify the Turag river basin boundary using remote sensing techniques. Aerial photographs and Topographic maps from Survey of Bangladesh have been used for this study. Various remote sensing data namely Landsat TM (Thematic Mapper) and Quick Bird have been also to support the analysis. Digital Elevation Model (DEM) and as well as the Global Position System (GPS) based ground truth information have been used for the verification of the analyzed results. The Turag river basin boundary has been delineated and length of the basin boundary is 197.79 km and the total area of the Turag river basin is 1160.48 sq-km. Remote sensing data was very useful for identification and delineation of Turag river basin boundary but further high resolution remote sensing data can improve the accuracy level. Moreover, different seasonal temporal data (dry and wet) are also required for achieving the convincing results. However the study showed that different type of remote sensing sensors data are also useful for this study.

Key Words: Satellite, Sensors, Landsat TM, Aerial photography, Quick Bird, Digital Elevation Model

Introduction

Turag River is one of most important rivers passes through the northwestern part of Dhaka city and finally has fallen to the Buriganga River and Dhaka city stand on the bank Buriganga. Turag River plays a very significant role as main drainage channel and carries the water from upstream to Buriganga River without entering in to the Dhaka city but it works as one of the important contributors for groundwater recharging sources of the most populated city Dhaka, the capital of Bangladesh. Turag River basin is also one of the most dynamic river basins in Bangladesh in terms of Land Uses and Land Cover Changes (LULCC), as it is located near the capital city. The present study has been undertaken to delineate the Turag River basin boundary therefore the researchers may undertake their study as a basin wise which may termed as 'basin approach'.

Importance of 'Basin Concept' for Sustainable Natural Resources Management

The river basin is a very important unit in the context of geo-morphological studies. Different researches defined the river basin in different ways but generally it is the area which plays as the main contributor for giving water to a specific river flows. Various components for hydro-geological studies of an area like total rainfall, water flow measurement, ground water recharge and fluctuation and as well as the evapo-transpiration can be closely and continuously measured and monitored if that are is a 'river basin'. That is why Zhang, *et al.*, 1990 emphasized that river basin plays an important role in geomorphic and hydrologic research and addressing the quantitative measurement of river basin perimeters which leads to a wide variety of applications within the context of spatial data bases.

Now a day, for ensuring the sustainable management of all natural resources, an approach of Integrated Catchment Management (ICM) or Integrated Water Resources Management (IWRM) is largely used and accepted worldwide. The concept of Integrated Catchment Management (ICM) or Integrated Water Resources Management (IWRM) is widely admitted by the scientific community as well as water resources management planner and decision maker in developed and under developed countries of the world. The ICM or IWRM approach has been acknowledged by various researchers (Mitchell, 1989; Newson, 1997) over the last three decades.

An integrated approach to catchment management is very essential to the success in the implementation of sustainable solutions for irrigation, drainage and flood control. Recently, the accelerating awareness of the scarcity of water resources, water circulation to climate change, slow desertification to agricultural ecology, over exploitation and more dependency on ground water for irrigation and as a result of

depletion of ground water table are the challenges and needed to be addressed with due regard to environmental consideration and social impacts at present and future (Aradas *et al.,* 2009).

Working at 'catchment scale' has been identified as the best practice for the assessment of water resources by Environment Agency of England and Wales in the United Kingdom (Holmes, *et al.* 2003)

The chemical, biological and physical processes are functionally integrated to each other within a basin boundary therefore now a day all the study of environmental applications are being considered within a basin boundary. Water runoff in the terrain, water movement through channels and rivers are operating within a basin and these are governing by terrain slope (Moore, *et al.,* 1993). Several authors has documented clearly that the DEM is the main derivative of slope, aspects, exposure and inter visibility of a river basin (Maidment, 1993; Fisher, 1994).

Identification of the Basin Boundary

A river basin boundary is the area which is drained that river and its tributaries. It is also termed as drainage basin which is consists of two components, firstly the streams and rivers that carry the water and secondly the land area from where the water is drained out. The drainage basin is separated from its neighbour basin by the line called drainage divide.

1.3 Delineation of a River Basin Boundary

There are several methods adopted by various researcher and in general those are: i) Manual delineation and ii) Automated delineation.

In case of manual delineation contour lines, trigonometric pillars, spot heights and also the features involved in depicting the surface hydrology are taken into consideration. On the other hand the automated delineation is mainly based on the terrain information and for this the source may from Digital Elevation Model (DEM), Triangular Irregular Network (TIN) model etc.

In the present study manual delineation method had been adopted for Turag river basin boundary delineation. The main reason behind this, the study area is mostly flat and a very less variation in terrain height. Secondly, there is unavailability for high resolution DEM. However, after delineation of Turag river basin boundary it has been superimposed/ overlaid on the existing DEM and reasonable matching has been between the delineated basin boundary and the surface topology.

Data and Software Used

Black and white of aerial photographs of 2000 has been used under supervision from competent authority within SPARRSO laboratory. Survey of Bangladesh (SOB) Topographic maps (1:50,000 scale). Landsat TM data and the Quick Bird images have also been used for the study. Digital Elevation Model (DEM) derived using bands 3N and 3B from an ASTER Level-1A data set. (http://asterweb.jpl.nasa.gov/content/03_data/01_Data_Products/release_DEM_relative.htm**)**

Digital image processing (DIP) of the satellite data were carried out in ERDAS IMAGINE software. Vector layers have been prepared in Arc/Info software.

Using Remote Sensing method: Delineation of Turag river basin has been accomplished by manual delineation from black and white aerial photographs. As supplementary information, topographic maps (1: 50,000 scale), Google Earth images and as well as Landsat images were also used to assist the visual interpretation. On screen digitization technique has been used for this purpose which is very useful for easy editing and reached on the decision for trial again and again up to the satisfaction on a certain level.

Using Topographic map method: The basin boundary has also been delineated using the topographic maps as a base and digitizing for storage and analysis in Arc/Info GIS. The basin boundary has been delineated by a combination of interpretation spot height, trigonometric pillars, road networks, artificial dams and feathers depicting the surface hydrology such as rivers, khals, canals, and ditches for water reservation.

Finally comparing the outputs derived from the above two sources the final basin boundary has been generated.

Results and Discussion

There are 6 (six) segments of the basin area has been identified as below:

Basin Segment no. 1 (BS1): BS1 starts from the east side of Turag river at Gabtali Bridge and ended at Basaid mauza of Bara Ashulia Union under Savar Upazila. Here the artificial boundary rules have been followed. Basically this is a highway boundary.

Methodology

The following methodology has been adapted for the present study. The flow chart of the methodology for the present work has been shown in figure 1.

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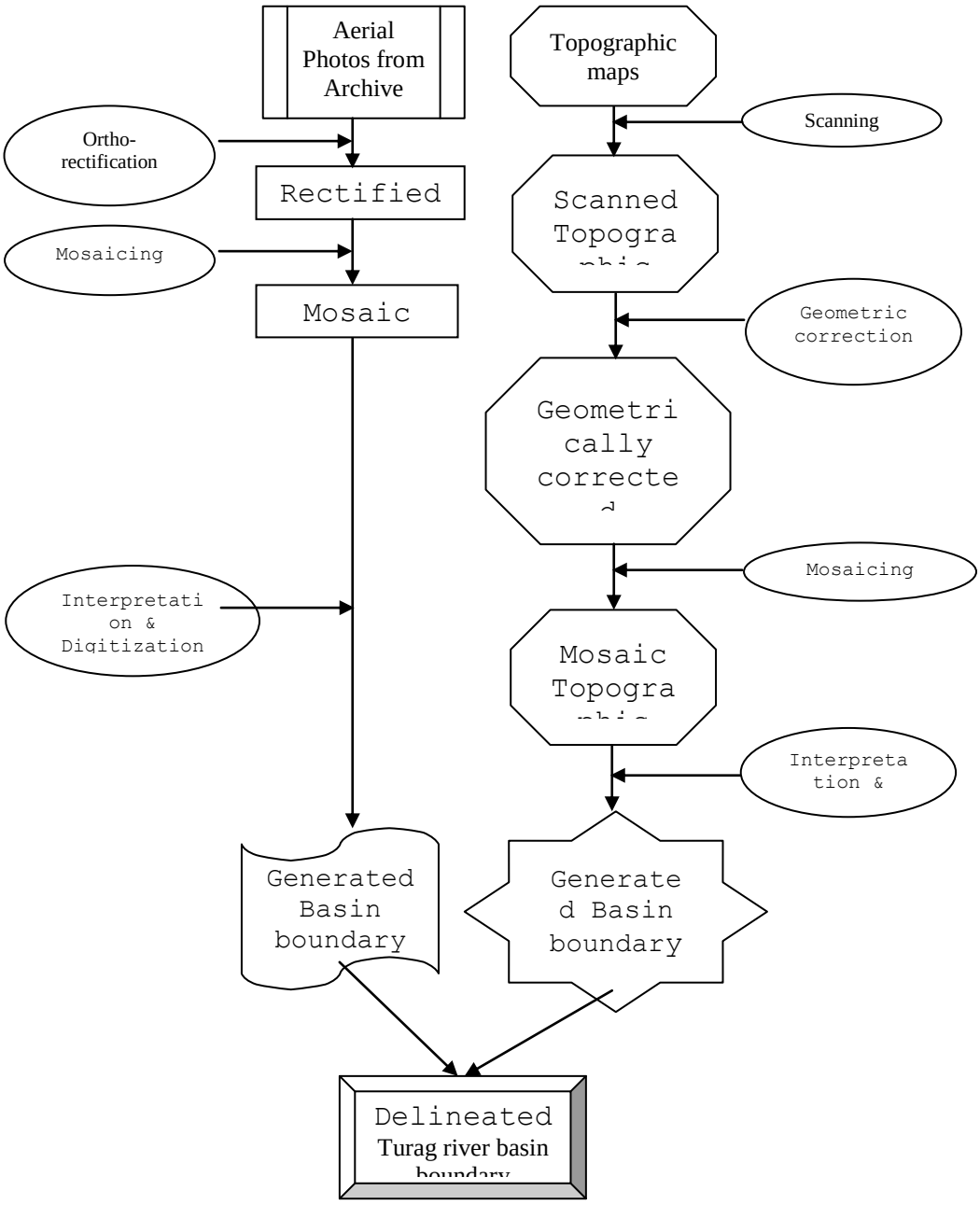

Fig 1: Shows the flow chart of the methodology for the present work.

Table 1: Interpretation and identification Basin segment no. 1 (BS1) of Turag river basin

Segment no.	Identity of the segment	Data source	Interpretation elements in use
BS1	Gabtali Bridge to Basaid mauza of Bara Ashulia Union under Savar Upazila.	Landsat MSS/ Landsat TM	Artificial boundary highway.

Basin Segment no. 2 (BS2): BS2 as we named here in our present study. It starts from the Basaid mauza of Bara Ashulia Union under Savar Upazila and ended at Konabari Mauza of Kaliakair Upazila under Gazipur Zila. Here the natural boundary rules have been followed. It follows a ridge line keeping the elevated land to its right and followed by very low land. The start of primary order drainage line starts from here and end up the the low land towards its right.

Table 2: Interpretation and identification Basin segment no. 2 (BS2) of Turag river basin

Segment no.	Identity of the segment	Data source	Interpretation elements in use
BS2	Basaid mauza of Bara Ashulia Union under Savar Upazila to Konabari Mauza of Kaliakair Upazila under Gazipur Zila.	Quickbird /Landsat TM	Natural boundary ridge line.

Basin Segment no. 3 (BS3): BS3 as we named here in our present study. It starts from the Konabari Mauza of Kaliakair Upazila of Gazipur Zila and ended at the junction point of Bansi and Turag River at Mirzapur Upazila of Tangail Zila and Kaliakair Upazila under Gazipur Zila. Most of its path it has followed the artifical boundary, basically metal road. At the end it has kept the Turag River on its right side.

Table 3: Interpretation and identification Basin segment no. 3 (BS3) of Turag river basin

Segment no.	Identity of the segment	Data source	Interpretation elements in use
BS3	Konabari Mauza of Kaliakair Upazila of Gazipur Zila to the junction point of Bansi and Turag river at Mirzapur Upazila of Tangail Zila.	Landsat TM/ Quickbird	Mainly artificial boundary metal road.

Basin Segment no. 4 (BS4): BS4 as we named here in our present study. It starts from the junction point of Bansi and Turag river at Mirzapur Upazila of Tangail Zila and ended at Meharban Mauza of Bhaluka Upazila under Mymensingh District. At the end point it has been connected with Mymensingh Dhaka Regional highway inside the Madhupur forest. Basically it is the challenge to identify the basin boundary line here. We have studied the drainage pattern insensitively here and identified the primary order drainage line and also considering the slope and elevation values.

Table 4: Interpretation and identification Basin segment no. 4 (BS4) of Turag river basin

Segment no.	Identity of the segment	Data source	Interpretation elements in use
BS4	Junction point of Bansi and Turag river at Mirzapur Upazila of Tangail Zila to Meharban Mauza of Bhaluka Upazila under Mymensingh District.	Quickbird/TM	Regional highway, primary order drainage.

Basin Segment no. 5 (BS5): BS5 as we named here in our present study. It starts from the Meharban Mauza of Bhaluka Upazila under Mymensingh Zila and ended at Kakoli area under a under Tejgaon Thana of Dhaka Zila. Here the artificial boundary rules have been followed. Basically this is a highway boundary.

Table 5: Interpretation and identification Basin segment no. 5 (BS5) of Turag river basin

Segment no.	Identity of the segment	Data source	Interpretation elements in use
BS5	Meharban Mauza of Bhaluka Upazila under Mymensingh Zila to Kakoli area under a	Landsat TM/ Quickbird	Artificial boundary highway.

	under Tejgaon Thana of Dhaka Zila		

Basin Segment no. 6 (BS6): BS6 as we named here in our present study. It starts from the Kakoli area under Tejgaon Thana of Dhaka Metropolitan area and ended at east side of Turag River at Gabtali Bridge. Here the artificial boundary rules have been followed. Basically this is the peripheral boundary of intense urbanization.

Table 6: Interpretation and identification Basin segment no. 6 (BS6) of Turag river basin

Segment no.	Identity of the segment	Data source	Interpretation elements in use
BS6	Kakoli area under Tejgaon Thana of Dhaka Metropolitan area to east side of Turag river at Gabtali Bridge.	Landsat TM/ Quickbird	Artificial boundary basically this is the peripheral boundary of intense urbanization.

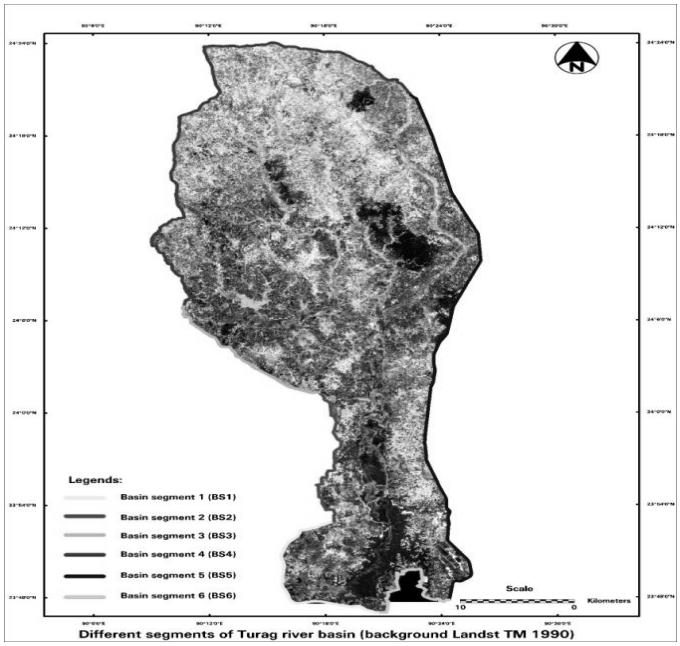

Fig. 2: Different segments of the Turag river basin

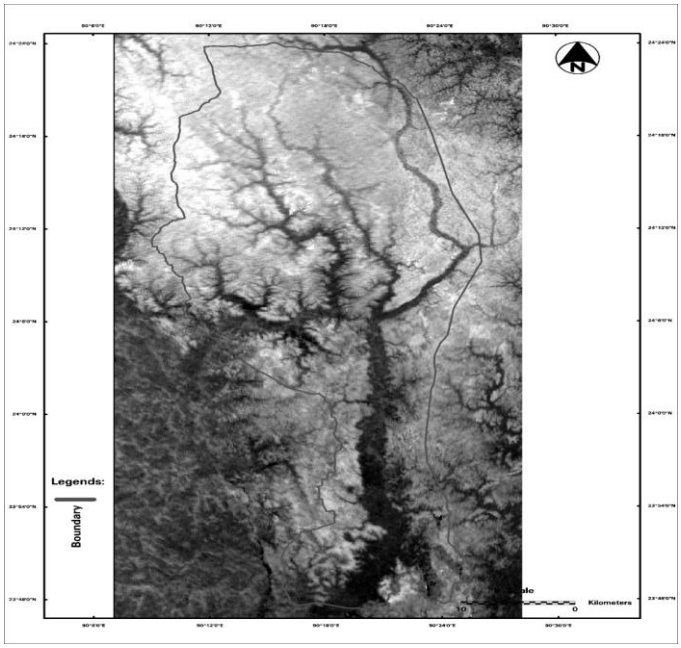

Fig. 3: Delineated Turag river basin boundary overlay on DEM

Table 7: Length and extent of different basin segments as identified in Turag river basin

Sl. No.	Segment name	Extent of segment in general	Segment length (km)
1	Basin Segment no. 1 (BS1):	Starts at Gabtali Bridge and ended at Basaid mauza of Bara Ashulia.	20.6
2	Basin Segment no. 2 (BS2):	Starts at Basaid mauza and ended at Konabari Mauza of Kaliakair.	19.52
3	Basin Segment no. 3 (BS3):	Starts at Konabari Mauza of Kaliakair and ended at the junction point of Bansi and Turag river	17.6
4	Basin Segment no. 4 (BS4):	Starts at the junction point of Bansi and Turag river and ended at Meharban Mauza of Bhaluka Upazila	59.12
5	Basin Segment no. 5 (BS5):	Starts at Meharban Mauza and ended at Kakoli area of Tejgaon Thana	64.72
6	Basin Segment no. 6 (BS6):	Starts at Kakoli area and ended at	16.23

		Gabtali Bridge	
Total length			**197.79**

The total length of the basin boundary is 197.79 km and the total area of the Turag river basin is 116047.58 ha (1160.48 sq-km) located in Savar, Tejgaon, Kaliakoir, Gazipur, Sripur, Mirzapur, Shakhipur and Bhaluka upazilas under Dhaka, Gazipur, Tangail and Mymensingh Zillas.

Problems encountered in Turag River Basin Boundary Delineation

However, in general there are two types of problem for basin boundary delimitations:

1. Physical Problems
2. Cultural Problems

Physical Problems

There are some situations, where two channels are naturally connected to each other and creates problem for boundary delineation. In some cases the first order streams are invisible and show the challenges for basin boundary delineation also. There was another challenge to identify the basin boundary where the land was covered by dense trees. Satellite cannot see the ground through penetrating the dense vegetation, under such situation Digital Elevation Model (DEM) has been used to identify the drainage divide.

Cultural Problems

In some area the land management has been done on the natural land use and the natural boundary has been disrupted. As for example the International Airport, Dhaka Export Processing Zone (DEPZ) etc. have been constructed and here the roads/highways have been taken as arbitrary line for basin boundary.
As a measure of overcoming such situations the 'best estimation' approach has been taken into consideration.

Conclusion

In the present case the automated delimitation has not been done due to almost flat topography of the area. Minimal extent of topographical heterogeneity is required (topographic gradients are too small compared to the resolution of the DEM) for Delimitation of river basin within flood plains based on automatic digital terrain analysis using commonly available algorithms (Krause and Bronstert, 2005). However manually delimited basin boundary with river networks has been superimposed on a DEM (90 m pixel size) and interpreted visually to have an understanding how it goes with the information on height available in DEM. Generally, rivers, khals and lowlands areas corresponded with lower values on DEM. Results appear to be comparable to drainage patterns (Figure 3) which can be interpreted visually from contours of the elevation data.

Acknowledgements

The authors are thankful to Bangladesh Space Research and Remote Sensing Organization (SPARRSO) for the encouragement extended for this study.

References

Aradas, R.D.; Machado, L. I.; Maurino, M.; Norton M. R. 2009. *Urban Drainage: System Modelling for Integrated Catchment Management.* in www.halcrow.com/html/ documents/pdf/australia/bsas_urban_drainage.pdf

Fisher, P. F. 1994. Probable and fuzzy models of the view shed operation. In: *Innovations in GIS 1,* (ed. by F. M. Worboys) Taylor and Francis, pp.167-176. In http://www.ncgia. ucsb.edu/conf/SANTA_FE_CD-ROM/ sf_papers/miller1_david/miller_paper1.html

Holmes, M.G.R.; Young, A.R.; Goodwin, T.H.; and Grew, R. 2003. A catchment-based water resource decision support tool for the United Kingdom in *siti.feem.it/mulino/dissem /intcon/holmes.pdf.*

Krause, S. and Bronstert, A. 2005. An advanced approach for catchment delineation and water balance modelling within wetlands and floodplains, *Advances in Geosciences 01/2005* in: http://www.researchgate.net /publication/26438324

Maidment, D. R. 1993. Developing a spatially distributed unit hydrograph by using GIS. *International Association of Scientific Hydrology Publications* 211, pp. 181-192. In David R Miller and Jane G Morrice, Assessing uncertainty in catchment boundary delimitation in: http://www.ncgia. ucsb.edu/conf/SANTA_FE_CDROM/sf_papers/miller1_david/miller_paper1.html

Mitchel, B. 1989. Integrated Water Management. In: Mitchel, B. (ed.). Integrated Water Management. In: Urban Drainage: System Modelling for Integrated Catchment Management In: http://www.eoearth.org/

article/Land-use_and_land-cover_change

Moore, I. D. 1993. Hydrologic Modelling and GIS. In: *Environmental Modelling and GIS II*, (ed. by M. F. Goodchild, B. Parks, C. Johnston & S. Glendinning), GIS World in http://www.ncgia.ucsb.edu/conf/SANTA_FE_CD-ROM/sf_papers/miller1_david/miller_paper1.html

Newson, M. 1997. Land and Water: Interactions. In: Newson. M. 1997. Land, Water and Development. In: Urban Drainage: System Modelling for Integrated Catchment Management In David R Miller and Jane G Morrice, Assessing uncertainty in catchment boundary delimitation in: ;http://www.ncgia.ucsb.edu/conf/SANTA_FE_CD-ROM/sf_papers/miller1_david/miller_paper1.html

Zhang, M. C., Campbell, J. B. and Haralick, R. M. 1990. Automatic delineation of drainage basins within digital elevation data using the topographic primal sketch Mathematical Geology. *Mathematical Geology*, 22(2): pp. 189-209 in http://www.springerlink.com/content/l4885jr887k4754q/http://asterweb.jpl.nasa.gov/content/03_data/01_Data_Products/release_DEM_relative.html