DIGITAL ELEVATION MODEL (DEM) IN GIS

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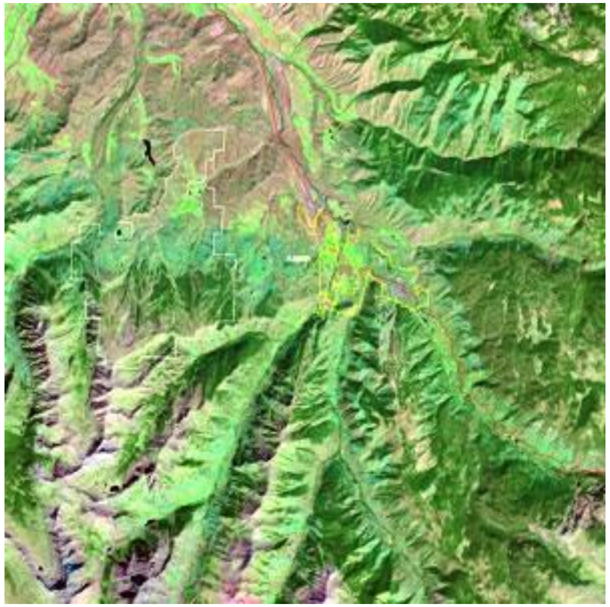

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Introduction:

Digital Elevation Model (DEM) is the digital representation of the land surface elevation with respect to any reference datum.
DEM is frequently used to refer to any digital representation of a topographic surface.

DEM is the simplest form of digital representation of topography .

DEMs are used to determine terrain attributes such as elevation at any point, slope and aspect.

Terrain features like drainage basins and channel networks can also be identified from the DEMs.

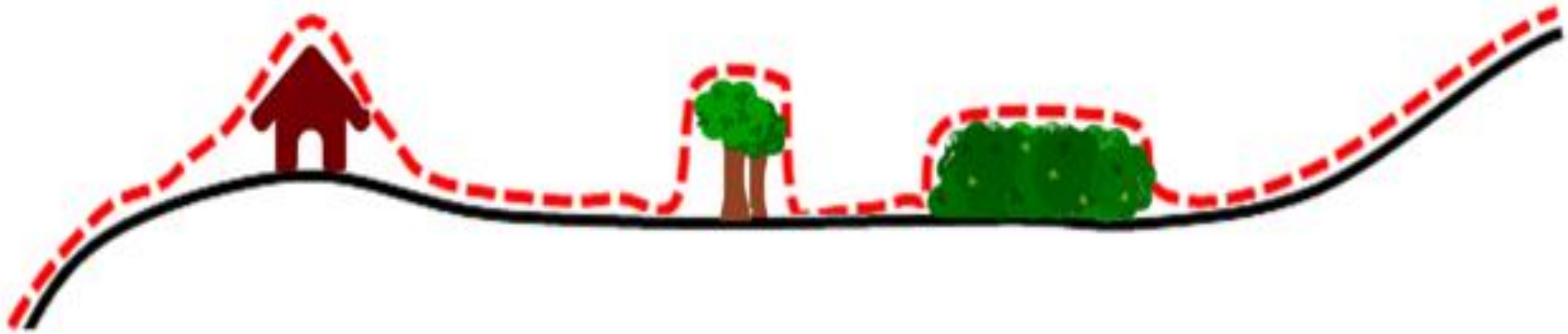
DEMs are widely used in hydrologic and geologic analyses, hazard monitoring, natural resources exploration, agricultural management etc.

Hydrologic applications of the DEM include groundwater modeling, estimation of the volume of proposed reservoirs, determining landslide probability, flood prone area mapping etc.

Three main type of structures used are the following.

a) Regular square grids

b) Triangulated irregular networks (TIN) c) Contours.



A **digital elevation model** (**DEM**) is a digital model or 3D representation of a terrain's surface, created from terrain elevation data.

There are three similar names as *digital elevation model* (DEM), *digital terrain model* (DTM) and *digital surface model* (DSM).

DEM is a subset of the DTM, which also represents other morphological elements.

Creation of DEMs:

Several methods are available to create DEM.

a) Conversion of printed contour lines

The first method is conversion of printed contour lines and use it in raster or vector form.

The elevation contours are "tagged" with elevations. Any other additional elevation data are created from the hydrography layer.

Finally, an algorithm is used to interpolate elevations at every grid point from the contour data.

b) Photogrammetry:

This can be done manually or automatically:

i) Manually, an operator looks at a pair of stereophotos through a stereoplotter and must move two dots together until they appear to be one lying just at the surface of the ground

ii) Automatically, an instrument calculates the parallax displacement of a large number of points.

Types of DEM:

A DEM can be represented as a raster (a grid of squares, also known as a heightmap when representing elevation) or as a vector-based triangular irregular network (TIN).

The TIN DEM dataset is also referred to as a primary (measured) DEM, whereas the Raster DEM is referred to as a secondary (computed) DEM.

A 7.5-Minute DEM covers 30- x 30-meter data spacing.

Production:

Mappers may prepare digital elevation models in a number of ways, but they frequently use remote sensing rather than direct survey data.

One powerful technique for generating digital elevation models is interferometric synthetic aperture radar where two passes of a radar satellite.

DEMs are commonly built using data collected using remote sensing techniques, but they may also be built from land surveying.

DEMs are used often in geographic information systems, and are the most common basis for digitally produced relief maps.

The SPOT 1 satellite (1986) provided the first usable elevation data for a sizeable portion of the planet's landmass.

Older methods of generating DEMs often involve interpolating digital contour maps that may have been produced by direct survey of the land surface. Several factors play an important role for quality of DEM-derived products:

terrain roughness;

sampling density (elevation data collection method);

grid resolution or pixel size;

interpolation algorithm;

vertical resolution;

terrain analysis algorithm;
Reference 3D products include quality masks that give information on the coastline, lake, snow, clouds, correlation etc.

Methods for obtaining elevation data used to create DEMs:

Lidar-*Light Detection And Ranging* (sometimes *Light Imaging, Detection, And Ranging*)
Stereo photogrammetry from aerial surveys
Multi-view stereo applied to aerial photography
Interferometry from radar data

Real Time Kinematic GPS
Topographic maps
Theodolite or total station
Doppler radar
Surveying and mapping drones
Range imaging.

Gridded structure :

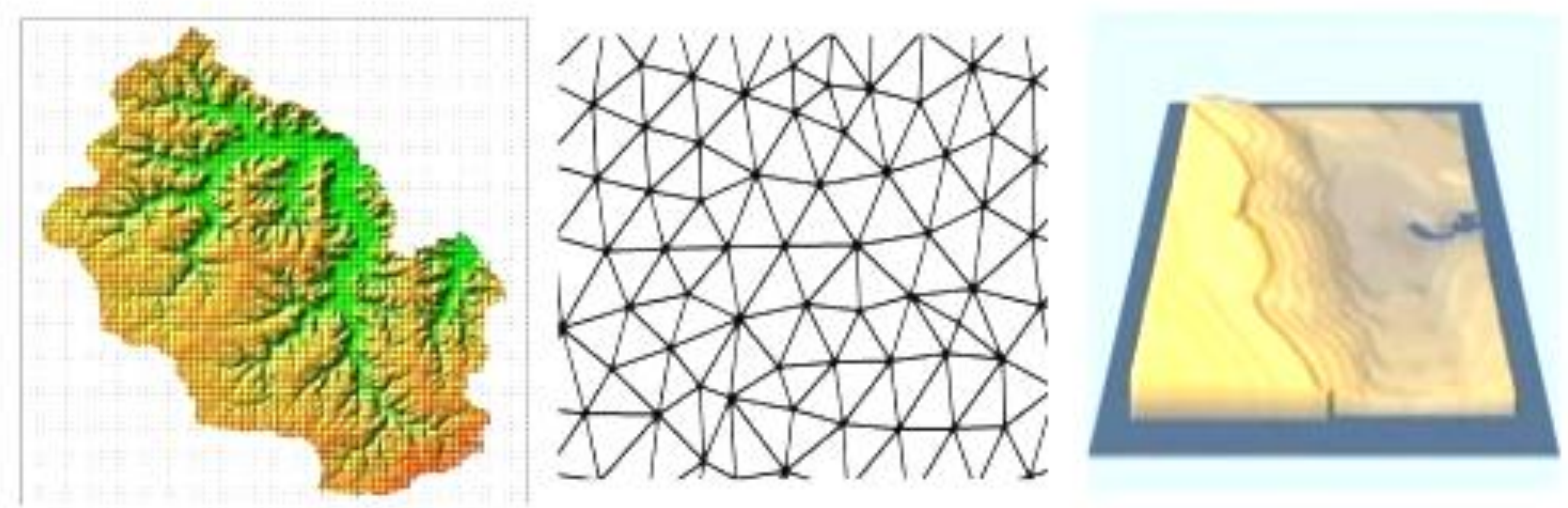
Gridded DEM (GDEM) consists of regularly placed, uniform grids with the elevation information of each grid.

The GDEM thus gives a readily usable dataset that represents the elevation of surface as a function of geographic location at regularly spaced horizontal (square) grids.

Measure of quality:

The quality of a DEM depends on its horizontal and vertical accuracy.

Accuracy of the GDEM and the size of the data depend on the grid size.



(a) (b) (c)

Different types of DEMs (a) Gridded DEM (b) TIN DEM (c) Contour-based DEM

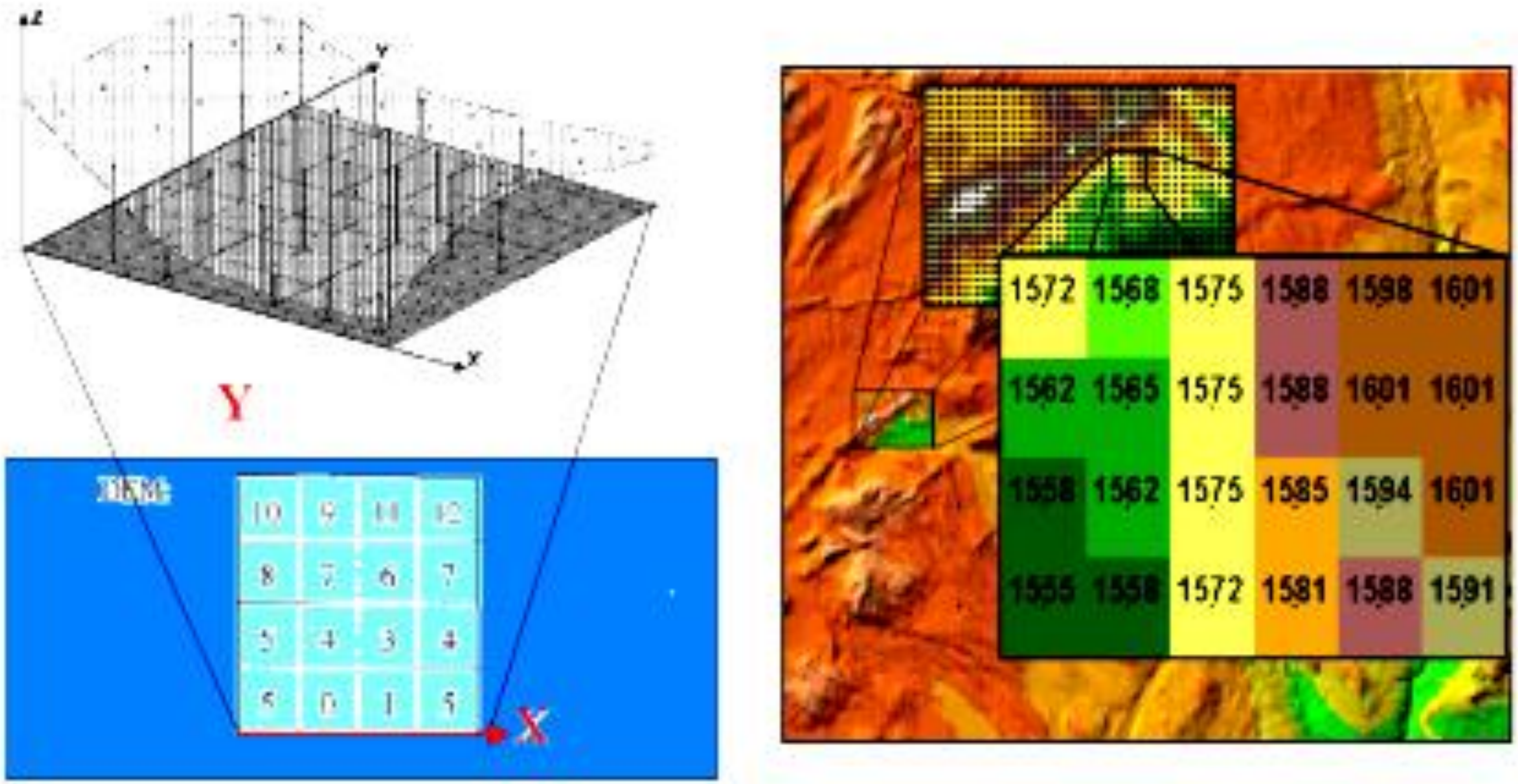


Figure 3. Gridded DEM

TIN structure :

TIN is a more robust way of storing the spatially varying information.

It uses irregular sampling points connected through non-overlapping triangles.

The vertices of the triangles match with the surface elevation of the sampling point and the triangles (facets) represent the planes connecting the points.

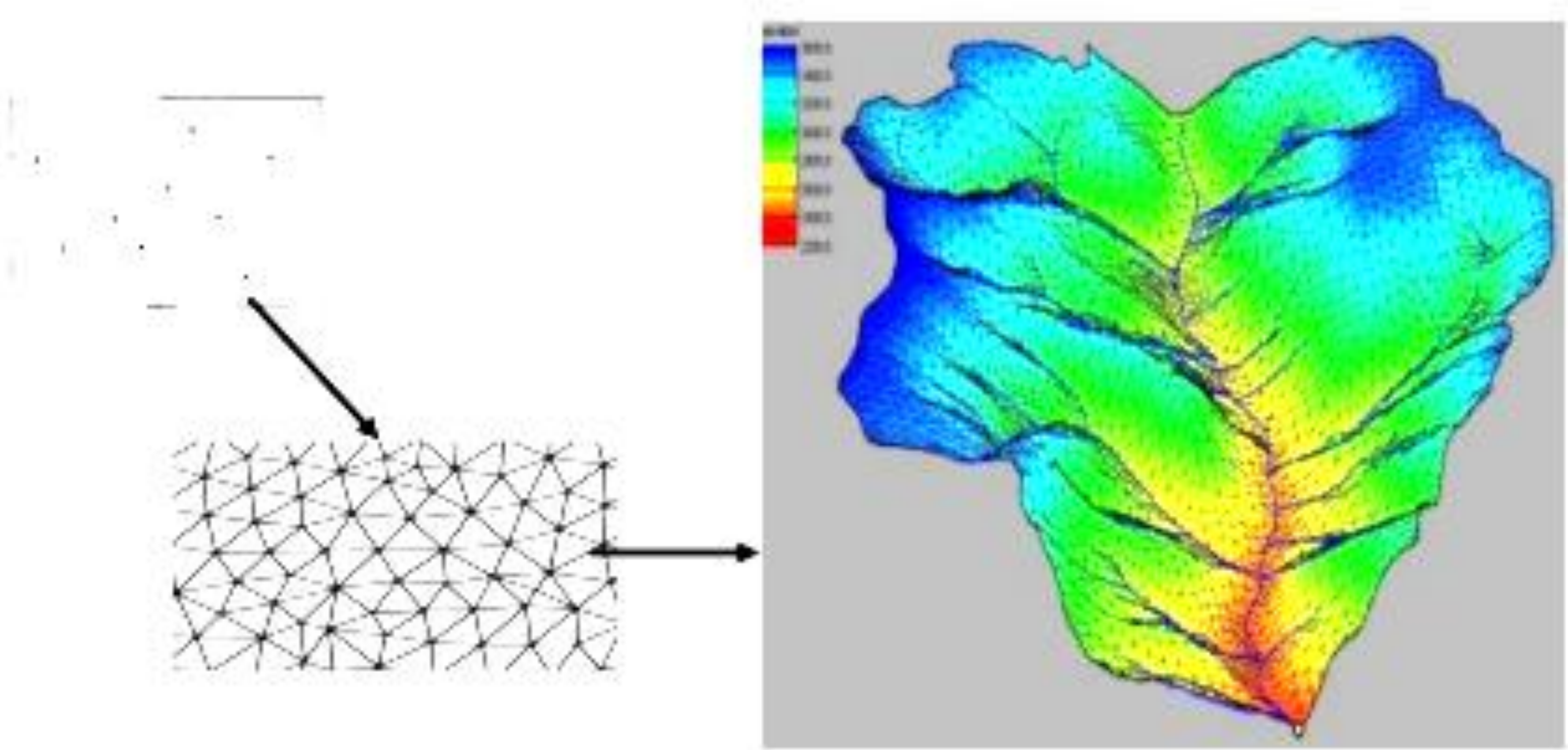


Figure 4 TIN DEM

Contour-based structure :

Contours represent points having equal heights/ elevations with respect to a particular datum such as Mean Sea Level (MSL).

In the contour-based structure, the contour lines are traced from the topographic maps and are stored with their location (x, y) and elevation information.

These digital contours are used to generate polygons, and each polygon is tagged with the elevation information from the bounding contour.

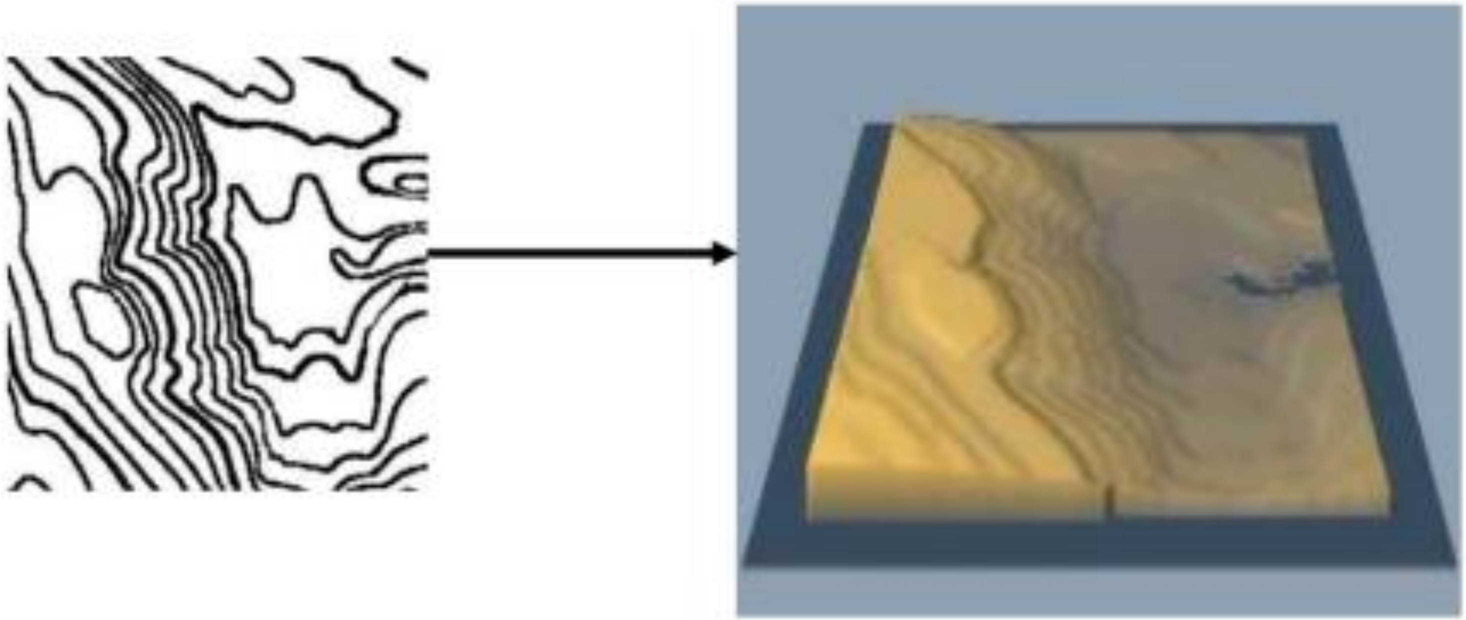


Figure 6. Contour-based DEM

Common uses of DEMs :

Extracting terrain parameters.
Modeling water flow or mass movement (for example, landslides).
Creation of relief maps.
Rendering of 3D visualizations
Creation of physical models (including raised-relief maps).
Rectification of aerial photography or satellite imagery.

Reduction (terrain correction) of gravity measurements (gravimetry, physical geodesy). Terrain analyses in geomorphology and physical geography.

DEM is used to determine the attributes of terrain, such as elevation at any point, slope and aspect.

DEM is also used to find features on the terrain, such as drainage basins and watersheds, drainage networks and channels, peaks and pits and other landforms.

Modeling of hydrologic functions, energy flux and forest fires, etc can be done using DEM data.

Determination of the drainage network and the associated drainage divides provides an important first step in the creation of a hydrologic information system.

DEM applications:

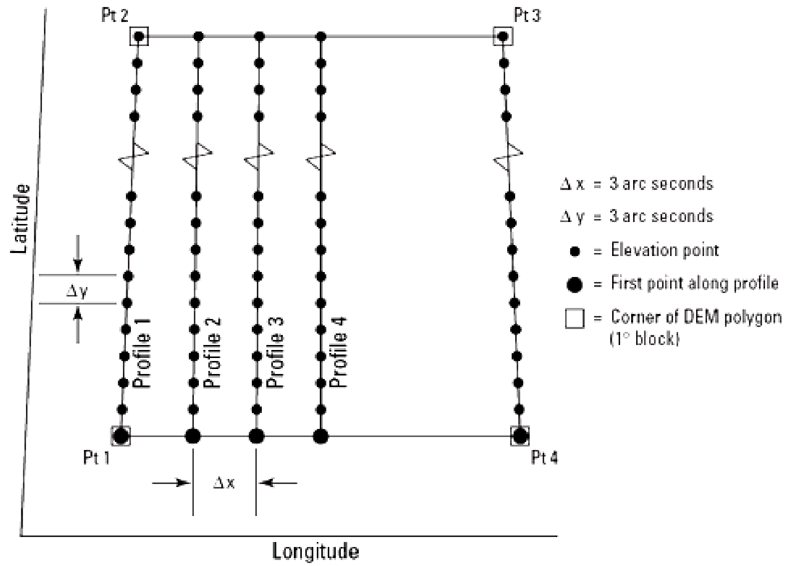
1) Estimating elevation
2) Estimating slope and aspect
3)Determining drainage networks
4) Determining the watershed

5) Terrain stability – Areas prone to avalanches are high slope areas with sparse vegetation, which is useful when planning a highway or residential subdivision.

6) Soil mapping – DEMs assist in mapping soils which is a function of elevation (as well as geology, time and climate).

7) To create a profile graph from digitized features of a surface.

Digital Elevation Model (DEM), consists of a sampled array of elevations for a number of ground positions at regularly spaced intervals, as shown in this fig.



LIDAR and DEM:

Light Detection and Ranging (LIDAR) sensors operate on the same principle as that of laser equipment. Pulses are sent from a laser onboard an aircraft and the scattered pulses are recorded.

The time lapse for the returning pulses is used to determine the two-way distance to the object.

LIDAR uses a sharp beam with high energy and hence high resolution can be achieved.

It also enables DEM generation of a large area within a short period of time with minimum human dependence.

The disadvantage of procuring high resolution LIDAR data is the expense involved in data collection.

Satellite interferometry with synthetic aperture radar such as Shuttle Radar Topography Mission uses two radar images from antennas at the same time to create DEM.

SRTM (Shuttle Radar Tomography Mission) is a good source of DEM data for almost anywhere in the

world. The CGIAR-CSI GeoPortal is able to provide SRTM 90m Digital Elevation Data for the entire world.

The SRTM digital elevation data, produced by NASA originally, is a major breakthrough in digital mapping of the world, and provides a major advance in the accessibility of high quality elevation data for large portions of the tropics and other areas of the developing world.

The SRTM digital elevation data provided on this site has been processed to fill data voids, and to facilitate it's ease of use by a wide group of potential users.

The NASA Shuttle Radar Topographic Mission (SRTM) has provided digital elevation data (DEMs) for over 80% of the globe.
This data is currently distributed free of charge by USGS.
USGS DEMs are raster grids of elevation values that are arrayed in series of south-north profiles.

Like other USGS data, DEMs were produced originally in tiles that correspond to topographic quadrangles.

Large scale (7.5-minute and 15-minute), intermediate scale (30 minute), and small scale (1 degree) series were produced for the entire U.S.

The resolution of a DEM is a function of the east-west spacing of the profiles and the south-north spacing of elevation points within each profile.

BHUVAN data sources-CARTOSAT in India:

Indian Space Research Organisation provides all DEM data of India through it portal Bhuvan.

Catrosat-1 and 2 provide all these sources.