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MORPHOMETRIC ANALYSIS OF THE PRAVARA RIVER BASIN THROUGH SRTM AND TOPOSHEET DATA

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ABSTRACT

In the present study use DEM generated from Toposheet (20m) and SRTM (90m) data to compare the quality between them. Arc GIS software is used for thematic mapping and layer generation. Morphometric analysis and student 't' test has done through Microsoft excel. Bivariate statistical method is used for solving the student 't' test. The coarse resolution SRTM data do not reflect minor variations in the relief, whereas toposheet generated DEMs show more details. Finer resolution data would have captured the true landscape process in the study area. Higher fractal values and significant at 95 per cent confident level shows that variations are significant. Higher variability in Fractal Dimension suggest that, there are different landform units in watershed area, SRTM data will not do justice to all the units, hence a higher resolution toposheet data is more desirable.

Key Words : *DEM, Resolution, SRTM, Toposheet.*

Introduction

A landform is a natural physical feature on the earth's surface having a shape at a given scale, characteristic and formed by natural processes. It is the basis for all the earth surface processes and important for planning of geology, hydrology, agriculture, ecology, climatology, geomorphology and others. (Andy Jarvis, 2004) Automatic extraction of topographic parameters based on digital elevation models (DEM) and GIS are increasingly being used in the geomorphological and hydrologic research covering a wide range of scales, from global to local (Florinsky, 1998, Toutin 2001, Gerstenecker, et al, 2005, Demirkesen 2008, Klingseisen, et al, 2008). Several primary terrain feature derived from a DEM are an essential condition for the structure of channel networks. These include the curvature, slope and flow net determination. Slope is generally computed from the drop in elevation between a cell and the lowest along with its eight adjoining cells. (Khan, et al, 2014.)

Natural River patterns develop in response to the increasing effects of the upper catchment area, topographic slope and the permeability of the surface materials (Montgomery, D.R., 1988, Horton, R.E., 1945) many of researchers are used Digital elevation model for morphometric analysis as well as terrain analysis. During the last two decades the availability of DEM/DTM data has been continuously growing, data accuracy has improved, and additional algorithms have been developed and implemented through the industry standard and stand-alone GIS software programmers (Florinsky, 1998, Kamp, et al, 2005). SRTM DEM contains more information as compared to the DEM derived from the 1:50,000 topographic map, it cannot directly used for the extracting of channel network than it was used as an outside features. This was done to overcome the problems arising out of the mismatch between drainage lines derived from the SRTM DEM and the channel network on the topographic map. (Jarvis, et al, 2004) Most DEM have the generalization of land surface. Built into them if this generalization is within the spatial range of the processes that are operating in the landscape of interest there is no problem. If the generalization is greater than the resolution of the landscape processes any result obtained from DEM to be treated with caution (Pain, 2005).

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In the present study, DEM from topographical contours of 20m interval and SRTM image of 90 m resolution were used for deriving the morphometric parameters and for the landform characterization of a region, *forming a part of the* Western Deccan Traps, India. The emphasis of this investigation is placed on the comparison of the terrain derivatives from contour DEM and SRTM DEM to assess the utility of both in the landform studied of varying scales.

Aims and objectives

The main objective of the present study is to compare the changes in morphometric and basin parameters with respect to the DEM extracted from toposheet and SRTM data. That comparision also proved by statistical method which is fractal dimension.

The Study Area

The area which is selected for the study is the Pravara River Basin. This is located in the state of Maharashtra, Ahmednagar district, and tehsil of Akole, Sangmner, Rahuri, Shrirampur, Nevasa, and Shevgoan. The location map shown in the figure (01).

Pravara river is the tributary of the Godavari River. The Pravara river rises in the eastern slope of the Sahayadris between Kulang and Ratangad, the height of 1,468 meter ASL. The total catchment of the basin area is about 2,653 sq.km. About 12 miles after rising it falls down in rocky parts up to 200ft. deep, and then widening for thirteen kilometer through deep narrow gorge, which is wider valley at the east and bellow the central plateau at which village Rajur is located. Total length of the Pravara River is 193.12 Km. (120miles).

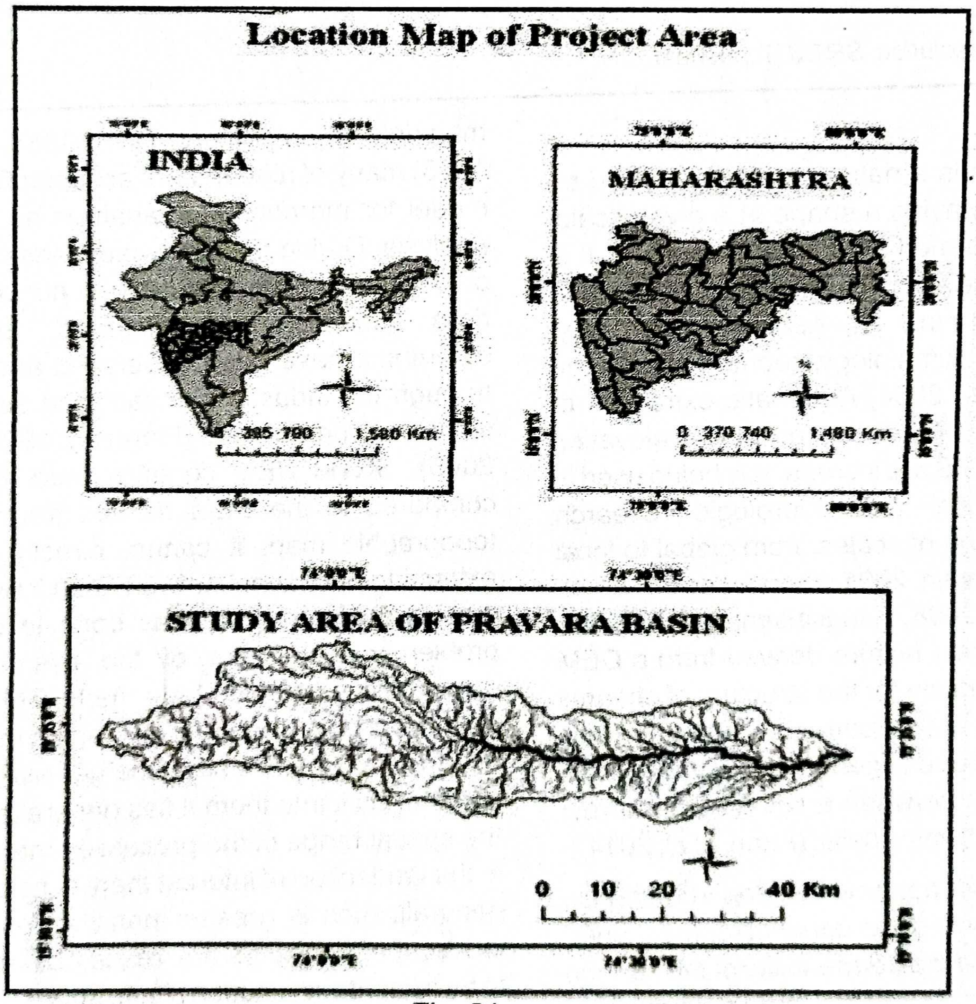

Fig. 01

Methodology

To carry out the objectives in this project work the following methodology has been adopted.

- Obtaining the topographical map 1:50000 scale of the study area from Survey of India (SOI) (Toposheet surveyed in 1968-70) and also downloading of SRTM 90m (Satellite data taken in 2008) resolution data.
- Digitization of the Toposheet with necessary layers of contour, river & spot heights. Extraction of the interested area from SRTM Data.
- Morphometric & basin parametric analysis by the ARC GIS 9.3 software.
- Graphical comparison of the data and calculation of Fractal Dimensions for both the data.
- Statistical tests apply to see the accuracy of the data.

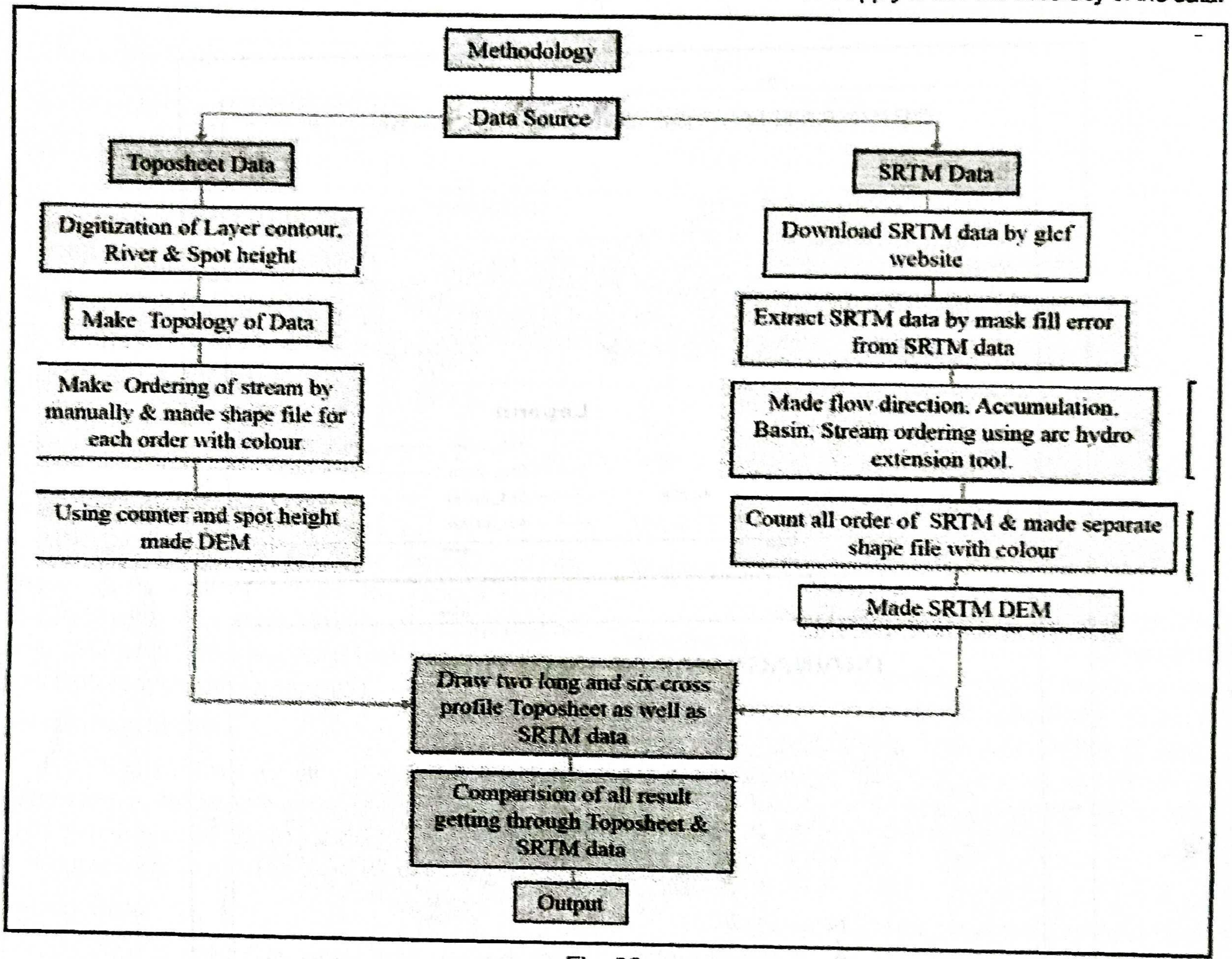

Fig. 02

In the period of 1960 to 70 there was not available the data like SRTM, Cartosat and other satellite data, therefor I used Toposheet data at 20m contour interval and SRTM data at 90m resolution because before 2010 there was not accessible any free satellite data for grater resolution than SRTM 90m.

Digital Elevation Model

Geo-spatial information describing the elevation of the land surface above a common datum plane is defined as DEM. Digital terrain models represent segments of spatial data bases related to terrain features and landforms, and offer the most common method for extracting vital topographic information (Desmet and Govers 1995, Kamp, et al. 2005, Singh, et al, 2007). The DEM exacted from SRTM poses the problem of less information contains whereas area is flat. This was experienced by using SRTM (Shuttle Radar Topography Mission) DEM of the study area as an external drift to generate the final digital elevation model for the region.(Journel, A.G 1978)In this study DEM models were generate for both Toposheet & SRTM data. It represent visual difference of both data types.

Morphometric Parameters of The Basin Area

Morphometric parameters are measured from drainage map generated from Toposheet and SRTM Data. These drainage map are shown in figure 03.

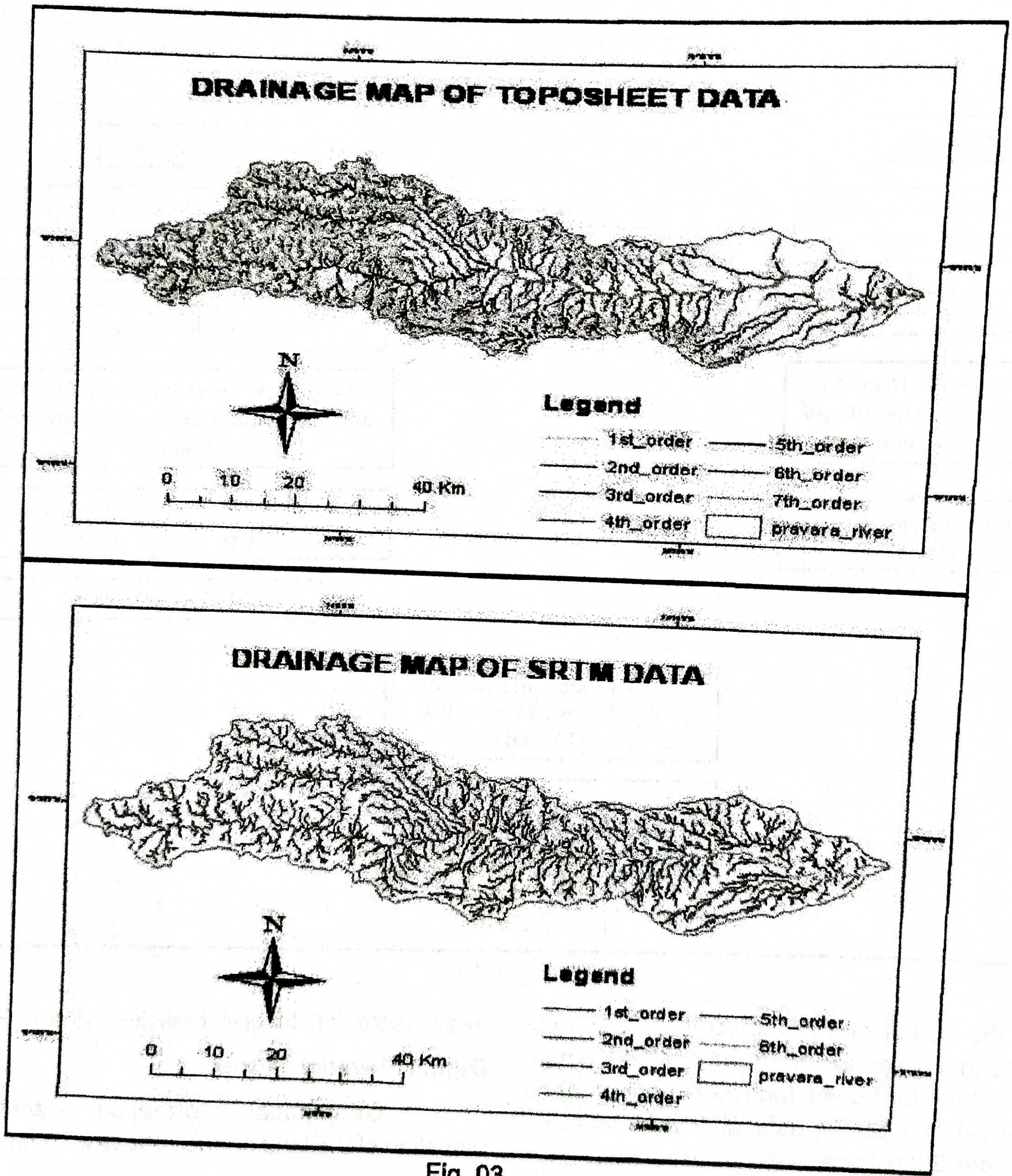

Fig. 03

Table 01 : Drainage Basin and Network Morphometry.

Parameters	Toposheet data	SRTM data
Linear Aspect		
Stream Order	7	6
Total Stream Length	3476167.4011010 m.	1099439.839 m.
Length of Main Stream	193.12 km	178.09 km
Stream Length Ratio	5.61	5.13
Bifurcation Ratio	4.605	5.807
Aerial Aspect		
Drainage Density	1.31 km/km^2	0.41 km/km^2
Stream Frequency	2.59$km/\ km^2$	0.99 km/Km^2
Relief Aspect		
Relative Relief	1160m	1033 m
Relief Ratio	0.006	0.0053
Slope	0.0035	0.0031

Source: Morphometric Analysis done by DEM generated from Toposheet (1968-70) and SRTM (2008) Data.

Linear aspect

Computation of the linear aspects such as stream number, stream order for various orders, stream lengths for various stream orders, bifurcation ratio, and length ratio are described below. All these parameters are shown in table 01).

Stream Number (Nu)

It is the total number of streams gradually decreases as the stream order increases. Using Arc GIS, the number of streams of each order and the total numbers of streams were computed.

Stream Order

The disparity in order and size of the tributary basins are largely due to physiographic and structural conditions of the region. By applying of this ordering procedure using GIS shows that the drainage network of the study area is in the Toposheet data get the 7th order of the stream and 6th orders by the SRTM data. It means some streams are not shown in the SRTM data.

Stream Length (Lu)

Length of the stream is different for the different order of the stream as well as toposheet and SRTM data also. Total stream length of all the orders of the streams indicated by toposheet data is 3476167.4 m. (3,476.16 km.) and 1099439.83m. (1,099.43 km) by SRTM. 198.12 km is the length of the main stream in the toposheet data and 178.14 km. for the SRTM data.

Length Ratio (RL)

The length ratio (RL) is defined as the ratio of mean stream length (Lu) of segment of order (u), to mean stream segment length (Lu-1) of the next lower order u-1.leangth ratio for the toposheet data is 5.62, and for the SRTM data is 5.13.The RL has an important relationship with the surface flow discharge and erosional stage of the basin (Sreedevi, et al, 2005).

Bifurcation Ratio (Rb)

The term 'bifurcation ratio' (Rb) was introduced by Horton (1932) to express the ratio of the number of streams of any given order to the number in the next lower order. According to Strahler (1964), the ratio of number of streams of a given order (Nu) to the number of segments of the higher order (Nu+1) is termed as the Rb. Bifurcation ratio calculated for the toposheet data is 4.605 and 5.807for the SRTM data. Bifurcation ratio of the toposheet data is between 3 to 5 and it indicates geological and structural control in the basin of the study area (Sreedevi, et al, 2005). But bifurcation ratio of the SRTM data is more than the 5 it indicates that there is geological and structural control in the basin area and it shows the mature topography of the basin area (Sreedevi, et al, 2005).

Fractal Dimension Analysis

Linear Fractal dimension for the rivers & sample gullies were calculated by employing Divider Relation (Laverty 1987). The value of D ranges between 1 (almost straight) to 2 (nearly filling the plane). Statistically self-similar line reveals a constant value of D over a range of scales (Mandelbrot ,1967). The D value of the curve is estimated by measuring the length of curve using various step size increases. D can be calculated by the following equations :

$$\text{LOG } L = k + b \log d$$

$$D = 1 - b$$

Where 'L' is the length of curve, 'd' is the step size, b is the slope of the regression and K is the constant. From the above equations D is the function of the regression slope B. Steeper the negative slope (b is negative values), the higher is the Fractal Dimension. This technique was applied to the longitudinal and cross two profiles (profile shown in following figure 04 which are drown on the DEM map of Toposheet and SRTM data in which results are presented in the table 02.

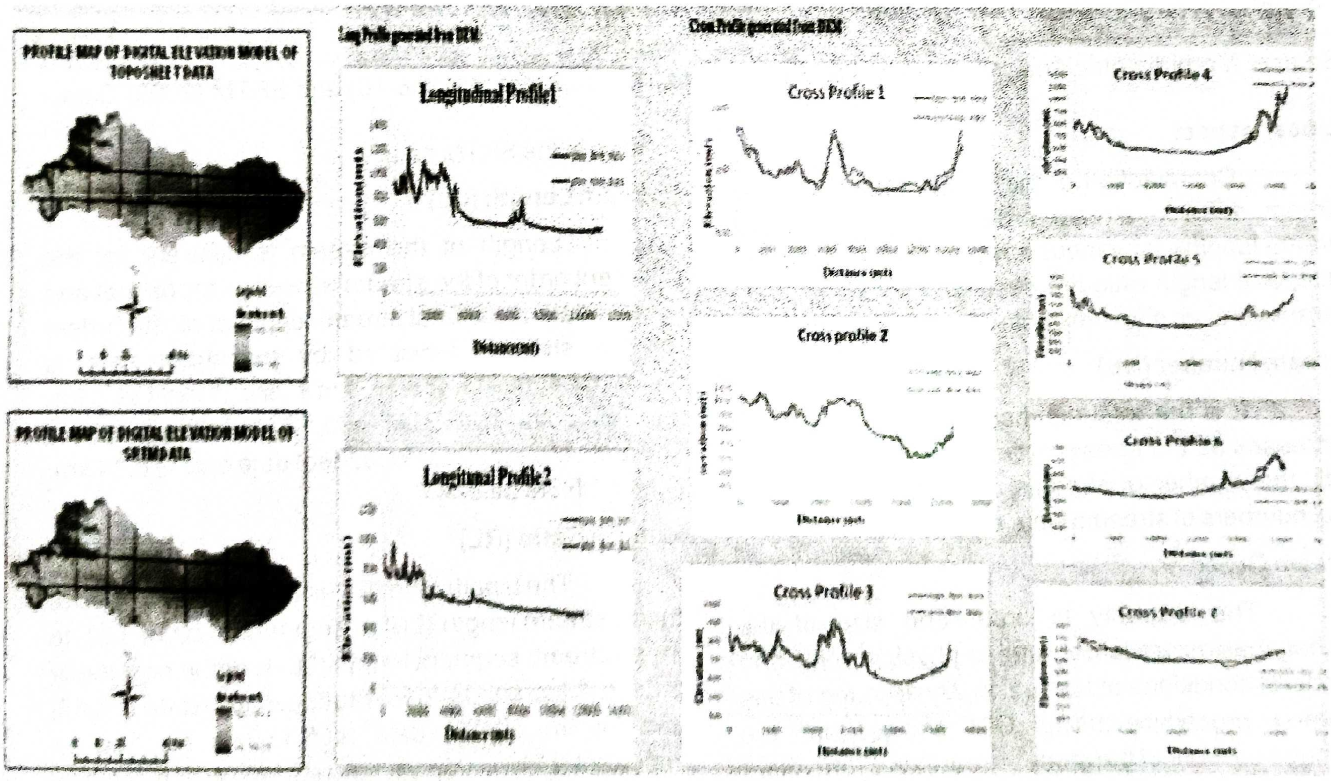

Fig. 04

Table 02 : Fractal Dimension Value for Both Toposheet & SRTM Data. Comparison Between Fractal Dimensional Value of Toposheet and SRTM Data.

Profile number	Fractal dimension value for Toposheet data	Fractal dimension value for SRTM data
Cross Profile 1	1.04	1.032
Cross Profile 2	1.148	1.113
Cross Profile 3	1.119	1.013
Cross Profile 4	1.096	1.082
Cross Profile 5	1.043	1.035
Cross Profile 6	1.031	1.031
Cross Profile 7	1.055	1.002

Source : Cross Profile Drawn by Toposheet (1968-70) & SRTM DEM (2008.)

Above table show the fractal dimension for both Toposheet and SRTM data. These value are getting from the Cross profile which are drawn on the DEM map of Toposheet as well as SRTM data. This DEM maps give the variation in elevation in both the data. Above values are clearly show that the difference between the fractal dimension values.

The fractal dimension values of Toposheet data are higher than the SRTM data. Only the sixth value of the Fractal Dimension is same for both the data, because of in the actual field of the basin area there is not that much variation in the landform and surface elevation also not variation both DEM maps.

Significant Test

Fractal dimension value are gives variation but there is not support that's why there should need to apply the some statistics technique to prove the significant difference in both SRTM and Toposheet data. For this testing chose the "Student 't' test" (Statistical technique).by this testing get the values are:

Table 03 : Calculated and Table Value of 't' Test.

Value of 't'	2.25
Table value	1.94

Source : Fractal Dimension Value Taken From Cross Profile for Both Toposheet and SRTM DEM (Value Used From Table 02).

Value of the 't' is more than the table value at the level of 0.05. It means, at the 95% confidence level we can say that, significant difference in the data reflectance in the Toposheet and SRTM data.

Major Findings

- Toposheet data is useful for the study of the drainage as well as Morphometric study of the basin area. This holds true for the present area
- Toposheet data gives the ordering up to 7th stream order while SRTM data gives the ordering up to the 6th order.
- Bifurcation ratio from SRTM data is greater than that of toposheet data indicating highly structural & geological control.
- Length of the main stream in the toposheet data is 193 km. and this length given by the SRTM data is 178 km. Total length of the toposheet data is 3476167.4 m. it is much more then SRTM data. It is 1099439.8 m.
- Toposheet shows more Drainage density & Stream frequency.
- According to basin parameter, Toposheet shows *minor details and gives greater results compare* to SRTM data

- Fractal dimension values calculated from super impose profile of DEM are greater in Toposheet data.
- The result from student 't' is more significant for Toposheet than SRTM data, at 95% significant level.

Conclusion

Present research paper compare Toposheet 20m contour interval and SRTM 90m resolution data. The result revels that Toposheet data gives better results than SRTM. Morphometric analysis shows clear difference in resolution of both data in this analysis also shows toposheet gives high clarity than SRTM. DEM extracted from Toposheet and SRTM which are used for formation of drainage map and drawing the cross sections which are used for fractal dimension analysis. Value of fractal dimension also shows toposheet data is gives greater result than SRTM data. Students 't' test is also significant at 95 per cent level which proves that toposheet data is better than SRTM data.

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