## Your knowledge on topic :

My topic is “Geospatial database creation for Indo-Gangetic delta for source-to-sink relation mapping”. Mapping of source to sink (Himalaya-source, Bay of Bengal-sink) requires estimation of river discharge. River discharge is defined as the total volume of water flowing through a channel at any given point and is measured in cubic metres per second. The discharge from a drainage basin depends on precipitation, evapotranspiration and storage factors. The knowledge of river flow propagation speed and the time for flows to pass downstream and various other flow parameters like river width, roughness coefficient, river depth, river slope are important in the estimation of River discharge. Measurement of flow parameters using remote sensing data and GIS requires to be calibrated with the insitu gauge data and accuracy of the method used should be computed with the RMSE error as the probability of error is most as the data are satellite images and often there is setback in case of cloud cover where data acquisition is problematic. The equation of flow continuity is used for the comparison of river discharge at virtual station and ground station (for example. the discharge estimates at virtual station 1 and virtual station 2 are validated using the closest ground station using equation $\mathbf{A_1V_1 = A_2V_2}$). Manning’s formula is widely used for calculation for the flow discharge using the flow parameters.

## Gap identified in existing knowledge :

After reading some of the research papers, I came to a common conclusion that the algorithms or Landsat Images used for the calculation of the river width needs to be accurate as a slight change in the river width would affect the river velocity which in turn can lead to high **RMSE** error in calculation of the river discharge. Areas in the RivWidth algorithm that need work are: The production of developing binary water masks in IDL that are compatible for multiple formats and the ability to calculate multiple river segments that are not connected to one another.

## Justify the gap in research :

Pavelsky's method of calculating river widths is accurate and using it has proved to be effective in calculating widths in a large and remote area. Incorporating a water mask subprogram into the algorithm would be significantly more efficient. An accuracy limitation with this method is in the ability of the image not RivWidth. Being limited to a 30x30-meter resolution leaves a notable amount of error in the calculation of width. This leaves only the largest rivers and tributaries to be calculated in the basin. Temporally this method has difficultly. Most satellites capable of being used for this process revolve around the planet and are not static which means that there is a period of time before it takes another image of that same area. In this case it is 16 days and if the image taken is covered by clouds it has to wait to take another image. For example, the Rivwidth has an issue with connecting braided rivers if the distance between the segments is too great. So while the estimation of the river width it would consider the overall width which can lead significant error in estimation of river velocity.

Figure 1: for example in the above figure if we try to compute

width for the marked circle it would consider overall width which might lead to error in river velocity calculation. (Ganges river)

All these non-contact satellite-based monitoring methods have some disadvantages. Remote sensing is susceptible to the high reflective nature of trees in the visible and infrared section of the spectrum which can affect accurate estimation of water body surface area and width (**Ward et al., 2013**). Satellite based remote sensing however only show river variability (and either vertically or horizontally, not both simultaneously) and not river flow itself, always requiring in-situ information to achieve a flow estimate. A further limitation is the temporal resolution of most satellite data which typically has an inverse relationship with the spatial resolution. This means in the instances where relatively high resolution is required, there will be the limitation of having less observations per unit time. Remote sensing methods ultimately, cannot estimate discharge directly yet (**Costa et al., 2000**). Ground observations are required to make the translation into flow estimates. The above statements are evident that there is significant error in calculation of river discharge estimation using remote sensing flow parameters.

## Objectives of your work :

1) To measure the river width of the Ganges River and combined with measurements of river slope with other flow parameters to estimate the river discharge.
2) To calibrate the virtual station discharge data to the closest ground data to minimise the RMSE error in discharge estimation.
3) Increasing the efficiency of the methods behind determining discharge variables to determine the river morphology on a larger scale.
4) To understand the movement of the river versus it's surrounding to gain its economic importance.

# INTRODUCTION

## RELATION MAPPING

Map making with remote sensing data requires geometric and radiometric processing methods (monoscopic and stereoscopic) adapted to the nature and characteristics of the data in order to extract the best cartographic and topographic information.

## RIVER DISCHARGE

River discharge is the volume of the water flowing through a particular channel or a given area of interest. Measurement of river discharge is necessary in relation mapping of Indo Gangetic delta where primarily my source is Himalayan region and sink is Bay of Bengal. The ground observation method is the most accurate measure of river discharge. However, ground river discharge is obtained by estimating the hydraulic characteristics of stream channels including depth, width, and velocity as stated in the equation above. From Manning's equation (**Manning, 1891**), hydrological relationships that could potentially estimate the river discharge from space is as follows: The discharge equation (Q) can be deduced as:

$$\frac{Q}{A} = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}},$$

## RIVER VELOCITY

A time lag analysis is carried out to estimate the time lag of the river width changes between any two station A and station B which lies in the path flow of the stream. A time lag is the time interval for the peak river width measurement observed at station A to be recorded at station B. The peak river width used in most of the cases is taken to be the average of the daily river width measurements. Using the time lag and the distance separation between stations A and B, the average river velocity (assuming a uniform velocity) can be computed. The time and distance separation allow average propagation speed to be computed.

## ROUGHNESS COEFFICIENT

The roughness coefficient of river channels depends on a number factors such as the vegetation type and structure, the cross-section area, degree of meandering, and obstructions in the river (**Coon, 1998**).

**Values for the computation of the roughness coefficient (Chow, 1959)**

| Channel Conditions | | Values | |
|---|---|---|---|
| Material Involved | Earth | n0 | 0.025 |
| | Rock Cut | | 0.025 |
| | Fine Gravel | | 0.024 |
| | Coarse Gravel | | 0.027 |
| Degree of irregularity | Smooth | n1 | 0.000 |
| | Minor | | 0.005 |
| | Moderate | | 0.010 |
| | Severe | | 0.020 |
| Variations of Channel Cross Section | Gradual | n2 | 0.000 |
| | Alternating Occasionally | | 0.005 |
| | Alternating Frequently | | 0.010-0.015 |
| Relative Effect of Obstructions | Negligible | n3 | 0.000 |
| | Minor | | 0.010-0.015 |
| | Appreciable | | 0.020-0.030 |
| | Severe | | 0.040-0.060 |
| Vegetation | Low | n4 | 0.005-0.010 |
| | Medium | | 0.010-0.025 |
| | High | | 0.025-0.050 |
| | Very High | | 0.050-0.100 |
| Degree of Meandering | Minor | m5 | 1.000 |
| | Appreciable | | 1.150 |
| | Severe | | 1.300 |

$$n = (n_0 + n_1 + n_2 + n_3 + n_4)\, m_5$$

Figure 2 :Values for the computation of the roughness coefficient(**Chow, 1959**)

## WATER MASK DETERMINATION

Before running RivWidth an unsupervised classification had to be made. Then the combination of classes has to be made in order to segregate water from the rest of the classes. The default ENVI classification algorithms is used to perform the water mask determination. Finding Landsat images that are clear of cloud cover or mostly clear of cloud cover is one of the most time consuming parts of the analysis.

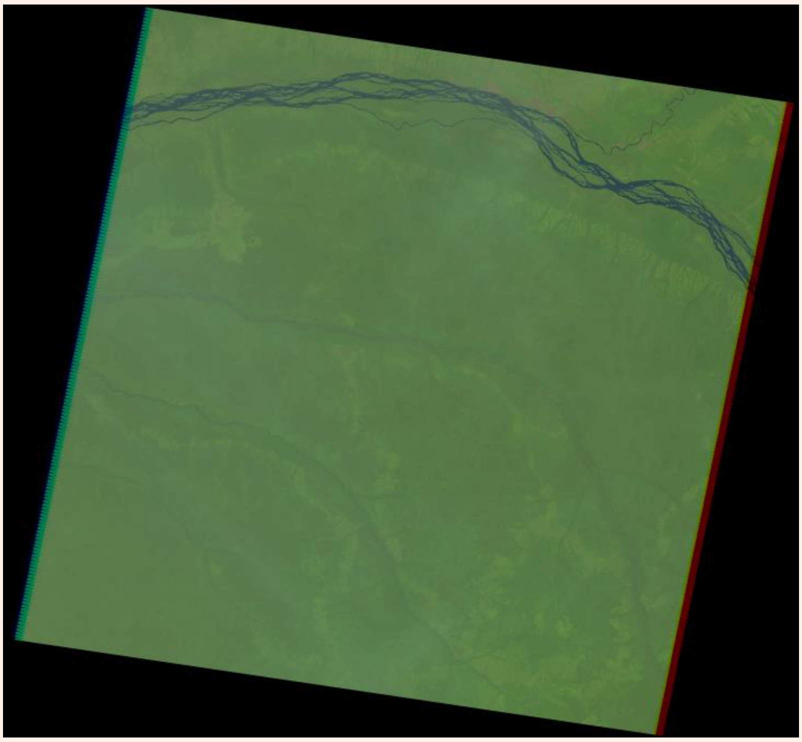

Figure 3: Original Landsat image of tile 178/59 (Path/Row) (Mart) (Congo river)

After finding a usable image it is put through this classification process that ENVI offers and in doing this the user is required to pick the k-mean and iterations for the classification. This is dependent on the tile and can change. After classifying the image properly where water is identified in a separate class the combination of classes is then possible.

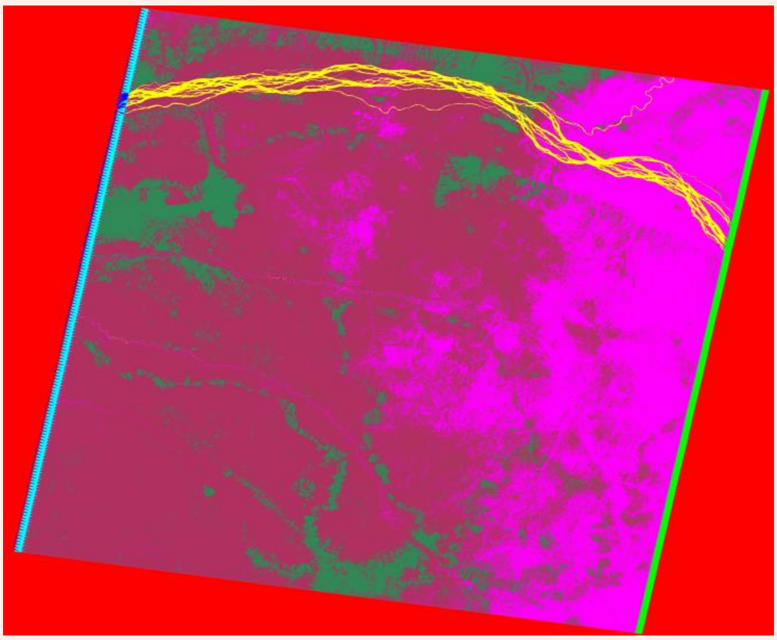

Figure 4: Unsupervised classification of tile 178/59 (Path/Row). The river is shown in yellow.

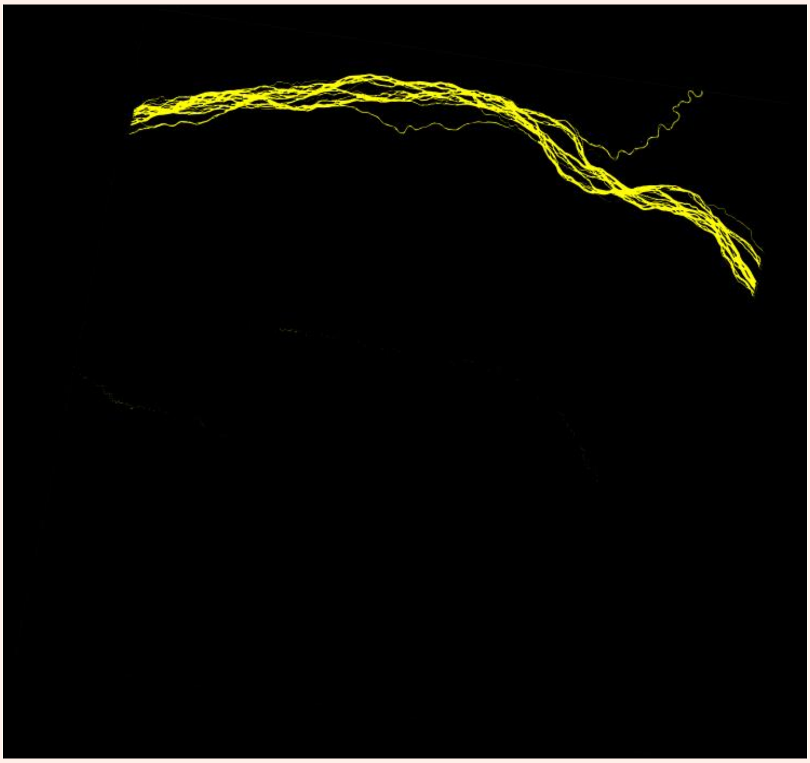

Figure 5: Water mask of tile 178/59 (Path/Row). The river is shown in yellow.

## RIVER DEPTH ESTIMATION

Reach average depth was calculated from average annual discharge. The relationship between the average annual discharge and the catchment area determined from the literature (**Shahin, 2002**),

$$Q_m = 0.0287A^{0.9155}$$

The mean discharge estimates were applied to the depth formula:

$$\bar{D} = 0.27Q^{0.39}$$

This formula was developed through existing data sets in an attempt to calculate a universal scaling for width and depth (**Moody and Troutman, 2002**). This was used due to the fact that a method could not be devised to obtain depth measurement from remotely-sensed data. Taking from the above calculation and using it as an average for depth in the below equation made it possible to calculate along every point in the flow path. This is simple an adjustment of depth based on width in sub-reach intervals.

$$D(i) = \left(\frac{\bar{W}}{W(i)}\right)^{\frac{3}{5}} \bar{D}$$

## REFERENCES


1) *D.P. Ward, S.K. Hamilton, T.D. Jardine, N.E. Pettit, E.K. Tews, J.M. Olley, S.E. Bunn. 2013 Assessing the seasonal dynamics of inundation, turbidity, and aquatic vegetation in the Australian wet-dry tropics using optical remote sensing Ecohydrology, 6 (2013), pp. 312-323, 10.1002/eco.1270.*
2)

*J.E.Costa, K.R. Spicer, R.T. Cheng, F.P. Haeni, N.B. Melcher, E.M. Thurman, W.J. Plant, W.C. Keller 2000 Measuring*

*Stream Discharge by Non-contact Methods: A Proof-Of-Concept Experiment.*

3) *Manning, R. On the flow of water in open channels and pipes. Trans. Inst. Civ. Eng. Irel. 1891, 20, 161–207.*
4) *Coon, W.F. Estimation of Roughness Coefficients for Natural Stream Channels with Vegetated Banks; US Geological Survey: Reston, VA, USA, 1998.*
5) *Chow, V.T. Open Channel Hydraulics; McGraw-Hill: New York, NY, USA, 1959.*
6) *Pavelsky, T.M., & L.C. Smith, 2008, RivWidth: A Software Tool for the Calculation of River Widths from Remotely Sensed Imagery. IEEE Xplore. http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=4382932, Accessed May 2013*
7) *Shahin, M, 2002, Hydrology and water resources of Africa: Dordrecht, Kluwer Academic, 659 pp.*
8) *Moody, J. A., & Troutman, B. M., 2002, Characterization of the spatial variability of channel morphology: Earth Surface Processes and Landforms, v. 27, p. 1251- 1266*
9) *Nicholas Martin 2013, Remote Sensing of River Widths and Discharge Estimation for the Mainstem Congo River*