INTEGRATED TERRAIN ANALYSIS OF SOUTHERN HARIPUR TEHSIL USING TECHNIQUES OF GEOGRAPHICAL INFORMATION SYSTEM IN KHYBER PAKHTUNKHWA PROVINCE, PAKISTAN

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ABSTRACT: In this study, geographical information system (GIS) techniques used to study the relief structure for slope, aspect, hill shade, contours and generation of Digital Terrain Model (DTM) of Southern Haripur Tehsil. Remotely sensed data of Shuttle Radar Topographic Mission (SRTM), Digital Elevation Model (DEM) data having 90 by 90 meter resolution of USGS was used for the terrain analysis. In this study it was found out that the northern area of Haripur was higher in elevation and south eastern slope was gentle and having less height. Central area of Haripur district was found almost flat. South western part of the district had less height. The northern slopes were steep and higher in elevation and southern slopes were gentle and lower in height. It was also observed that the north eastern area of Southern Haripur Tehsil was extremely vulnerable for land sliding due to steep slopes, high elevation and fragile geology. This study illustrated that the GIS techniques were more effective for terrain information.

Keywords: Slope, aspect, geographical information system, hill shade, digital terrain Model and shuttle radar topographic mission

(Received 14-11-2016 Accepted 22-06-2018)

INTRODUCTION

Terrain analysis of a particular area is important for physical setting of the area. Generally, slope was studied using the contour data. Digital terrain models (DTM) is a major constituent of geographical information system (GIS) and used for 3D GIS analysis. Remotely sensed shuttle radar topographic mission (SRTM) digital elevation model (DEM) data of 90 by 90 meter resolution is used for terrain analysis.

The topographical analysis is done in Balakot region of Pakistan. Techniques are applied on the shuttle radar topographic data (SRTD). World reference system II (WRS) with 90m spatial resolution are utilized for the Balakot region. Slope and aspect were found to analyze land cover (Soomro, et *al*., 2011). Analysis of Gokceada islands land cover are aimed by using Landsat enhanced thematic mapper (ETM) and topographic maps of 1/25000 scale. Aspect and slope maps are generated (Bektas, *et al*,). A new approach is used for dealing the depressions in digital elevation models to calculate flow values. Slope, aspect and flow direction is calculated by using United States geological survey (USGS) digital elevation model (DEM) data of shuttle radar topographic mission (Arnold, 2010). The elevation model generated from shuttle radar topographic mission DEM data of 90 by 90 meter resolution is used for the relief analysis of Kolhapur district of Bharat and slope and aspect is found (Chavare, 2011). A new GIS supported mountain permafrost distribution model is developed on Andes mountains by using 30 m resolution images of Landsat 5 and Landsat 7. Slope Elevation, potential solar radiation, aspect, slope angle and regional effects are determined. Three classes of permafrost are distinguished in this model i.e. likely Permafrost, Possible Permafrost, No Permafrost. Aspects and Solar radiation were the two most important factors that affected the permafrost existence in mountainous environments. Digital terrain model is developed through visible and view shed analysis. Contours are also generated (Aaronson, *et al.*, 2010). One of the geomorphologic studies is designed and analyzed for the geomorphologic units of Pravara River basin in northern part of Ahmednagar district in Maharashtra state. Digital elevation model, slope map, aspect map, shaded relief, topographic profiles, basin, satellite super impose map, geomorphologic map of Pravara River basin is created by using GIS technologies (Wawale, 2012). A research is done on topographic shielding is done in central Tian Shan to the western China which is the source area of Urumqi River. It is found that the topographic surface derived from the digital elevation model is affected strongly by the quality of DEM. It is also found that increases the contour interval, decrease the elevation variation in topographic surface (Kui, 2013). DEMs are mostly used for computing topographic parameters to determine flow accumulations and drainage networks. It is found that the slight slopes are suitable to compute flow direction

(Senevirathne and Willgoose, 2013). In a research study conducted in three sites i.e. Moose Mountain, Sherbrook and Okanagan, two topographic surfaces i.e. slope and aspect is generated by using digital elevation model. Larger slopes are found 20%.Slope of Sherbrook site is 4%.Two sites of high relief i.e. Moose Mountain and Okanagan possess 6% and 2% respectively of the total area. Aspect is found equally distributed from 1° to 360° for every site (Toutin, 2002).

The objective of present study was to analyze the relief structure for slope, aspect, hill shade, contours and generation of digital terrain model (DTM) of Southern Haripur Tehsil.

MATERIALS AND METHODS

The selected area for this research study was Southern Haripur Tehsil in Haripur district. Haripur ("The Town of Hari or Vishnu") was a district of Hazara division of Khayber Pakhtunkhwa, province of Pakistan. Its altitude was about 610 m (2,000ft) above sea level.

The material and methods used to perform the terrain analysis in this study were shown in the following flow diagram in figure 1.

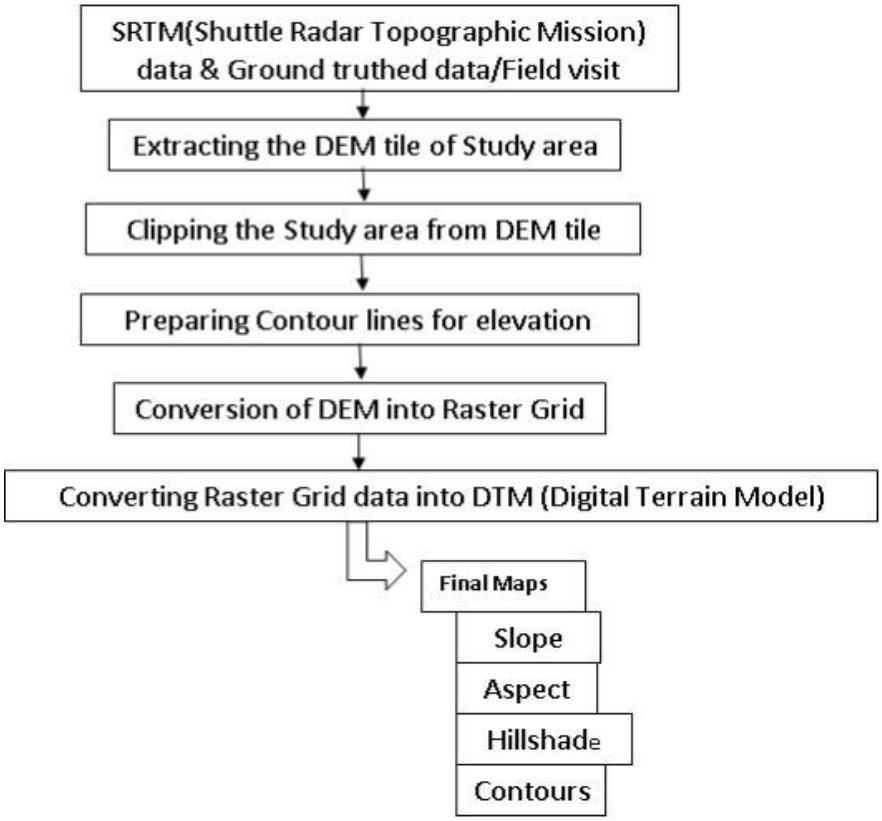

Figure-1: Flow chart of terrain analysis of southern Haripur Tehsil

SRTM 90 by 90 m DEM data of USGS and ground truthed data was used for the terrain analysis. SRTM was an international project by United States national geospatial intelligence (USGI) and national aeronautics space administration (NASA). This data was freely downloaded from the internet. Slope, Aspect, Hill shade, contour analysis and DTM were generated by using GIS techniques available in ArcGIS 9.3 software and its 3D analysis extension. The DEM tile of the area of interest was extracted from the SRTM data using the VT Builder software and it was converted into geotiff format to add into ArcGIS 9.3 software. The datum of the DEM tile was world geodetic system (WGS).The DEM tiles N33E072, N33E073, N34E072 and N34E073 were merged to get the required huge tile of the study area that was given below in figure 2. By using the digitized polygon boundary of Southern Haripur Tehsil the DEM of study area for terrain analysis was clipped as shown in the following fig-5.

Digital Terrain Model (DTM): Digital Terrain Model is 3 dimensional representation of the terrain surface generated from elevation data of terrain. The raster DEM data 90m by 90m meter resolution of USGS was converted into raster grid point data as shown in the fig-6. According to a study (Zhang and Fraserba, 2008) terrain point data delineate the terrain in more detail. It was

found that that the created digital terrain model was in the range of 3.0 to 6.0m.

This converted Point data of elevation was used to generate DTM of southern Haripur tehsil by using 3D Analyst extension available in ArcGIS 9.3 software. This DTM showed the sources of Haro River. The generated DTM is shown in following fig-7 and fig-8.

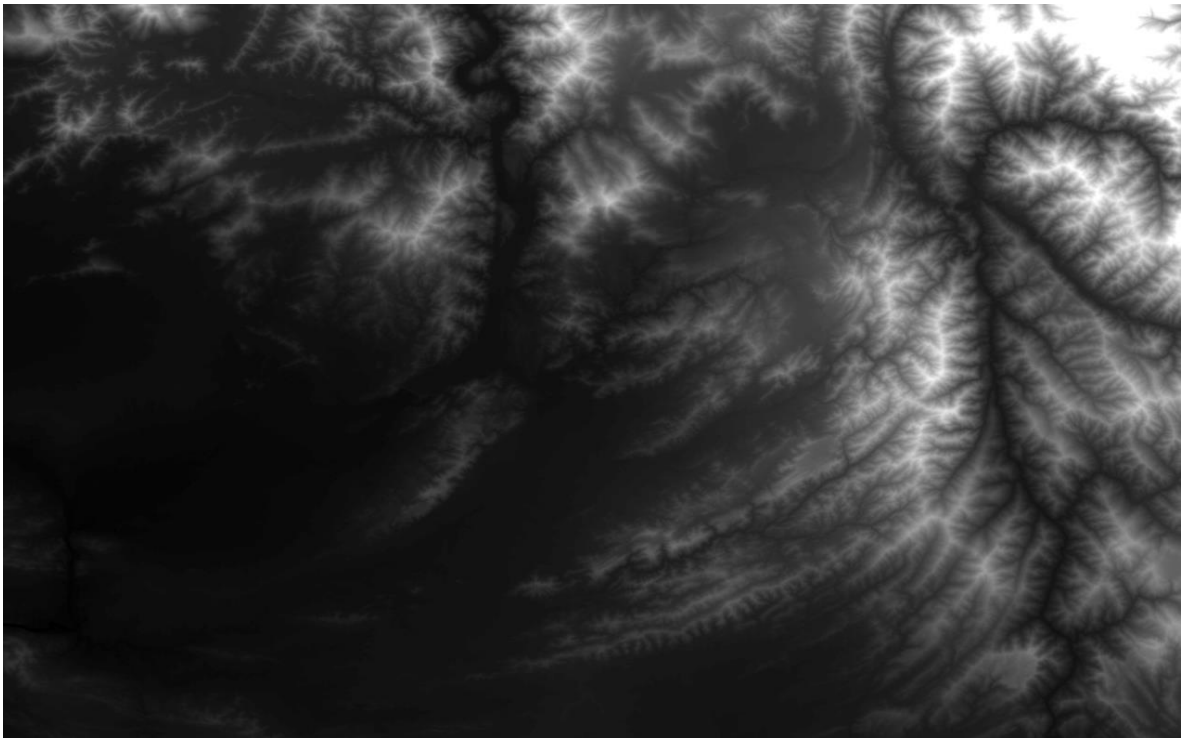

Figure-2: Processed huge DEM tile of SRTM Source: USGS

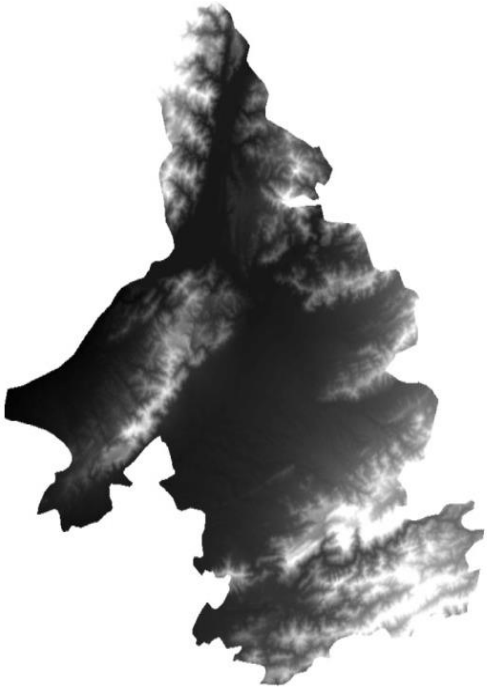

Figure-3: General study area of Haripur District clipped from huge tile

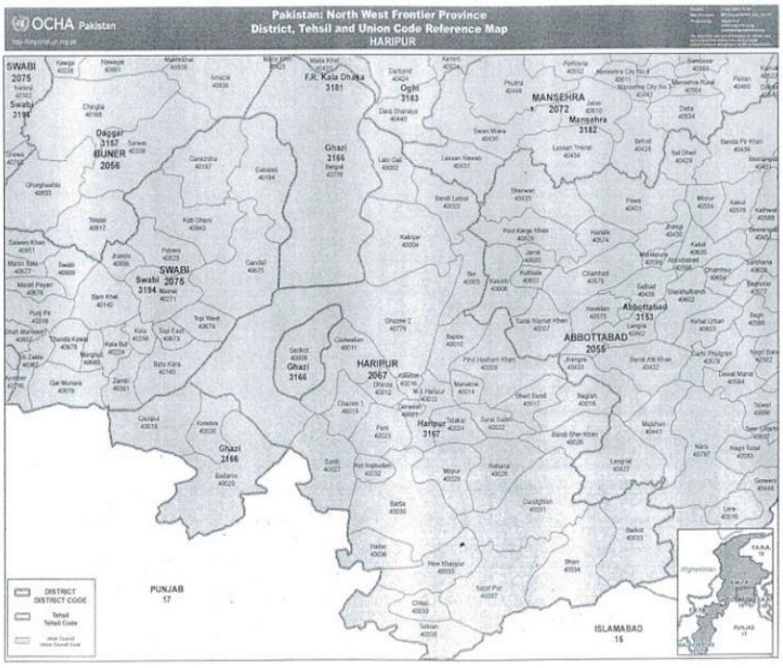

Figure-4: Boundary map used to clip the general study area

Figure-5: Clipped DEM 90 by 90 m of study area

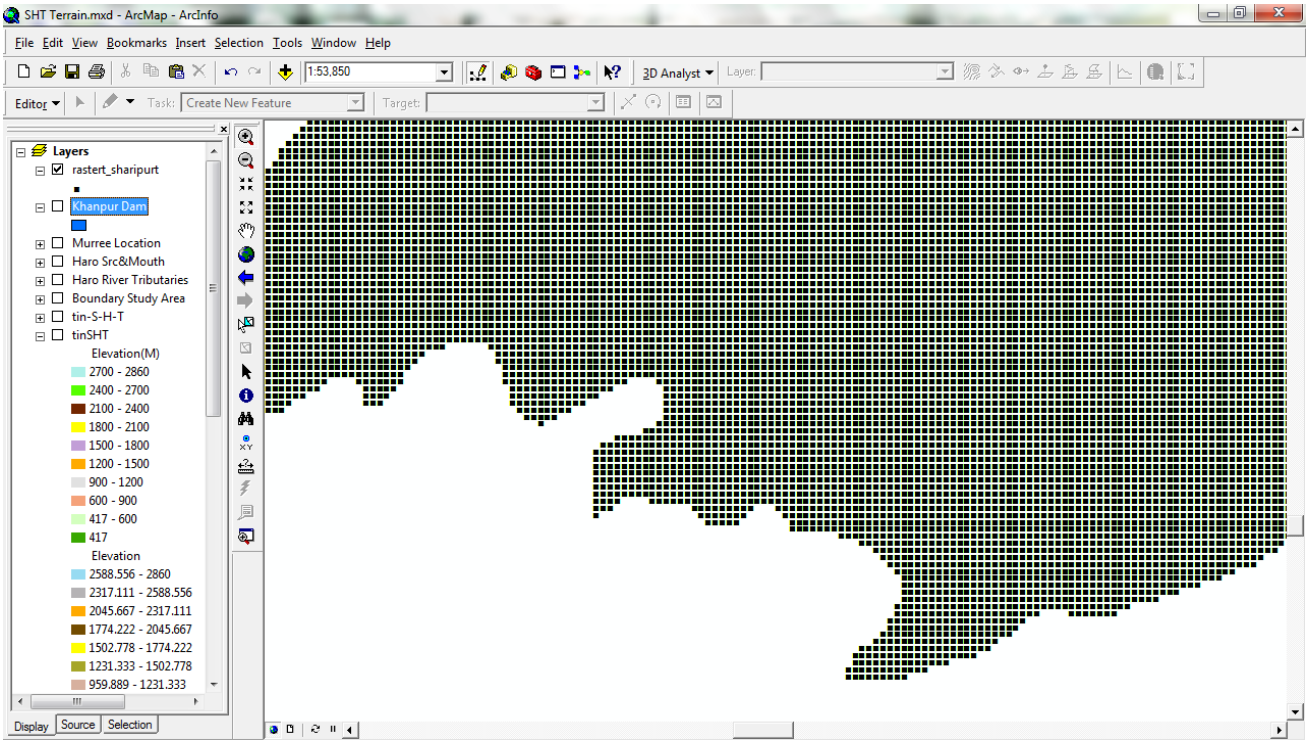

Figure-6: Converted point data of elevation from the clipped DEM

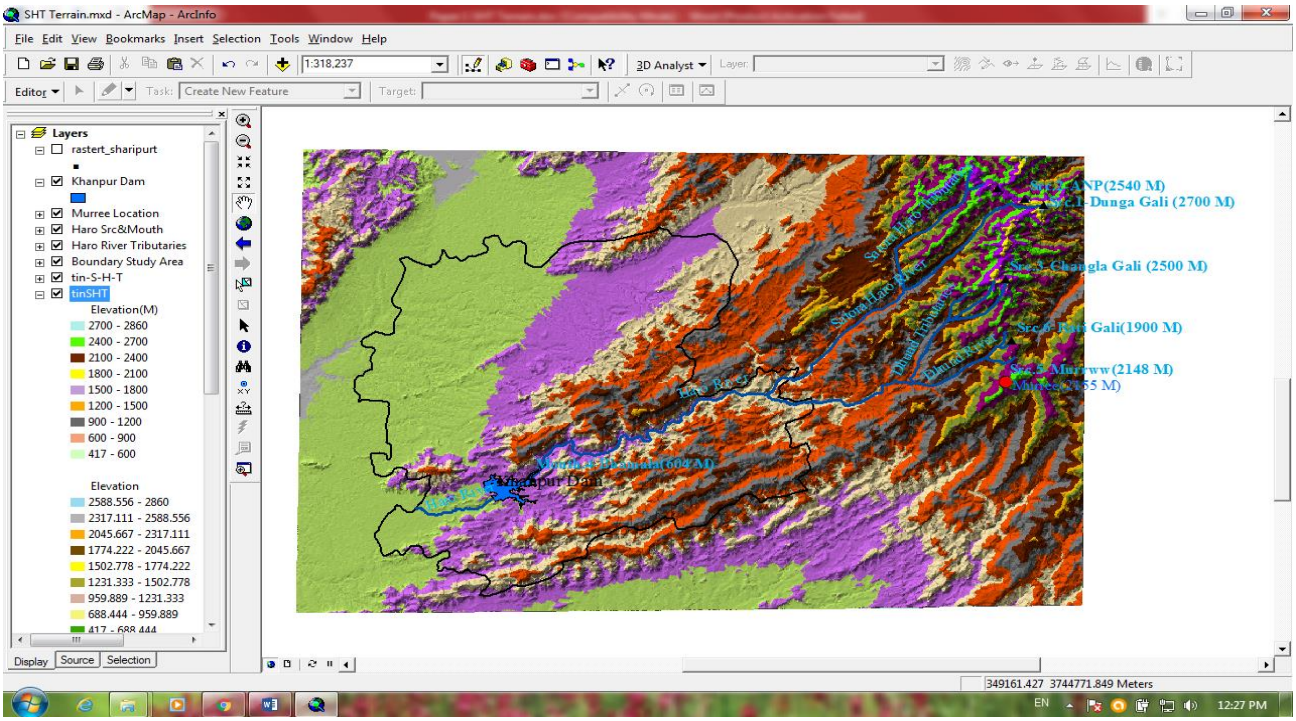

Figure-7: DTM of whole tile of study area

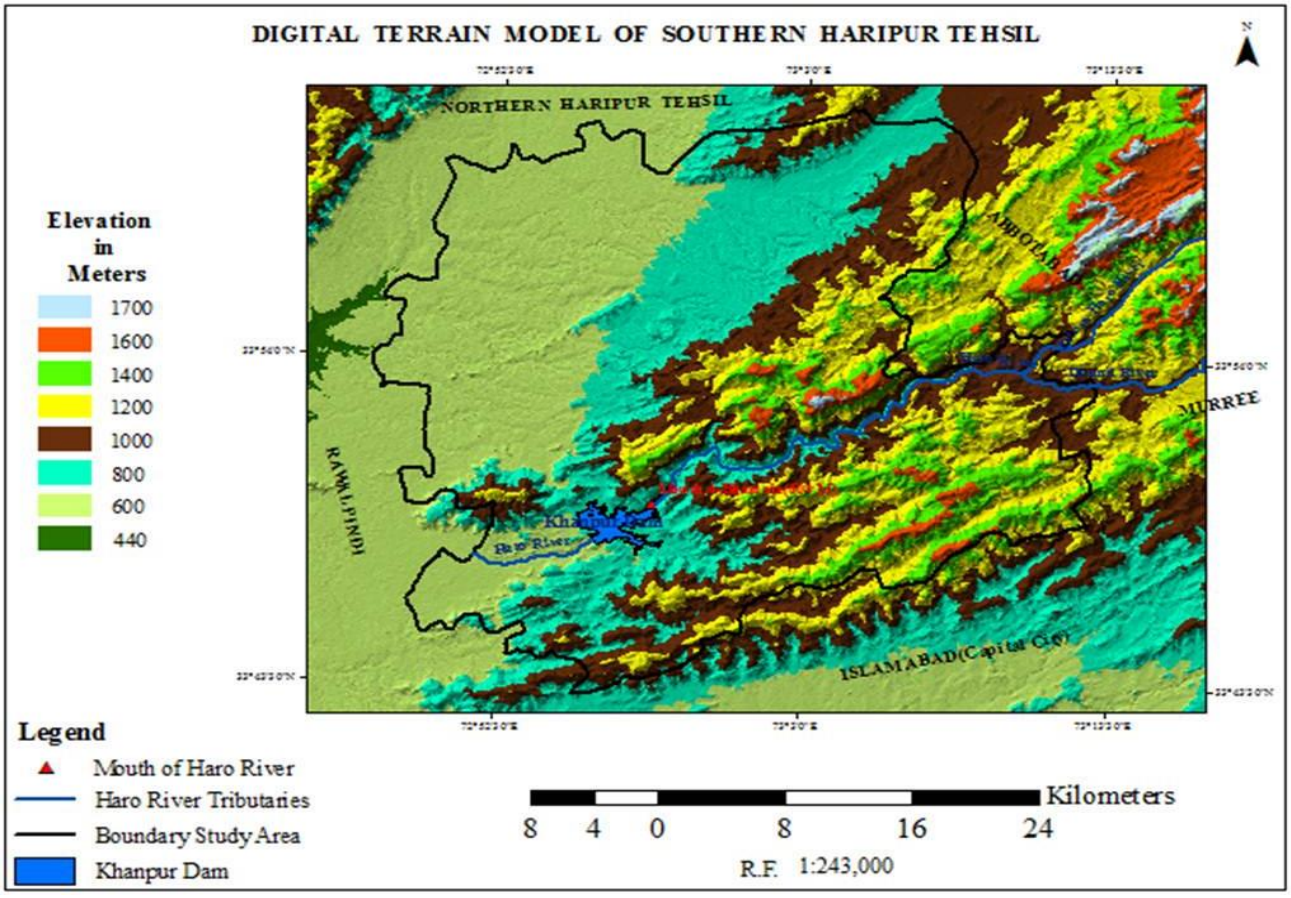

Figure-8: DTM of Southern Haripur Tehsil

RESULTS AND DISCUSSION

Terrain analysis of Southern Haripur Tehsil: Following types of terrain analysis were performed on Southern Haripur Tehsil.

Slope analysis: Two types of slope analysis were performed as given below:

Slope percent: By performing the slope percent analysis on specific study area (Southern Haripur Tehsil) it was found that its north-western area possessed 10% slope and this slope increased gradually to the right bank of Haro river. It was also found that northern slope of Haro River was up to100% while to the south of Haro River, slope was found 40 to 70%. Near the Margalla Hills maximum slope was also 40 to 70% but at some places, it was 100% available as shown in fig-9.

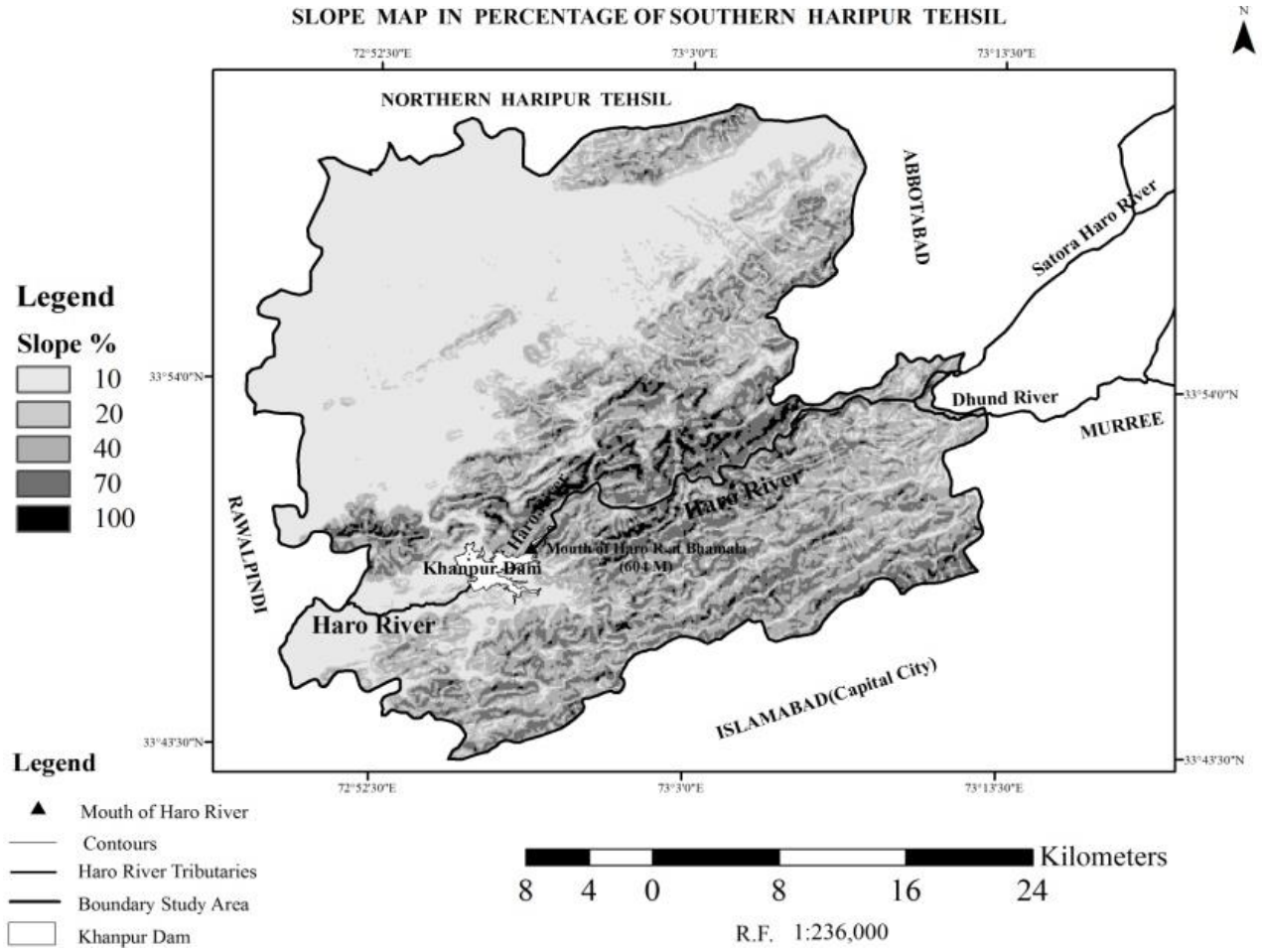

Figure-9: Percent slope map of Southern Haripur Tehsil

Slope in degrees: There were nine classes found by performing the slope analysis in degrees in the study area. There was 0 to 4 degree slope found in north-western area. It was found that from the north-west of the study area to the north of Haro River the slope was gradually increasing up to 57 degree which was the highest steep slope as in a study (Soomro, *et al*., 2011) conducted in Balakot region after a landslide disaster in 2005 the slope, aspect, digital hillshade, profile curvature and surface model are analyzed. To the south of the Haro River the slope was found from 17 to 37 degree but near the Margala Hills it was from 37 to 57 degree at some places as shown in fig-10.

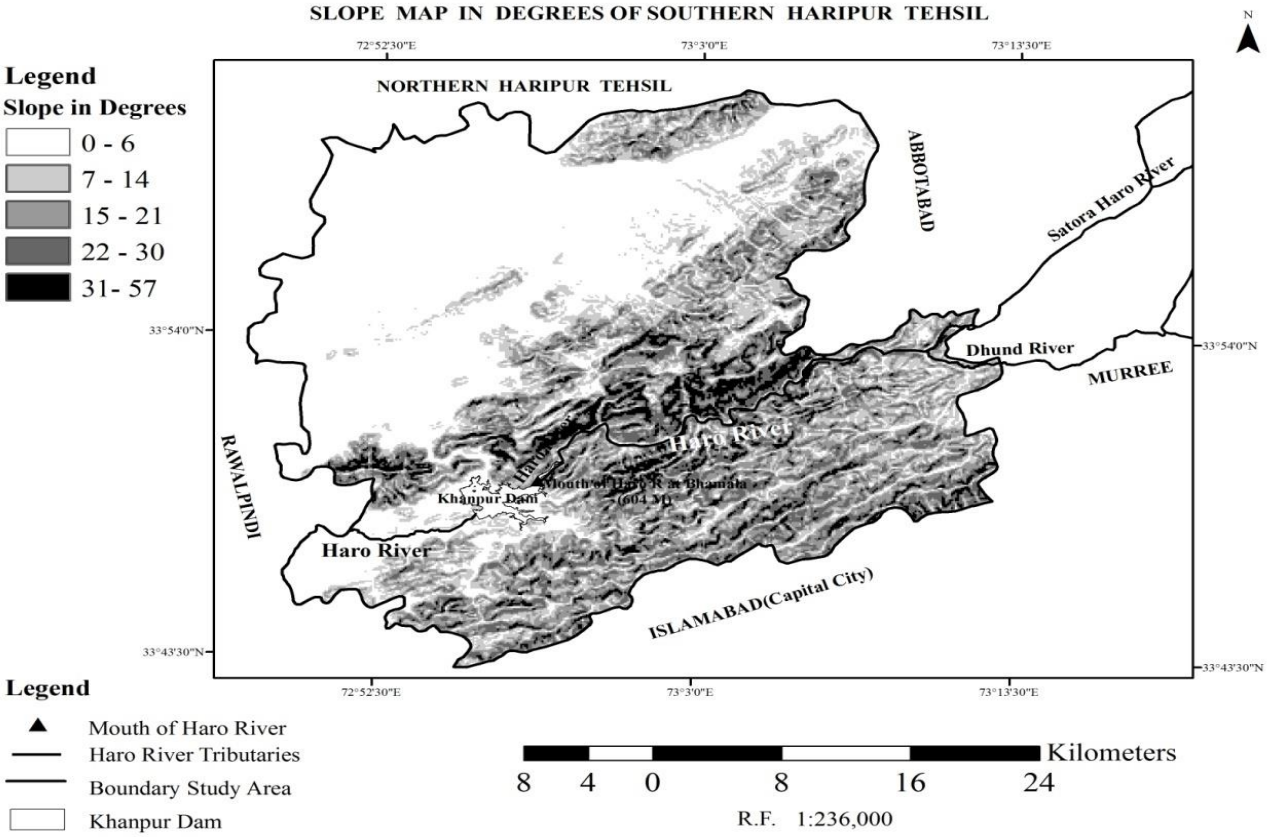

Figure-10: Slope in degree of Southern Haripur Tehsil

Aspect analysis: For many environmental processes, as the slope orientation affects the solar radiation strongly received by the surface. Aspect map is generated and flow direction is found in a study (Pistocchi, 2014). Slope aspect analysis was performed on the study area. There were 10 classes of aspects having value of equal interval 45 found. It was also found that the north eastern area of Haripur was almost flat and having no slope direction. According to the azimuth angle in clock wise direction there was 0-22.5 degree and 337.5-360 degree slope, the aspect was to the North. From 22.5-67.5 degree, the slope direction was to the Northeast. From 67.5-112.5 degree, the slope direction was to the East. From 112.5-157.5 degree, the slope direction was to the South-east. From157.5-202.5 degree, the slope aspect was to the South. It was also found that from 202.5-247.5 degree, the slope direction was to the South-west. From 247.5-292.5 degree, the slope aspect was to the west of study area. It was also the result of aspect analysis that from 292.5-337.5 degree, the slope aspect was to the North-west as shown in fig-11. Such type of slope and aspects are found in Kolhapur district of India (Chavare, 2011).

Hill shade analysis: It was identified that the north western area had low shaded relief. Hill shade map showed the south-eastern area possessed high variation in surface that's why this area was highly predicted for land sliding as shown from hill shade value ranged 0-89 in fig-12.

Contours: Interval between Index contours was set 200 meter and of Intermediate contour was 100 meter as shown in figure 13. North-western area was almost flat having elevation ranges from 500 to 800 meter suitable for urban settlement and less vulnerability for land sliding. It was found that study area possessed undulating surface. Northern area of Haro River was very steep. Potential of material to move downward increases due to steep slope which indicates that the steep slopes are more susceptible to erosion (Yohannes, *et al*., 2015). Southern slopes of Haro River had very gentle slope so these slopes were less susceptible for land sliding. It was also found that the southern slopes of Margalla Hills and northern eastern slopes of Haro river having elevation ranges from 1300-1500 meter were highly susceptible for land sliding and were not suitable for building houses on slopes. As in a research aspect, slope, volumes, hill slope and contours were found to prove the surface analysis useful (Forkuo, 2008). Only the tops of higher area possessing gentle slopes were suitable for settlement. Only the tops of higher area possessed gentle slopes suitable for settlement.

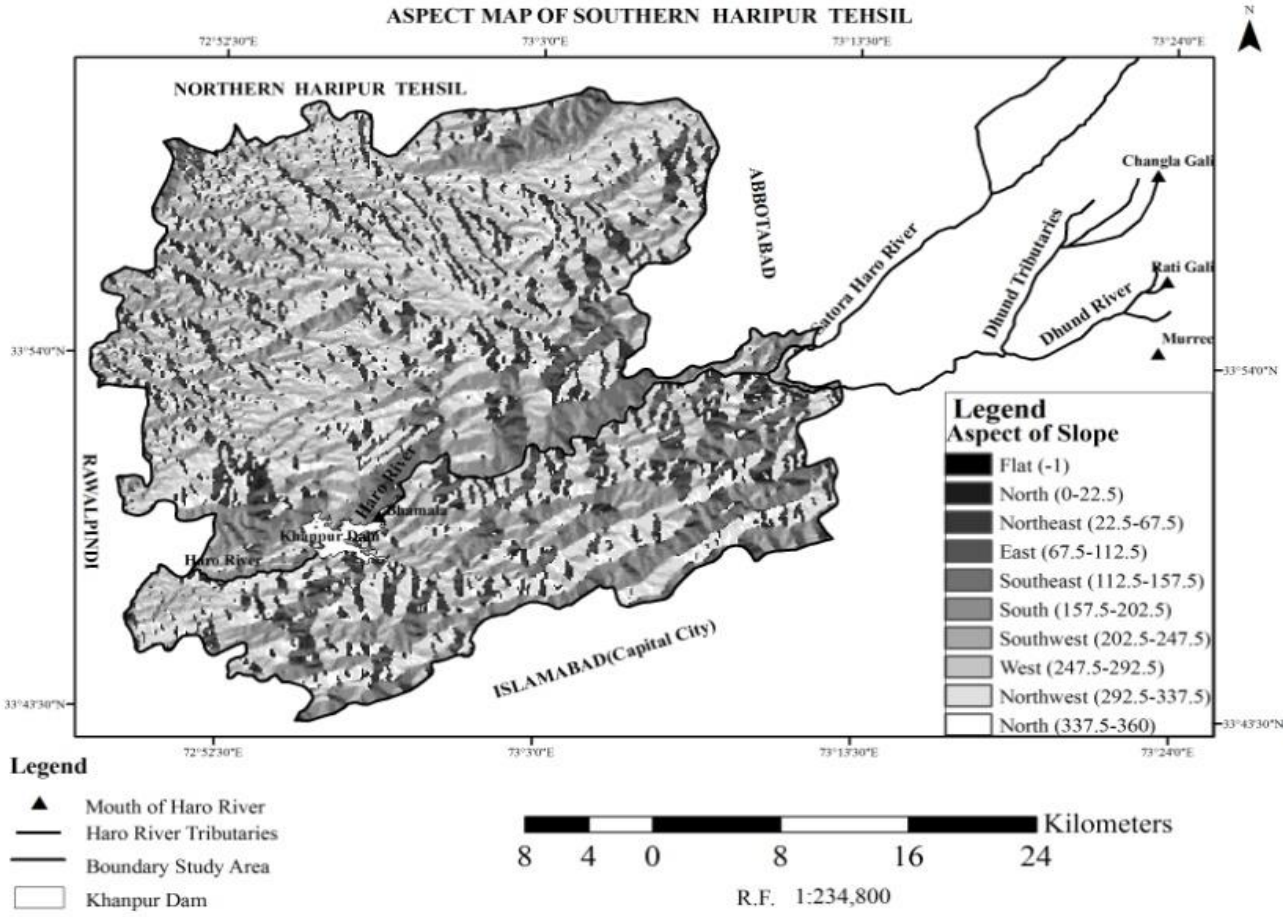

Figure-11: Aspect Map of Southern Haripur Tehsil

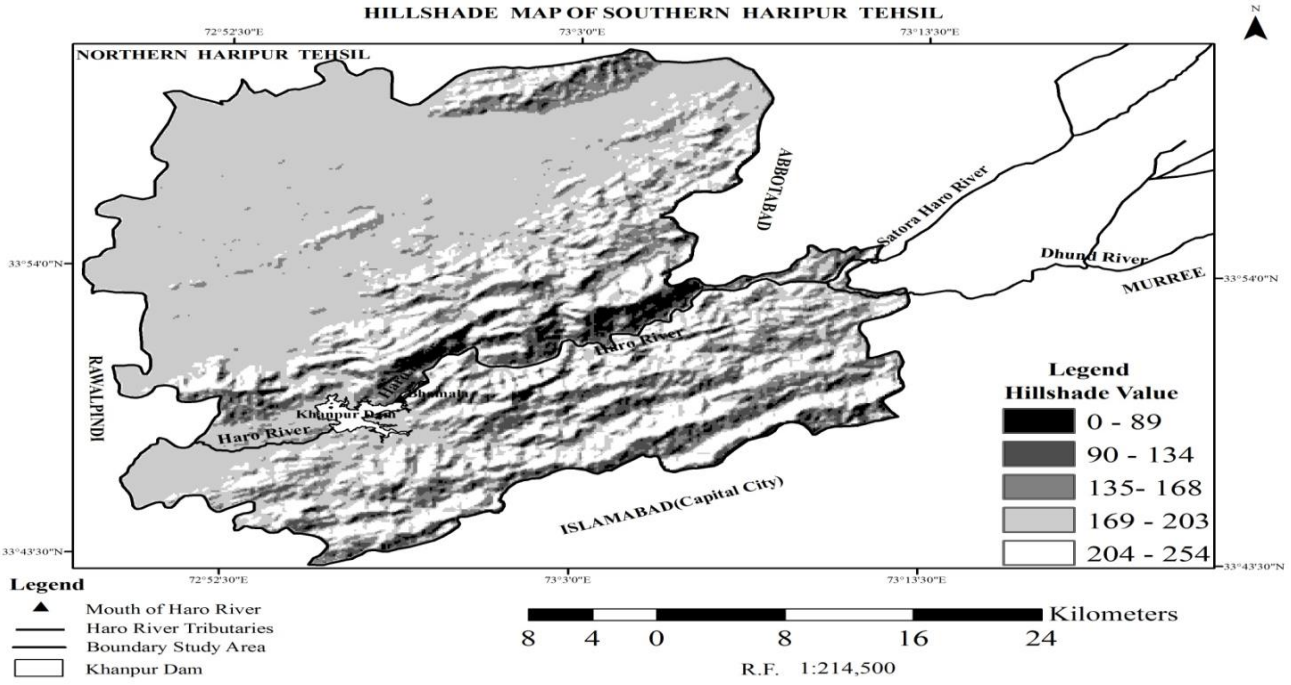

Fig-12: Hill shade map of Southern Haripur Tehsil

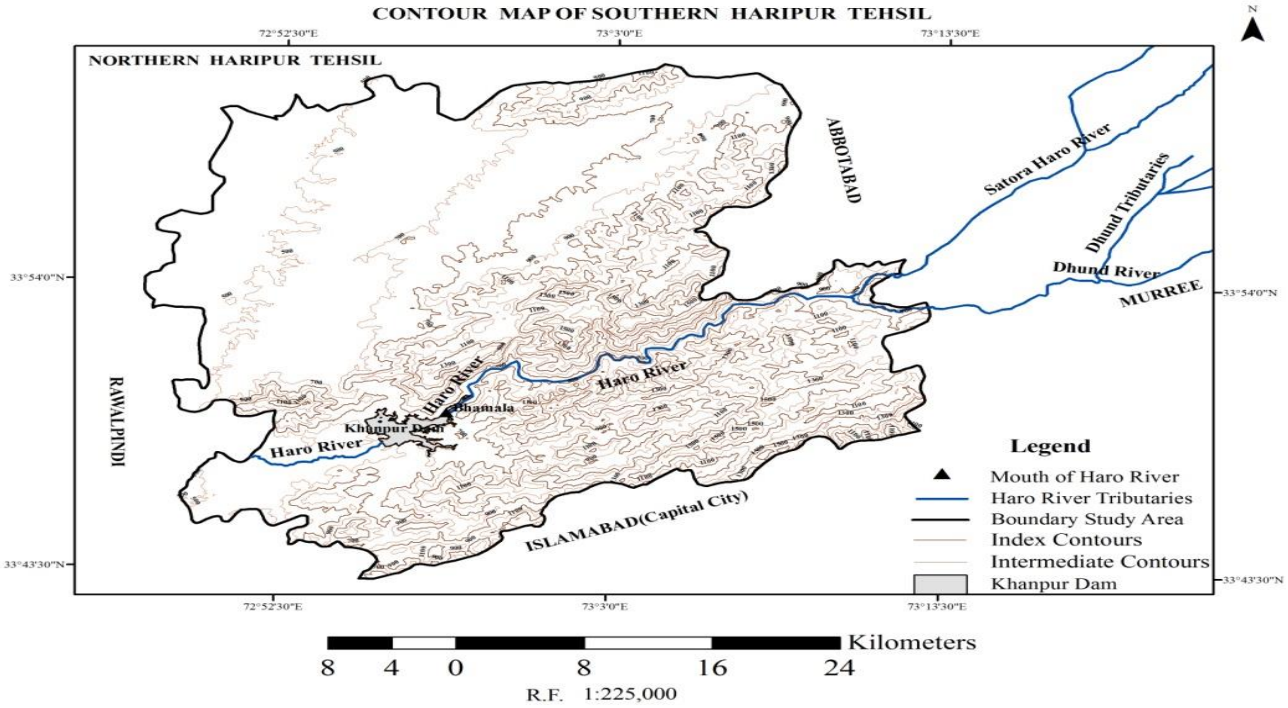

Figure-13: Contour map of Southern Haripur Tehsil

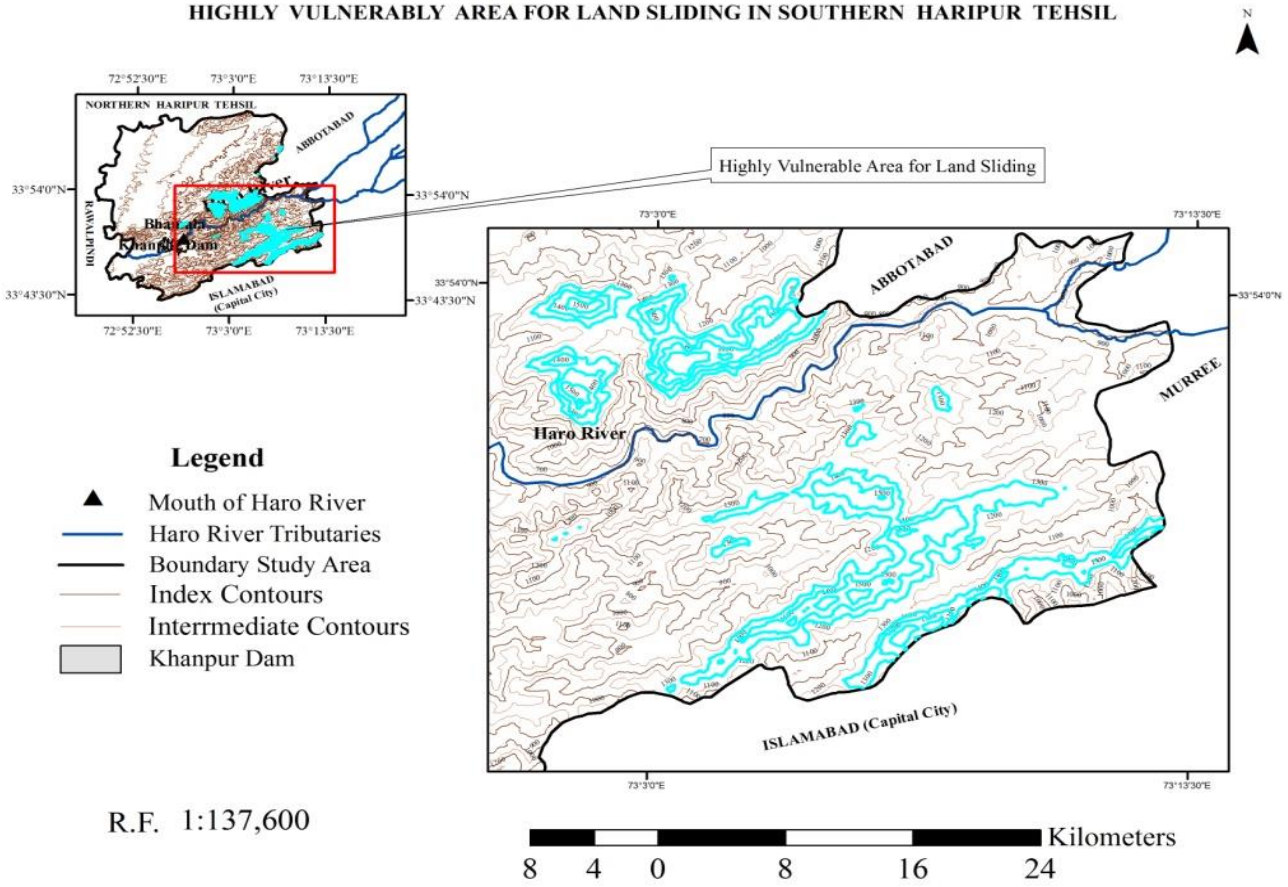

Figure-14: Contour map of highly vulnerable area for land sliding

Conclusion: In this study it was found that northern area of study area was steep and north east was less steep. The geology was fragile. Minimum slope was10% (6°) and maximum 100% (57°) in the north of Haro River. Study area was found undulating from aspect map. Only the area from -1 to 0 degree was flat. Southern slopes of Margala hills and northern eastern slopes of Haro river having elevation ranges from 1300-1500 meter and were highly susceptible for land sliding. Finally, it was predicted that the south-eastern area of study area is highly vulnerable for land sliding due to steep slopes and fragile geology and were not well suited for building the settlements.

Acknowledgement: The authors are thankful to Dr. Sajid Rashid Ahmad, Principal College of Earth and Environmental Sciences, Dr. Khalida Khan, Director Centre for Integrated Mountain Research, University of the Punjab, Lahore and Muhammad Ikram, Exe Principal , Soil Survey of Punjab who provided her their professional knowledge and guidance for research work that's why the author could be able to do this research.

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