RESEARCH ARTICLE

DEM BASED THEMATIC MAPPING OF KINWAT TALUKA USING GIS AND REMOTE SENSING TECHNIQUES

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Abstract:

A Digital Elevation Model (DEM), also termed Digital Height Model (DHM), represents the Earth's surface using raster or random point data. DEMs are crucial in mapping, hydrological studies, infrastructure planning, flood monitoring, and water resource management. Advances in Remote Sensing (RS) and Geographic Information Systems (GIS) have enabled their wide application. DEM accuracy depends on resolution, data type, and sampling methods. Stream networks can be delineated using flow accumulation models, aiding morphometric analysis of watersheds. In this study, satellite data and DEMs are applied for fluviological assessment and morphometric parameter extraction, emphasizing groundwater evaluation and watershed management.

Keywords: DEM, GIS, Remote Sensing, Watershed, Morphometry, Kinwat.

Introduction:

The digital elevation model is simply a statistical representation of the continuous surface of the ground by a large number of selected points with known coordinates in an arbitrary coordinate field. The new techniques of data acquisition and processing have been developed and new types of digital terrain models have come into sight from highway to railway design to agricultural management, flight simulation, flood monitoring and many more. DEM may be arranged in a raster or random form. Instead of the expression DEM also the term digital height model (DHM) is used. Digital Elevation Models do play a fundamental role in mapping. The digital description of the three dimensional surface is important for several applications. Today the most often used photogrammetric product are ortho-images generated by means of a single image and a DEM. The very high resolution space sensors are mainly operating in a single image mode; stereo pairs are not taken very often. A correct geo-referencing is only possible based on a DEM. But these DEMs have to be created. The existing and not classified worldwide DEMs usually do not have a sufficient accuracy and reliability for more precise applications or they may be too expensive. Interferometry SAR is based on the processing of complex SAR images acquired from slightly different points of view. Using Shuttle Radar Topography Mission, the digital elevation model for watershed of Godavari river basin has been obtained.

The present study analyzes the significance of satellite images and digital elevation model (DEM) for the assessment of fluviological characteristics and the extraction of morphometric parameters for the Tista watershed of India and Bangladesh (Pramanik, 2016). A DEM is a raster representation of a continuous surface, usually referencing the surface of the earth. The accuracy of this data is determined primarily by the resolution (the distance between sample points). Other factors affecting accuracy are data type (integer or floating point) and the actual sampling of the surface when creating the original DEM. Stream networks can be delineated from a digital elevation model (DEM) using the output from the Flow Accumulation function. Flow accumulation in its simplest form is the number of upslope cells that flow into each cell. By applying a threshold value to the results of the Flow Accumulation functions using Map Algebra, a stream network can be delineated. Channel networks with arbitrary drainage density or resolution can be extracted from digital elevation data.). Emerging of Remote Sensing (RS) and Geographic Information System (GIS) based on Digital Elevation Model (DEM) have been effectively utilized for delineating and selecting potential zone rainwater harvesting structure, in addition, play as vital role in plan and manage water resources (Jha & Peiffer 2006). In India, more than 90% of the rural and nearly 30% of the urban population depend on groundwater for meeting their drinking and domestic requirements (Reddy *et al.,* 1996), In addition, quantitative morphometric parameters of the drainage basin also play a major role in evaluating the hydrological parameters, which in turn helps to understand the groundwater situation (Krishnamurthy & Srinivas 1995).

A thematic map focuses in a specific idea or theme. A thematic map illustrates a particular subject and contrasts the general map, in which the variety of geological and geographical phenomena regularly appears together. Thematic maps also emphasize spatial variation of one or a small number of geographic distributions. These distributions may be physical phenomena such as climate or human characteristics such as population density and health issues. Thematic maps serve three primary purposes. First, they provide specific information about particular locations. Second, they provide general information about spatial patterns. Third, they can be used to compare patterns on two or more maps

A thematic map is a map that emphasizes a particular theme or special topic such as the average distribution of rainfall in an area. They are different from general reference maps because they do not just show natural features like rivers, cities, political subdivisions and highways. Instead, if these items are on a thematic map, they are simply used as reference points to enhance one’s understanding of the map’s theme and purpose.

Study Area Location:

The Kinwat Taluka came into existence in 1905 when a number of villages from Narsapur and Nirmal Talukas from the Adilabad District, were combined. Earlier, these villages were under the Hyderabad Division. In 2011, Kinwat had population of 247,786 with literacy rate of 82% and female sex ratio of 929.Kinwat is 150 km away from Nanded city. Kinwat has Rural Hospital.

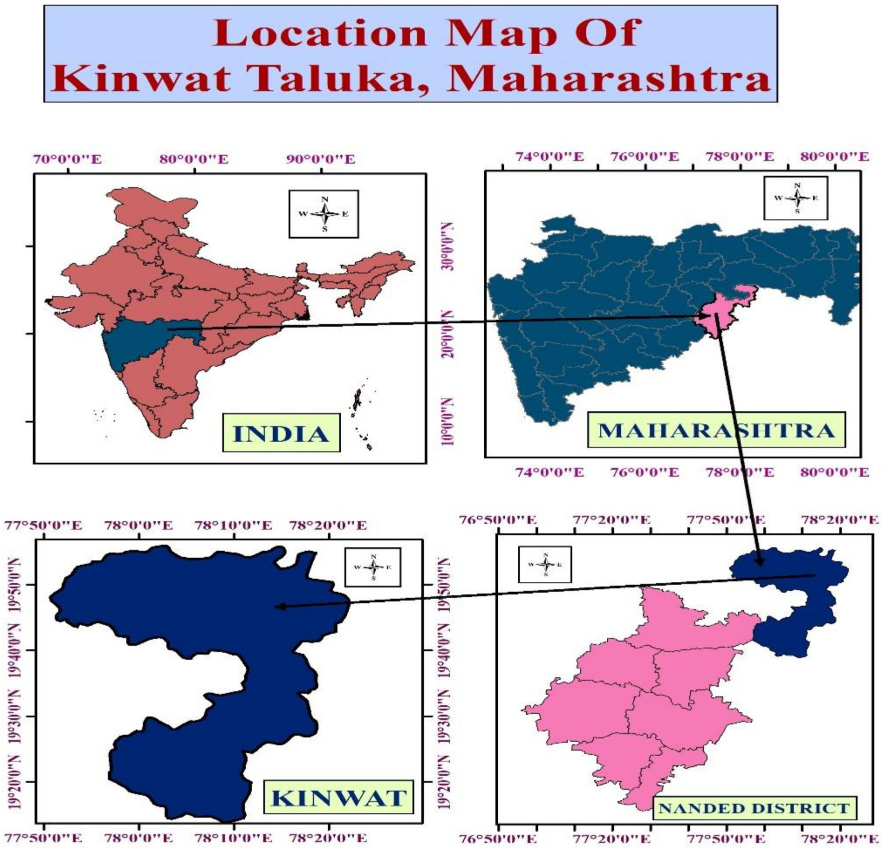

Figure 1: Location Map of Kinwat

Kinwat is located at 19.63°N 78.2°E [5] in the Indian state of Maharashtra in the district of Nanded. It has an average elevation of 314 meters (1030 feet). The Penganga River flows alongside the town while the Nagzari Dam is located just a few kilometers away from it. The dam is the only water source for nearby residents. Drinking water is taken from the deep ground levels by new colonies, leading to a possible cause for the sunken water table. The most popular residential area is SVM colony and Khoja colony. The city has few large-scale farms on Kinwat-Mandwa-Nagzari Road. Kinwat also has wide area forests. Kinwat has a waterfall at islapur, and hot springs at unkeshwar.

Objectives:

- To prepare DEM Map of study area using SRTM data.
- To prepare and identify Drainage map of Kinwat Taluka.
- To prepare LULC Map using google earth software.
- To preapare groundwater potential zone using overlay analysis of the study area.

Materials and Methods:

DEM Generation

Shuttle Radar Topography Mission is a good source of DEM data for almost anywhere in the world. It is available at 90 meter and, since the end of 2014, 30 meter resolutions. The first thing to do is to make a note of the Extend of the study area you want to model; the maximum and minimum latitudes and longitudes. If you have a longitude above 180°, subtract 360. Decimal degrees, rather than degrees, minutes and seconds, will be required for clipping later, so convert yours if necessary and make a note of them (USGS).

30m Data Generation

To generate DEM data from SRTM we should register and logged on in https://earthexplorer.usgs.gov/ to access and to download DEM data. The step by step methodology used is as follows: Under Coordinates select Decimal and click Add Coordinates. Enter the latitude and longitude of one of the 4 corners of the extent. Add the other 3 corners similarly. Then above Enter Search Criteria select the second tab, Data Sets. Find Digital Elevation, click on the plus sign to expand and find SRTM. Expand that and check SRTM 1 Arc-Second Global. Then go straight to the fourth tab, Results After a few seconds you should see the tiles you need listed. For each one, Click on Download options (5th symbol) and then click download beside Geo-TIFF. Save the file, close the Download Options form, and repeat for each of your tiles. Note that the save form says the file is a zipped archive, but its extension is .tif and it is not zipped. Move the .tiff files to the map folder

Data Used

The satellite data of IRS-1B (LISS-II) of path number 30 and row number 54 covering Kinwat tehsil were collected for the three date of pass viz., 11th November 1993, 30th January 1994 and 8th May 1994. For the generation of thematic/derived maps, both digital data on Computer Compatible Tape (CCT) as well as geocoded outputs on 1:50,000 scale were used. Topographic map and soil survey report from All Indian Soil and Land Use Survey for the part of the study area was used as collateral data.

Software Used:

ARC GIS

Arc GIS is a geographic information system developed by Environmental Systems Research Institute (ESRI), for working with maps and geographic information. It is used for creating and using maps, compiling geographic data analyzing mapped information sharing and discovering geographic information, using maps and geographic information in a range of applications and managing geographic information in a database. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the web.

Arc-Gis segregates the application in different cited modules to perform different jobs viz. Arc-Toolbox, ArcMap, Arc-Scene, Arc-Catalog (Source-Government Institute of India) etc.

Thematic Maps

- **Location Map:** It referred to as locator and is typically a simple map used to show the location of a particular geographic area. Location maps provide a reference to map users when the spatial location of the detailed map might be hard to determine.
- **Land Use / Land Cover Map:** It describes the vegetation, water, natural surface, cultural features on the land surface. Land cover corresponds to physical condition of the ground surface e.g. forest, grass land etc. Land use reflects human activities such as the residential, industrial, commercial, agricultural, recreational etc.
- **Aspect Map:** An aspect-slope map simultaneously shows the aspect and degree (steepness) of slope for a terrain or other continuous surface. Aspect categories are symbolized using hues

(e.g., red, orange, yellow, etc.) and degree of slope classes are mapped with saturation (or brilliance of color) so that the steeper slopes are brighter.

- **Hill-Shade Map:** Hill shade map gives better comprehension about the topography of the area, which suggest about relief and type of terrain. It can greatly enhance the visualization of surface for analysis or graphical display, especially when using transparency.
- **Slope Map:** Slope can be defined as the maximum change in elevation over the distance. Slope map is made to know the local and regional slope variation of the terrain which helps encounter the structural disturbances.
- **Contour Map:** It a topographic map on which the shape of the land surface is shown by contour lines, the relative spacing of the lines indicating the relative slope of the surface. The data used in constructing a structure-contour map may be obtained from geological surveys. On the basis of these data, the depth of the structural surface is established at various points in the area under study.
- **Drainage Map:** The term "drainage area" is defined as the land area where precipitation falls off into creeks, streams, rivers, lakes, and reservoirs. It is a land feature that can be identified by tracing a line along the highest elevation between two areas on a map, often a ridge. A drainage map of a region shows the distribution of all major as well as minor water transporting bodies which may contribute to overland flow. Drainage networks are generally depicted using lines tracing the path of actual water flow on land surface.

This chapter deals with the materials, methodology and various principles used in the study.

Methods:

Processes:

Georeferencing:

Georeferencing means that the internal coordinate system of a map or aerial photo image can be related to a ground system of geographic coordinates. The relevant coordinate transforms are typically stored within the image file (Geo-PDF and Geo-TIFF are examples), though there are many possible mechanisms for implementing georeferencing. The most visible effect of georeferencing is that Display software can show ground coordinates (such as latitude/longitude or UTM Coordinates) and also measure ground distances and areas. Doing these things with USGS GeoPDF maps requires the free Terra Go toolbar extension to Adobe Reader. In other words, Georeferencing means to associate something with locations in physical space. The term is commonly used in the geographic information systems field to describe the process of associating a physical map or raster image of a map with spatial locations. Georeferencing may be applied to any kind of object or structure that can be related to a geographical location, such as points of interest, roads, places, bridges, or buildings. Geographic locations are most commonly represented using a coordinate reference system, which in turn can be related to a geodetic reference system such as WGS-84. Examples include establishing the correct position of an aerial photograph within a map or finding the geographical coordinates of a place name or street address (Geocoding). Georeferencing is crucial to making aerial and satellite imagery, usually raster images, useful for mapping as it explains how other data, such as the above GPS points, relate to the imagery. Different maps may use different projection systems. Georeferencing tools contain methods to combine and overlap of these maps with minimum distortion. Using georeferencing methods, data obtained from surveying tools like total stations may be given a point of reference from topographic maps already available.

Rectification:

Image rectification is a transformation process used to project two-or-more images into a common image plane. This process has several degrees of freedom and there are many strategies for transforming images to the common plane. It is used in computer stereo vision to simplify the problem of finding matching points between images (i.e. the correspondence problem). It is used in geographic information systems to merge images taken from multiple perspectives into a common map coordinate system. If the images to be rectified are taken from camera pairs without geometric distortion, this calculation can easily be made with a linear transformation. X & Y rotation puts the images on the same plane, scaling makes the image frames be the same size and Z rotation & skew adjustments make the image pixel rows directly line up. The rigid alignment of the cameras needs to be known (by calibration) and the calibration coefficients are used by the transform. In performing the transform, if the cameras themselves are calibrated for internal parameters, an essential matrix provides the relationship between the cameras. The more general case (without camera calibration) is represented by the fundamental matrix. If the fundamental matrix is not known, it is necessary to find preliminary point correspondences between stereo images to facilitate its extraction. There are three main categories for image rectification algorithms: planar rectification, cylindrical rectification and polar rectification.

Clip

Extracts input features that overlay the clip features. This tool is used to cut out a piece of one feature class using one or more of the features in another feature class as a cookie cutter. This is particularly useful for creating a new feature class, also referred to as study area or area of interest (AOI) that contains a geographic subset of the features in another, larger feature class. The Clip Features can be points, lines, and polygons, depending on the Input Features type.

Mask:

In Arc Map, variable-depth masking is a drawing technique used to hide parts of layers that are drawn underneath symbols and annotation. This topic describe show to use polygons to mask underneath map layers to overlay dense symbols and to make maps more readable and useful. Masking is used to clarify maps that are densely packed with annotation and symbology. You can use a polygon mask layer to mask out particular aspects of one layer and add a layer of map text and other symbols on top of it. The goal is to make the map more readable. For example, many of the annotated polygons in the map below are filled with a pattern. Using a mask to remove the patterns around the annotation features makes the map easier to read and use.

Mosaic:

Merges multiple existing raster datasets into an existing raster dataset.

Thematic Mapping

Location Map

A locator map, sometimes referred to simply as a locator, is typically a simple map used in cartography to show the location of a particular geographic area within its larger and presumably more familiar context. Depending on the needs of the cartographer, this type of map can be used on its own or as an inset or addition to a larger map. Used on their own, location maps do not differ significantly from traditional maps, differing primarily in the fact that solitary locator maps focus the attention on a single location within the map frame, where traditional maps generally seek to portray a multitude of features across the entire frame. More commonly, location maps appear as insets or ancillary maps (maps adjacent to or near the primary map) in order to help the audience place the geographic area being mapped properly inside their internal frame of reference.

Geological Map

Process

Create a shape file → Digitize the Features (contacts) → Data management Tool → Features → Features to Polygon

A geologic map or geological map is a special-purpose map made to show geological features. Rock units or strata are shown by color or symbols to indicate where they are exposed at the surface. Bedding planes and structural features such as faults, folds, foliations, and lineation are shown with strike and dip or trend and plunge symbols which give these features three-dimensional orientations. Stratigraphic contour lines may be used to illustrate the surface of a selected stratum illustrating the subsurface topographic trends of the strata. It is not always possible to properly show this when the strata are extremely fractured, mixed, in some discontinuities, or where they are otherwise disturbed. Identification of Rock type or lithology from visual and digital interpretation from images is also a systematic integrated approach. In which Image elements like tone/ color, texture, pattern, shape, size, shadow, association and Terrain elements like landforms, drainage pattern and drainage density are studied. At first one shape file was created with line geometry. Lithological contacts boundaries have been digitized. After digitization the line shape file was polygonised. Rock units are typically represented by colors. Instead of (or in addition to) colors, certain symbols can be used. Different geologic mapping agencies and authorities have different standards for the colors and symbols to be used for rocks of differing types and ages

Land use / Land Cover Map

Process:

Satellite image → Image classification → Samples trainer → Interactive Supervised
Image Classification → Export data → LULC map

Land-Cover and Land-Use Change Discovery Approach Satellite imageries have been usually applied to examine the dynamic urban land use change analysis. Urban land use monitoring encompasses the use of multi-temporal images to detect the variation in land use due environmental situations and human activities amongst the acquisition dates of images. Land use and land cover is a vigorous constituent in the interfaces of the human activities with the environment understanding. Land use can be defined as the human activities towards the land. Human uses of land for different activities such as for agriculture, urban development. Land use associated with human activity through an explicit portion of land, While the land cover, is defined as the kind and state of vegetation such as forest, cropland, grass cover, wetland pastures, roads, and urban area. Land use entails divers" land covers found on the earth's surface and abstract notions forming mixture socio-cultural aspects having slight physical important in reflect once properties and have limited relation in remote sensing. Remote sensing data record the spectral properties of surface materials, and hence, are further thoroughly related to land cover land use cannot be measured directly by remote sensing, but rather requires visual interpretation image processing and spatial pattern analyses to derive land use from total land-cover information and other supplementary data. Image preprocessing is the most challenging in urban land cover change detection process and sometimes neglected. To identify land cover change with full confidence, accurately and precisely between consecutive years, the atmosphere disturbance should be modeled so that it will not Direct the surface reflect once of land cover change detection process. The accomplishment of land cover change detection analysis by using multi-dates remote sensing images depend up on the accurate radiometric and geometric correction. Multi-temporal Landsat imageries geometric correction and radiometric correction are the most important. Geometric correction is the process of georeferencing the satellite imageries to UTM map projection system to the zone of interest and ratifying by using an evenly distributed control points taken from digitized topographic map of corresponding areas and resampling to nearest neighbourhood. Geometric correction includes identifying the image coordinates similar with their true positions in ground coordinate and Re-sampling process is used to determine the digital values to place in the new pixel locations of the corrected output image. There are three common methods for resampling, nearest neighbour, bilinear interpolation, and cubic convolution. Radiometric correction: Radiometric normalization of multi-dates imageries is acute stage in change detection analysis. High accuracy geometric registration of the multi-dates image data is a basic requirement for change detection. The reflectance values measured by the sensors are not the pure representation of the values reflected by earth surface features due to some external (sun angle, path radiance, and atmospheric condition) and in-sensor factors. Consequently, this should be reduced because they make the task complicated. Dealing with multi-date image datasets requires that images obtained by sensors at different times are comparable in terms of radiometric characteristics. Therefore, if any two or more datasets are to be used for quantitative analysis based on radiometric information, as in the case of multi-date analysis for detecting surface changes, thought to be adjusted to compensate for radiometric divergence. It is about correcting data irregularities occurred systematically or unsystematically by using algorithms. Generally, the objective of radiometric correction procedure is to convert satellite generated digital accounted to ground reflectance that is absolute surface reflectance. Image enhancement: Image enhancement is the process applied to image data in order to more display or record the data for subsequent visual interpretation. Normally, image enhancement contains many ways and methods applied for increasing the visual distinguishing among structures in a scene. The intention is to form or create new imageries from an original image to increase the visual interpretation of image and to improve the visual interpretability of an image by increasing the apparent distinction between the features, spatial feature manipulation (spatial filtering, convolution, edge enhancement, and Fourier analysis) and multiple spectral bands of imagery (spectral rationing, principal and canonical components, vegetation components, and intensity-hue-saturation color space transformations). Choosing the appropriate enhancement for any particular application is the most challenging and an art and open a matter of personal preference. Remote sensing studies aiming on image classification has long attracted the devotion of the remote-sensing community as classification results are the basis for many environmental and socioeconomic applications.

Aspect Map

Process:

DEM model → Arc Tool Box → Spatial Analyst Tool → Surface → Aspect Map

An aspect-slope map simultaneously shows the aspect (direction) and degree (steepness) of slope for a terrain (or other continuous surface). The compass direction that a topographic slope faces, usually measured in degrees from north. Aspect can be generated from continuous elevation surfaces. Aspect categories are symbolized using hues (e.g., red, orange, yellow, etc.) and degree of slope classes are mapped with saturation (or brilliance of color) so that the steeper slopes are brighter. Aspect can have a strong influence on temperature. This is because of the angle of the sun in the northern and southern hemispheres which is less than 90 degrees or directly overhead. The aspect of a slope can make very significant influences on its local climate (microclimate). For example, because the sun's rays are in the west at the hottest time of day in the afternoon, in most cases a west-facing slope will be warmer than a sheltered east-facing slope (unless large-scale rainfall influences dictate otherwise). In some locales there are patterns of soil differences related to differences in aspect. Strong slopes with equator ward aspects tend to have soil organic matter levels and seasonal influences similar to level slopes at lower elevation whereas pole ward aspects have soil development similarities to level soils at higher elevations. Soils with a prevailing windward aspect will typically be shallower, and often with more developed subsoil characteristics, than adjacent soils on the leeward where decelerating winds tend to deposit more air-borne particulate material. Outside of the tropics, soils with an aspect directed toward an early afternoon solar position will typically have the lowest soil moisture content and lowest soil organic matter content relative to other available aspects in a locale. Aspect similarly influences seasonal soil biological processes that are temperature dependent.

Hill Shade Map

Process:

DEM model → Arc Tool Box → Spatial Analyst Tool → Surface → Aspect Map

A hill shade is a gray scale 3D representation of the surface, with the sun's relative position taken into account for shading the image. This function uses the altitude and azimuth properties to specify the sun's position. The Hill shade tool obtains the hypothetical illumination of a surface by determining illumination values for each cell in a raster. It does this by setting a position for a hypothetical light source and calculating the illumination values of each cell in relation to neighboring cells. It can greatly enhance the visualization of a surface for analysis or graphical display, especially when using transparency by default, shadow and light are shades of gray associated with integers from 0 to 255 (increasing from black to white).

Slope Map

Process:

DEM model → Arc Tool Box → Spatial Analyst Tool → Slope → Slope Map

Slope map provides a colorized representation of slope, generated dynamically using a server-side slope function on the Terrain layer followed by the application of a color map. The degree of slope is represented by a color map that represents flat surfaces as gray, shallow slopes as light yellow, moderate slopes as light orange and steep slopes as red-brown. This service should only be used for visualization, such as a base layer in applications or maps. A scaling is applied at small scales to generate appropriate visualization. If access to numeric slope values is required, use the Slope Degrees or Slope percent functions, which return values from 0 to 90 degrees, or 0 to 100%, respectively.

Drainage Map

Process:

Topo sheet → Rectification → Mosaic → Extraction → Digitization of Drainage

Feature → Export data → Drainage map

This map shows the drainage basin or catchment area and distribution of drainage channel of area under study. It shows the watershed characteristic of that area such as watershed area, no. of drainage channel, area under drainage channel, drainage density etc. It also shows the amount of water reaching over the area. Availability of water for the area can be calculated and one can compare actual and theoretical agricultural yield.

Contour Map

Process:

Topo sheet → Rectification → Mosaic → Extraction → Digitization of Contour

Feature → Export data → Contour map

A contour line of a function of two variables is a curve along which the function has a constant value, so that the curve joins points of equal value. It is a plane section of the three-dimensional graph of the function $f(x, y)$ parallel to the x, y plane. In cartography, a contour line (often just called a "contour") joins points of equal elevation (height) above a given level, such as mean sea level. A contour map is a map illustrated with contour lines, for example a topographic map, which thus shows valleys and hills, and the steepness or gentleness of slopes. The contour interval of a contour map is the difference in elevation between successive contour lines. More generally, a contour line for a function of two variables is a curve connecting points where the function has the same particular value. The gradient of the function is always perpendicular to the contour lines. When the lines are close together the magnitude of the gradient is large: the variation is steep. A level set is a generalization of a contour line for functions of any number of variables. Contour lines are curved, straight or a mixture of both lines on a map describing the intersection of a real or hypothetical surface with one or more horizontal planes. The configuration of these contours allows map readers to infer relative gradient of a parameter and estimate that parameter at specific places. Contour lines may be either traced on a visible three-dimensional model of the surface, as when a photogrammetric viewing a stereo-model plots elevation contours, or interpolated from estimated surface elevations, as when a computer program threads contours through a network of observation points of area centroids. In the latter case, the method of interpolation affects the reliability of individual isolines and their portrayal of slope, pits and peaks.

Result and Discussion:

The analysis of prepared Land use/Land classification output from satellite image was done in ArcGIS 10.8 which outcome of the above mentioned results of area extent of various features.

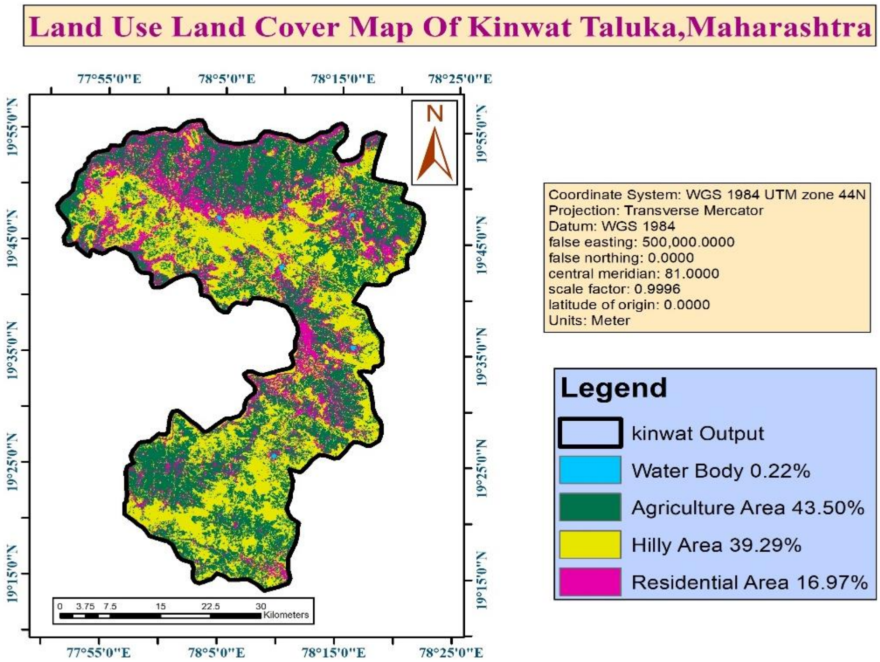

Figure 2: Land Use Land Cover Classification

Monitoring of year 2019 is carried out the result represents were the agriculture Land covered area by 43.50%, Residential occupies 16.97%, and Water bodies occupy 0.22%, and Hilly Region is 39.29% of the study area.

From the study of land use land cover Change detection was found (100% of total area)

Water Body (0.22%): Represented in blue, these areas include rivers, lakes, ponds, or reservoirs. A very small percentage of land is under water bodies, indicating limited water resources.

Agricultural Area (43.50%): Represented in green, this is the dominant land use category, covering nearly half of the region. It signifies that the area's economy likely relies heavily on farming activities.

Hilly Area (39.29%): Represented in yellow, these regions are topographically elevated and might include forested or barren lands. Such areas are less suitable for agriculture or construction but may support biodiversity and forestry activities.

Residential Area (16.97%): Represented in pink, these areas include towns, villages, and settlements. The significant percentage indicates a growing population and urban expansion.

Aspect Map:

The above obtained aspect map of Kinwat shows the face direction of slope of surface by representing a range of angular cover by different colors. Aspect map concludes that the maximum slope in the region lies along the North-South direction and thus their face is in the East-West direction.

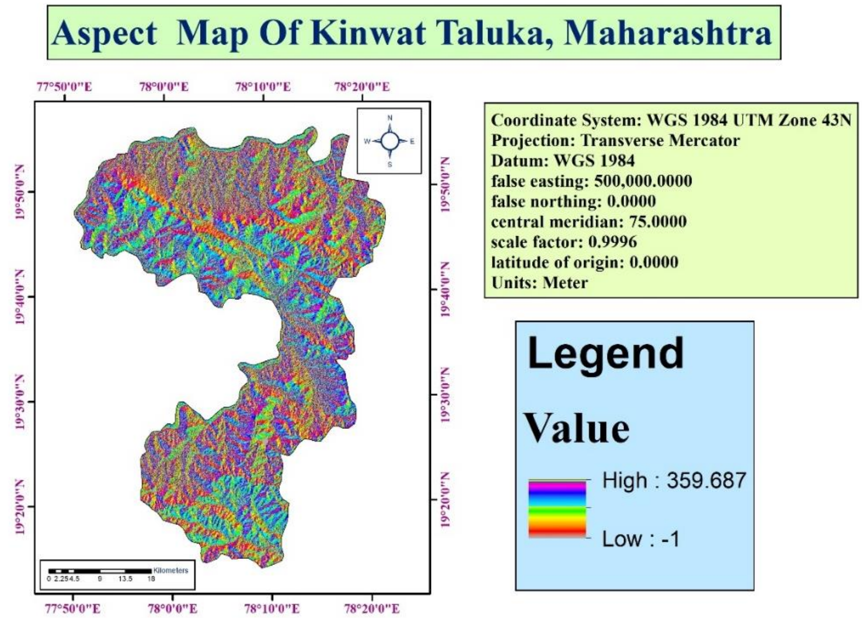

Figure 3: Aspect Map

Hill-Shade Map:

The hill shade of Kinwat was obtained in the above map which shows the elevation features of the region in a much differentiated manner. The region under black colour represents the areas that comes under shadow region and that in white signifies face towards the lighting source.

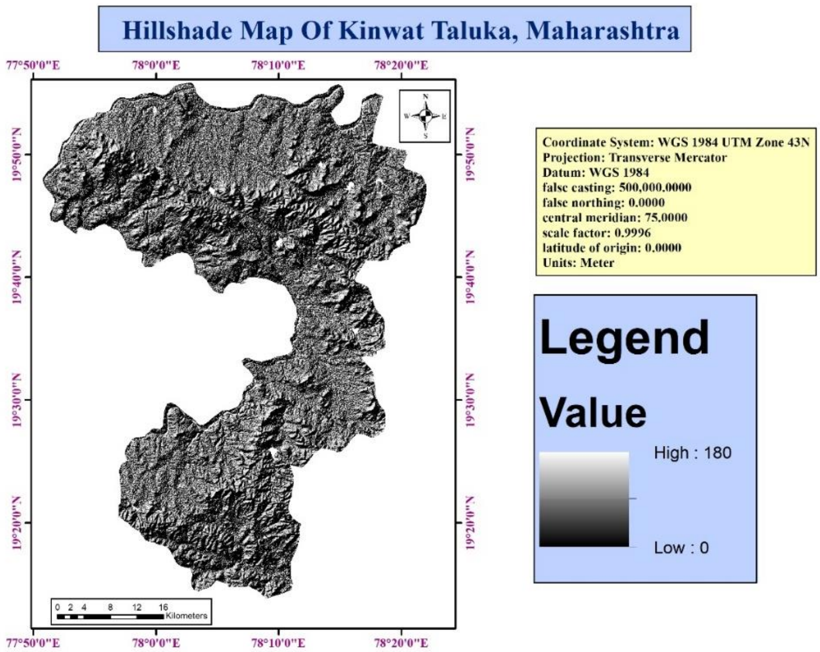

Figure 4: Hill shade Map

Drainage Map:

This is a Stream Order Map of Kinwat Taluka, located in Maharashtra. It illustrates the classification of streams within the region based on the Strahler Stream Ordering Method. The map aims to provide insights into the drainage network, watershed hierarchy, and hydrological processes in the area.

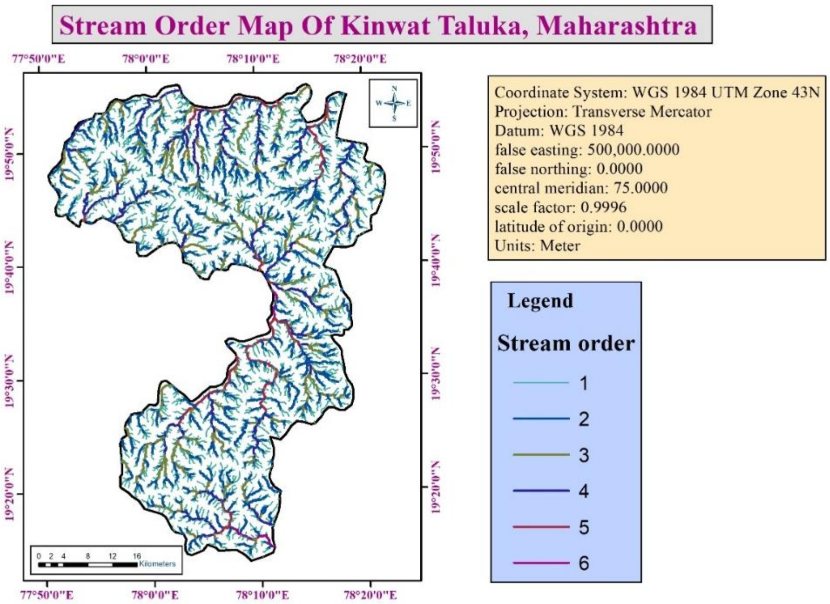

Figure 5: Drainage Map

The Strahler Stream Order System is a widely used hydrological classification method that assigns a numerical rank to streams:

- First-Order Streams (Blue): These are the smallest and originate from surface runoff or springs. They have no tributaries.
- Second-Order Streams (Dark Blue): Formed by the convergence of two first-order streams.
- Third-Order Streams (Green): Created when two second-order streams join.
- Higher-order streams (e.g., 4^{th}, 5^{th}, 6^{th}) represent progressively larger watercourses formed by the confluence of lower-order streams.
- Sixth-Order Streams (Red): Represent the largest and most significant rivers in the region, as seen in the map.
- Stream Patterns: The map shows a dendritic drainage pattern, which is typical of regions with uniform geology and no significant structural controls.
- Water Flow: The higher-order streams (4th to 6th) likely indicate major rivers or channels with significant water flow. The density of first-order streams reflects regions with extensive surface runoff, possibly due to rainfall or local topography.
- Drainage Network: The dense network of lower-order streams feeds into larger streams, highlighting the natural water collection system of the taluka.

Slope Map:

The above map when observed clearly shows that Northern region is covered with slightly slope to extreme slope area. Thus the region in Northern part of Kinwat covers Hilly terrain and thus has relatively higher slope as compared to other parts. The part southward from the hill comes under green colour in the map,thus the slope here would vary from negligible to slight slope.The average slope of the region is in the southward direction. This adds to the fact that natural drainage would flow from north towards south in the Godavari Riveron the south boundary of taluka.

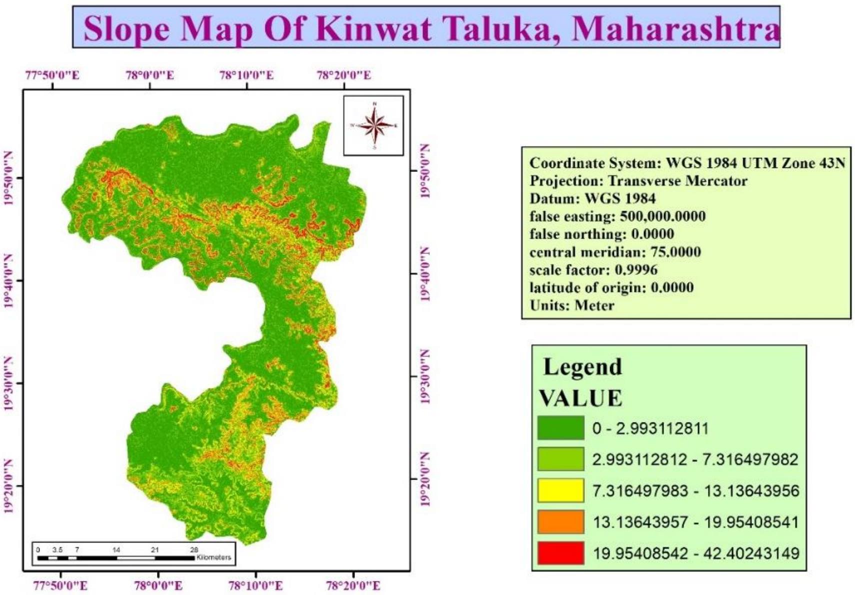

Figure 6: Slope Map

Contour Map:

The contour map of Kinwat showing elevations of different parts of taluka showed that the contour lines were close to each other in the northern part of the map as compared to relatively spaced contour lines in lower part of the map, which suggests that topography of Amravati ranged from hilly terrain in the northern region which gradually recedes to plains and plateau in southern region of taluka. The southern boundary of taluka is traced along by Godavari River, which disposes majority of drainage flow from the taluka. The highest elevation point of taluka was at an elevation of 460 m from mean sea level (MSL) and the lowest point was 300 m from MSL.

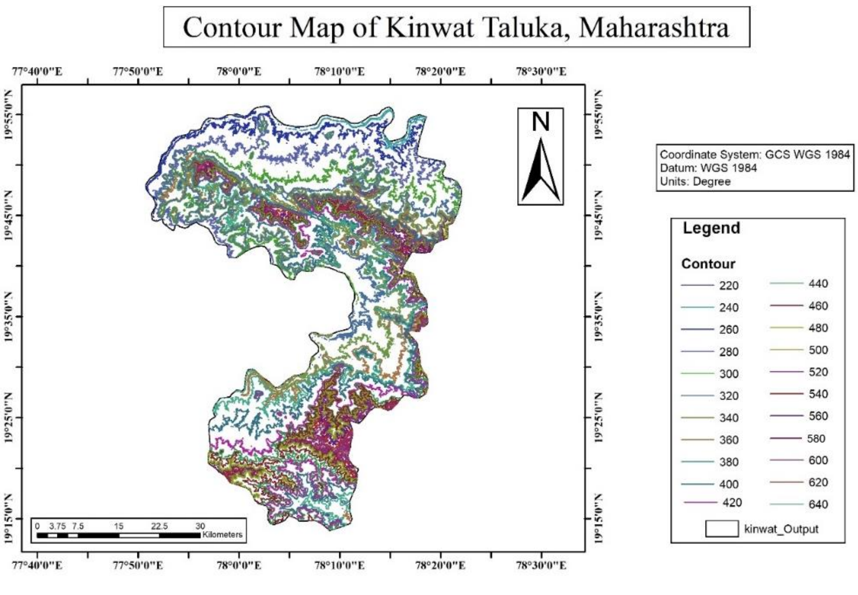

Figure 7: Contour Map

DEM (Digital Elevation Model) Map:

The above graph obtained from processing of Digital Elevation model shows the count of contour lines i.e. no. of contour lines having the mentioned value against x-axis on the y-axis. The graph shows that maximum high peaks are seen in the region of elevation 476 m to 295 m, which signifies that majority of taluka lies under elevation of the above range.

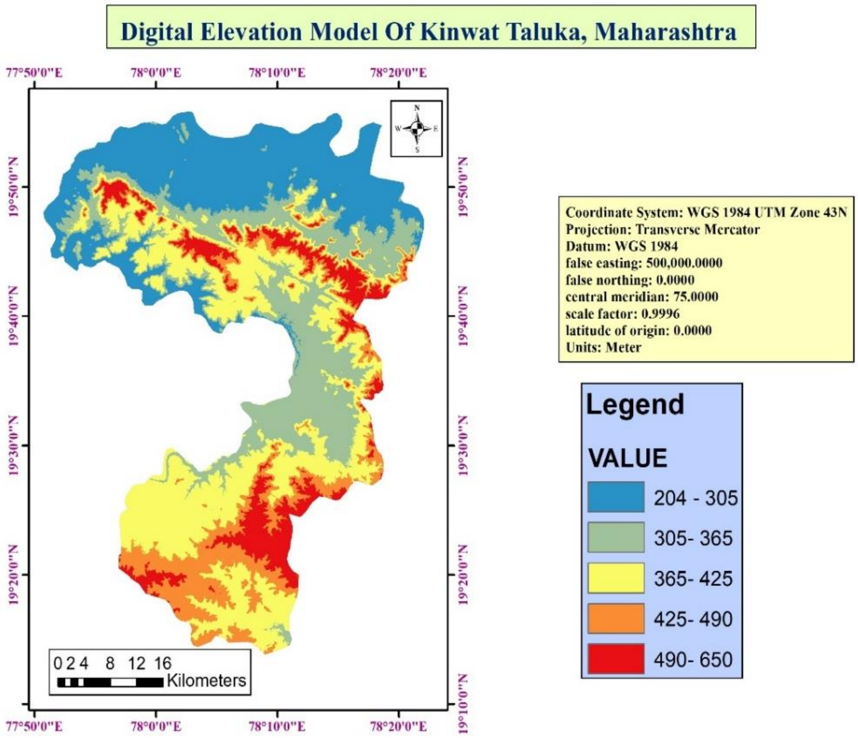

Figure 8: Digital Elevation Model

Conclusions:

Results of the investigation carried out demonstrate that digital relief analysis, DEM and satellite image evaluation using GIS have great relevance for the DSM of a target scale 1:50,000. The proposed methodology was adequate to identify Structures and Textures of soils. The Homogeneous relief units and interactively indicated depth areas along with their limitations are of special importance for comprehensible contour finding respectively demarcation of the borders of corresponding of soil units. Contour maps are invaluable for terrain analysis, helping planners and policymakers make informed decisions while balancing development and environmental sustainability. The satellite images used are only conditionally suitable for the spatial delineation of soil relevant contours, but the DEM-data used are more suitable for this purpose. The prerequisite is a multi-temporal evaluation, which can lead to stable patterns. At the same time, their strength lies in the content-related potential of the assessment of the inner heterogeneity of spatial units. Provides a visually intuitive understanding of terrain features. Enhances other maps (e.g., contour or DEM maps) by adding a three-dimensional perspective. Assists in terrain analysis for various environmental, planning, and developmental studies.

Thus, DEM-based DSM studies should take the DEM quality into account and its range to minimize the error distribution in the resulting DN values. Moreover, this information can be an orientation in future studies of DSM in areas with these characteristics. The adjustment of a DEM to a scale enables the development of future studies like digital mapping of properties with higher quality and reliability of the resulting information. In order to produce a detailed soil map using this methodology, additional fieldwork is necessary. Because the soils are a function of five formation factors: parent rock, relief, vegetation, climate and time.

The results proved that in order to get the best results for the use of the DEM in DSM, it is necessary to assess the DEM quality by additional indicators, aside from elevation. It is also necessary to use additional data such as satellites spectral data and ancillary data under the results of this study.

The GIS based software is user friendly and can easily support necessary procedures for digital soil mapping.

Sustainable Development: DEM helps balance environmental conservation with human development. Disaster Mitigation Understanding elevation helps predict and mitigate risks from landslides, floods, or erosion in hilly areas. Ecotourism: Identifies scenic high-elevation regions for promoting tourism activities.

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