

Application of 30m Resolution SRTM DEM in Nepal

Raghunath Jha

Department of Civil Engineering, Pulchowk Campus, Institute of
Engineering, Tribhuvan University, Kathmandu, Nepal
Corresponding author: *rnjha@ioe.edu.np*

Received: Feb 27, 2018 Revised: March 17, 2018 Accepted: March 25, 2018

Abstract: Digital Terrain Model (DTM) or Digital Elevation Model (DEM) is an important data for Raster Analysis in modern GIS. Its use is extremely important for almost all fields of engineering, especially Water Resources Engineering. In Nepal, high-resolution DTM is not available, and often funds are limited to generate high-resolution DTM using modern day technology such as LiDAR or Aerial Photography. As a result most of the works are based on SRTM DEM which is available free of cost. Presently, 1 arc second DTM is available in SRTM for Nepalese Territories. In this study, the applicability of 1 arc second or 30m resolution SRTM is checked in comparison with the Department of Survey Digital Topographic Map. It is found that SRTM DEM performs better than DEM generated from Data available with Survey Department.

Keywords: SRTM, 1 arc Second DEM, GIS, Topo Map

1. Introduction

Digital Elevation Model (DEM) is the most common parameter in GIS application. The algorithms have been developed to create slope, aspect, hillshade, viewshed, watershed boundary, river network etc [5]. These algorithmic applications are valuable and easy to use; a factor that has caused towards multiplication of software availability in the market. In Nepal, there are mainly two sources of Digital Elevation Models. They are (a) Global Elevation Datasets and (b) DEM generated from digitized contour lines and spot elevations using topographical maps of 1:25,000 or 1:50,000 developed by Department of Survey.

2. Global Elevation Datasets

There are numerous elevation datasets with global or nearly global coverage, but by far the most significant is SRTM.

2.1 SRTM: NASA Shuttle Radar Topography Mission

The Shuttle Radar Topography Mission (SRTM) was flown aboard the space shuttle Endeavour during February 11-22, 2000. The National Aeronautics and Space Administration (NASA) and the National Geospatial-Intelligence Agency (NGA) participated in an international project to acquire radar data which were used to create the first near-global set of land elevations.

The radars used during the SRTM mission were developed and flown on two Endeavour missions

in 1994. The C-band Spaceborne Imaging Radar and the X-Band Synthetic Aperture Radar (X-SAR) hardware were used on board the space shuttle in April and October 1994 to gather data about Earth's environment. The technology was modified for the SRTM mission to collect interferometric radar, which compared two radar images or signals taken at slightly different angles. This mission used single-pass interferometry, which acquired two signals at the same time by using two different radar antennas. An antenna located on board the space shuttle collected one data set and the other data set was collected by an antenna located at the end of a 60-meter mast that extended from the shuttle. Differences between the two signals allowed for the calculation of surface elevation.

Endeavour orbited Earth 16 times each day during the 11-day mission, completing 176 orbits. SRTM successfully collected radar data over 80% of the Earth's land surface between 60° north and 56° south latitude with data points posted every 1 arc-second (approximately 30 meters) [4] for United States and 3 arc-second for other parts of the world. Recently in 2017, 1 arc-second data is open for whole Nepal.

2.2 GTOPO30

- Global 30 Arc Second Elevation Data Set, distributed by the USGS [1]
- same resolution as DTED0 (<http://www.vterrain.org/Elevation/dted.html>), GLOBE and SRTM30 - but older and less accurate
- a collection of 33 files, grid spacing of approximately 1 km
- the file extension is "DEM" but it's not the same format as normal USGS DEM
- USGS HYDRO 1K Elevation Derivative Database (<http://edcdaac.usgs.gov/gtopo30/hydro/>) is a version of GTOPO30 which has been corrected using hydrology data
- for an amazing experience browsing (but not downloading) GTOPO30, ER Mapper's EarthEtc Imagery (<http://www.earthetc.com/imagery.aspx>) server can be tried, in particular their EarthStar World DEM dataset

2.3 NOAA GLOBE Project [3]

- like GTOPO30, another 30 Arc Second dataset (~ 1 km)
- it is newer or more accurate than GTOPO30 in some areas
- the data is not in any format at all - just large blocks of raw binary 16-bit values, with headers in a separate file
- has a number of nicely pre-rendered versions of the dataset

2.4 Other Global Elevation

- LandInfo - *Maps and International GIS Map Products*
 - the largest vendor of international map products
 - costs can be high; e.g. \$600 per 1-degree quad
- individual countries - the Locations Page can be browsed
- Converting from contour maps may be necessary if DEMs are not available for the area of interest

2.5 Digital Elevation Map developed from Topo Map

The Department of Survey with financial aid from the Government of Finland developed the topo map of whole Nepal between the years 1992 through 1998. Two different map scales were

used for developing the topo maps of northern and southern parts of Nepal. While the Northern portion (Himalayas and high hills) were mapped with 1:50000 scale, the Terai, hills and mountains were mapped with 1:25,000 scale. The contour interval in Terai was 10 m and in hills as well as mountains it was 20m. The contour interval of 40m was adopted in high mountains and Himalaya region. All topo maps were digitized by the survey department and the digital copy of the different thematic layers could be purchased from the department.

3. Preparation of DEM

3.1 SRTM data

The seamless data could be downloaded from <https://earthexplorer.usgs.gov/> [4]. The data is available in 1 degree by 1 degree. The data could be downloaded in different formats. The best format is GRID ASCII. If the gridascii data is downloaded, then grid could be converted using GIS software. The SRTM data sets are available in WGS84 Datum and Degree Decimal (dd) format. The grid should be projected in Everest Datum and Modified Universal Transverse Macerator (MUTM) format. The data should be resampled to 30m grid resolution. This grid is DEM of the study area. When the data were downloaded and checked there were lots of voids in the 1 arc second data, these voids were filled from 3arc second data sets and seamless data were produced shown in Fig. 1.

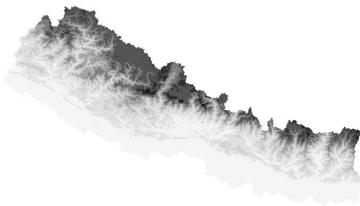


Fig. 1: SRTM data for Nepal

3.2 Topo maps

The contour lines and spot elevations were digitized from the printed map from the Department of Survey. Using QGIS software, a TIN (Triangular Irregular Network) was created from contour lines and spot elevations. From TIN, DEM of 30m grid resolution was created to make same resolution map as SRTM DEM.

4. Study Area

Two study areas, one in hills and the other in Terai were selected for application of DEM.

Hill Study Area: Hill study area was Rosi Khola in Kavre district. The location map is shown in Fig. 2. The catchment area is around 564.12 sq. km. The maximum and minimum elevation of this catchment is 545m and 2935m respectively and the average slope of the catchment is 27.17%. As the name itself suggests this catchment lies in a hilly area.

Terai Catchment: Terai catchment was selected on the boundary of Sarlahi and Mahottari districts. The area of the catchment is 110.56 sqkm. This area begins from Churiya hills and the elevation varies from 85m to 817m. It partly lies in a flat area

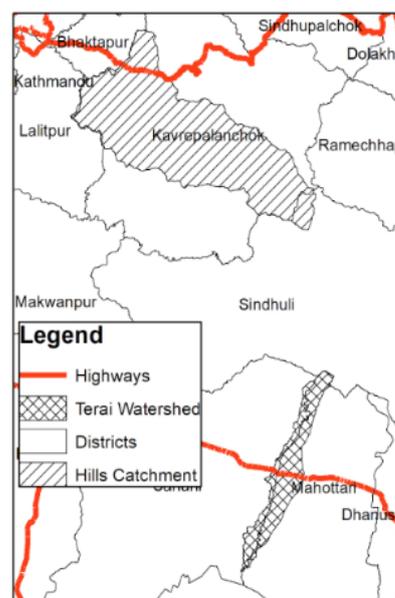


Fig. 2: Location Map of Hills and Terai Catchment

and partly in hills. The average slope of the catchment is 7.13%. The catchment location is shown in Fig. 2.

5. Methodology

The following standard process was applied to generate river and catchment boundary from SRTM DEM and DEM developed by Survey Department Digital Topo data [5] of same resolutions 30m. Open Source QGIS [2] software was used in this study.

1. Removal of sinks from DEM
2. Creating flow direction from DEM
3. Creating flow accumulation from the flow direction
4. Creating river network grid using a threshold value of 2500 grids
5. Converting the river network grid to stream network Delineating the catchment boundary at known pore point for both DEM

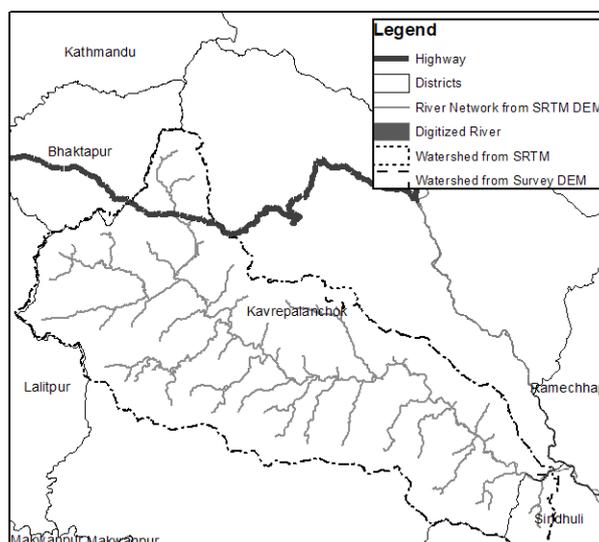


Fig. 3: Comparison of Rivers and Catchment generated from SRTM and Topo DEM in Hilly Area

6. Results and Discussion

(a) Hilly Catchment

The comparison of river network generated with the real river and catchment boundary has been shown in Fig. 3. This figure shows that the generated rivers from SRTM follow the digitized rivers better than generated rivers from Survey DEM. The generated catchment area from SRTM DEM is closer to the digitized watershed boundary as shown in Table 1. The other catchment characteristics such as minimum slope and maximum slope are within one percent error. The comparison of other catchment characteristics is shown in Table 2.

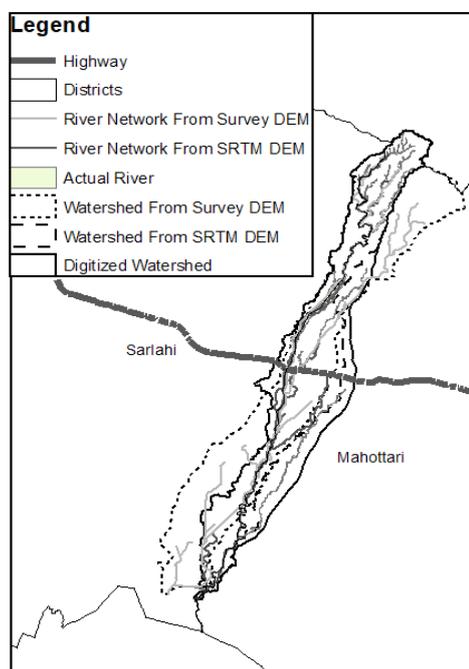


Fig. 4: Comparison of Rivers and Catchment generated from SRTM and Topo DEM in Plain Area

Flat Catchment

As previously described, the plain catchment is selected from border river of Sarlahi and Mahottari districts. It was found that the river generated from SRTM more closely resembles the real river (digitized river) than the river generated from the topo map as shown in Fig. 4. The catchment area generated from topo map does not match with the real river pattern. However, the catchment generated from the SRTM is closer matching to the real catchment. There is an error of 27.78% in the delineating catchment by Topo DEM. Other basin characteristics are shown in Table 3.

Table 1: Comparison of Catchment Characteristics between Actual, SRTM and Topo DEM in Hilly area

Description	Hills Catchment			Terai Catchment		
	Actual	Topo	SRTM	Actual	Topo	SRTM
Area in Sqkm	564	559.9	564.12	110.5	141.2	95.09
% Error	0	0.73	-0.02	0.00	27.78	13.95

Table 2: Comparison of Catchment Characteristics between SRTM and Topo DEM in Hilly area

Type of DEM	Slope in %			Elevation in Meter				River Length (KM)	
	Min	Max	Average	Min	Max	Average	SD	Maximum	Total
Topo	0	69.68	26.23	560	2930	1594.5	406.9	8.64	251.47
SRTM	0.0	68.7	27.17	545	2935	1600.2	407.7	9.8	262.7
% Error	0.0	1.5	-3.6	2.7	-0.2	-0.4	-0.2	-13.4	-4.5

Table 3: Comparison of Catchment Characteristics between SRTM and Topo DEM in Plain area

Type of DEM	Slope in %			Elevation in Meter				River Length (KM)	
	Min	Max	Average	Min	Max	Avg	SD	Longest River	Total River Length
Topo	0	55.9	5.6	86	804	272.4	173.2	97.7	15.3
SRTM	0.0	57.9	7.13	85	817	267.4	163.5	110.84	12.61
% Error	0.0	-3.5	-27.3	1.2	-1.6	1.8	5.6	-13.4	17.6

7. Conclusion

Two applications of both DEMs are shown above. In the hilly region, the behavior of both DEM is good. Both DEM generates nearly same catchment and other catchment characteristics are also nearly same. However, when catchments are generated in the flat region, the SRTM generates better catchment and river network. The topo-map has a supplementary contour interval of 10m in a flat region, this yield to a sparse contour in a flat region. DEM is generated from the sparse contour and limited spot elevations, which is not sufficient to generate the real river network. However, SRTM data has grid value for 30m grid resolution and can generate better river network and catchment boundary. For research application, where time and funds are limited to either digitize or buy the data from the Department of Survey, the SRTM DEM which is free and reliable DEM for hydrological and other GIS application could be highly useful.

References

- [1] GTOPO30, 1996, <https://lta.cr.usgs.gov/GTOPO30>
- [2] QGIS (1991), <https://www.qgis.org/en/site/>
- [3] NOAA GLOB Project (1999), <https://ngdc.noaa.gov/mgg/topo/globe.html>
- [4] SRTM Version 3 (2017), <https://earthdata.nasa.gov/nasa-shuttle-radar-topography-mission-srtm-version-3-0-global-1-arc-second-data-released-over-asia-and-australia>.
- [5] Yang J, Townsen RD and Daneshfar B (2005), A GIS-based approach to river network floodplain delineation, *WIT Transactions on Ecology and the Environment*, 83, ISSN 1743-3541.