GEOGRAPHICAL INFORMATION SYSTEM BASED WATERSHED DELINEATION IN SOUTHERN HARIPUR TEHSIL KHYBER PAKHTUNKHWA PROVINCE, PAKISTAN

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ABSTRACT: Presented study was to delineate the main watersheds and sub watersheds of Southern Haripur Tehsil, using the GIS (Geographical Information System) techniques. In this study, Arc GIS 9.3 software, spatial Analyst and Arc Hydro tool extension was used to delineate the watershed areas of Southern Haripur Tehsil in detail. DEM (Digital Elevation Model) data of SRTM (Shuttle Radar Topographic Mission) having 90 by 90 meter resolution of USGS was used for this watershed analysis. It was find out that the Southern Haripur Tehsil is comprised of 7 main watersheds out of which watershed of Dor River contributes to Tarbela dam, 35 sub-watersheds out of which one contributes to Khanpur dam, No. of streams of watersheds, their drainage pattern, drainage points, trace origins and areas in Sq.Km of main and sub watersheds of Southern Haripur Tehsil.

Keywords: Watershed delineation, Digital elevation model, Geographical information system and Southern haripur tehsil.

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INTRODUCTION

"A watershed is an area that contributes flow to a point on the landscape." Watersheds are an important focus of study because management of water volume and quality, soil conservation, flood control, wild life habitat and forests require understanding the many features of relevant watersheds. Thus, watershed modeling is an ideal application for GIS. A key component of watershed modeling is determining the drainage area that contributes flow to that point on the landscape, doing so requires identifying channels and divides and delineating watersheds. Thus GIS provides useful tools for good decision-making. (Poyer, 2010).

Many factors are focusing to people *i.e.* scientists, citizens, decision makers of government and resources managers about the management of watersheds and water related problems. All the various human activities which occur on the earth surface can be seen in an integrated way through watershed management. (Committee on Watershed Management, National Research Council.1999). Geographic Information Systems (GIS) have become more important tool in watershed delineation. The GIS-based process of watershed delineation starts with a raster gridded data of terrain that is called Digital Elevation Model (USGS, 2013). By using DEM data watershed boundaries can be demarcated by identifying all cells of DEM that are located uphill area of the outlet (Chinnayakanahalli *et al*., 2006). Flood hazard mapping using GIS tools assessment of affected people due to climatic change was done in Kankai watershed in Nepal. Flood frequency analysis was done using gambol's Method. It was concluded from the results of Kankai watershed analysis that flood has remained a major problem of the Kankai River for years that is why the agriculture system is in most vulnerable position (Karki *et al*., 2011).The water quality model of Tillamook Bay was generated. Non-point sources in the contributing areas and point source loadings from treatment of waste water were derived for the Tillamook Bay National Estuary Project. It was found that the major load of the bacteria was from dairy lands and sediment loads was strongly linked to the erosion in channels especially in low reaches (Patrice, 1999).

In the study of Roanoke River Watershed (covering four counties *i.e.* Roanoke, Montgomery, Floyd and Botetourt and two cities of Roanoke and Salem.) it was find out that layers for the Upper Roanoke River Watershed were created explicitly (Dietz, 2000). The morphometric characterization of Maun watershed, located in Tehri-Garhwal district of Uttar hand, India was done. It was found that the maximum area of Maun catchment lies between 1500 to 1700 m and elevation ranges from 960 to 2000m. It was also found that slope of most of the agricultural area was different from areas having gentle to moderate slope. It was also found that forest areas were mainly located on higher slopes (Pingale *et al*., 2012). Automatic Creation of Hydrological Models of River Drina catchment of Serbia was done. The SWAT model was used to delineate the catchment area into the set of HRUs (Hydrology Response Units) with homogenous land, soil, and vegetation parameters (Prodanovic, 2009). A research study was conducted on the Rio Illangama watershed in Alto Guanujo, Ecuador.It was found that there was very little difference between the manual delineation and

SRTM DEM based delineation, where as the ASTER based delineation differs from the manually delineated. (Pryde *et al*., 2007). The watershed behavior of flooding and inundation Pothowar (semi hilly) area of Pakistan was processed. Results of this study were that overwhelming of flood was then estimated by generating maps of flooded area of Pothowar region of Pakistan for different future scenarios by GIS interface (Tallat, *et al*., 2011). Aglar watershed, drains into the Yamuna River. In order to obtain spatial location of vegetation and land use through visual interpretation of scale 1:50,000 remotely sensed data of Landsat TM false colour composite was used. It was identified that Aglar watershed is forested having different vegetation and land use in northern and southern aspects of the watershed. Southern aspects populated more and there is terrain cultivation practiced and very few vegetation is available for fodder and fuel wood. The north aspect has thick vegetation and thin population (Pant, *et al.*, 1990).

The objective of this study was to delineate the main watersheds and sub watersheds of Southern Haripur Tehsil, using the GIS (Geographical Information System) techniques.

MATERIALS AND METHODS

The study area selected for this study is Southern Haripur Tehsil in Haripur district. Haripur (“The Town of Hari or Vishnu”) district is located in the Hazara division of province Khyber Pakhtunkhwa in Pakistan. The altitude of this district above sea level is 610 meters (2,000ft). Its point geographical location in DMS is WGS84 34°0′ 3.18″N latitude, 72° 56′ 14.00″E longitude and in DD is 34.000884°N latitude, 72.937223°E longitude. Haripur District is bounded by Mansehra and Abbottabad to the north east, by Swabi and Buner to the north-west, by Islamabad capital city to the south and by Rawalpindi district to the south west. Southern Haripur Tehsil (study area) is located to the south in the Haripur District. Its west to east extent is 72.547595°E (DMS: 72° 32′ 51.34″E) to 73.223263°E (DMS:73° 13′ 13.75″E) and south to north extent is 33.716569°N (33° 42′ 59.65″N) to 34.440462°N (34° 26′ 25.66″N). The study area is bounded by Abbottabad to the east, by Northern Haripur Tehsil to the north by Rawalpindi to the west and south-east, by Islamabad capital city.

Arc GIS 9.3 software product of ESRI (Environmental System Research Institute) was used for watershed delineation and following methodology was processed.

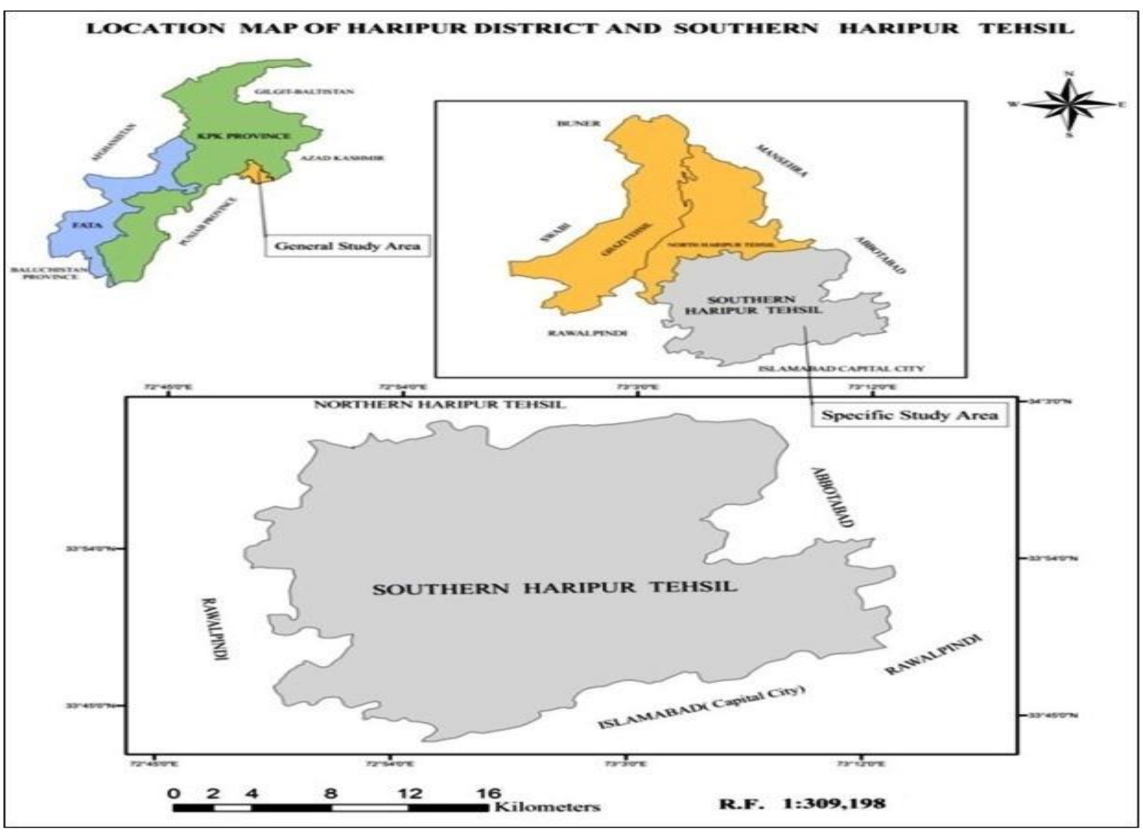


Figure-1: Location map of study area

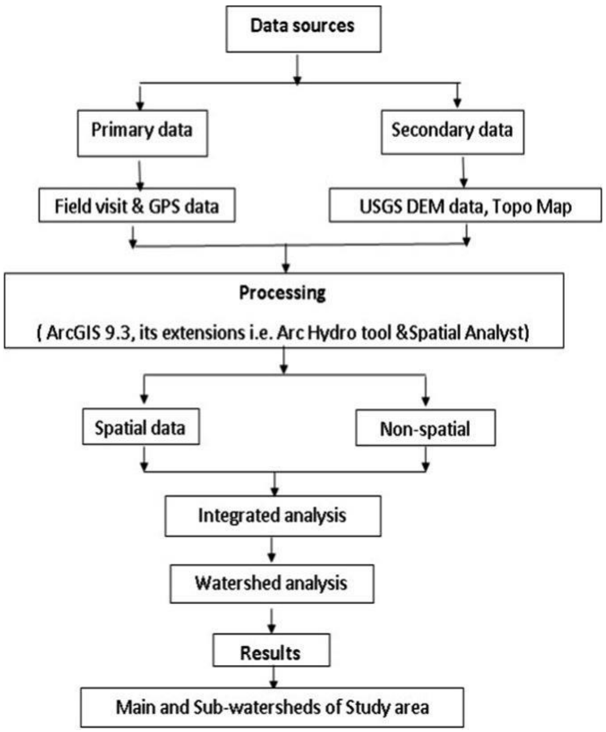


Figure-2: Data Flow Diagram of methodology

Data sources: Single band raster data of SRTM (Shuttle Radar Topographic Mission) DEM (Digital Elevation Model) having tile of 90 by 90 meter resolution was obtained from USGS website. Each cell in this DEM contained only one value representing surface elevation. It was converted into DEM grid format of geo tiff using VT builder software. It was added into Arc Map, an Arc object of Arc GIS 9.3 software. Primary data or ground trothed data was also used. Field visit was also done for ground trothing.

Geometrical correction of the DEM: The DEM of the District Haripur was geometrically corrected and WGS 1984 UTM zone 43N was given in the Arc Catalog to the DEM.

Extraction of Haripur District and study area (Southern Haripur Tehsil): District of Haripur and study area were clipped from the DEM tile. First watershed analysis was applied on the whole of Haripur District generally and then main and sub watersheds were delineated of study area specifically by using extensions of Arc Hydro tool and Spatial analyst (www.esri.com).

The SRTM DEM tiles of USGS (N33E072, N33E073, N34E072 and N34E073) were merged in VT Builder software as shown below:

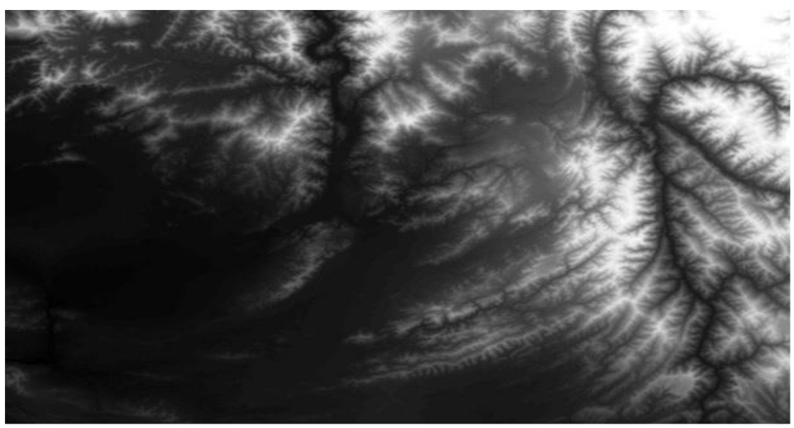


Figure-3: Processed DEM data of SRTM Source: USGS,

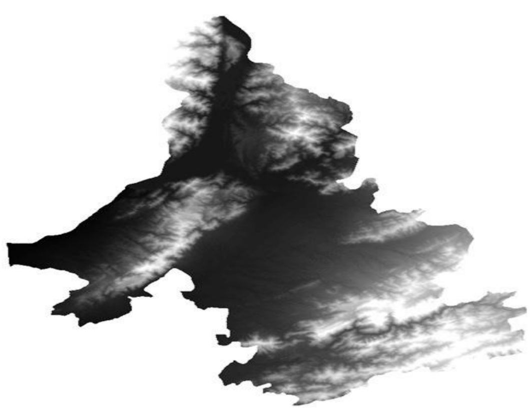


Figure-4: General study area of Haripur District clipped From huge DEM Data

Figure-5: Specific study area of southern Haripur Tehsil clipped from huge DEM Data

Processing: First Spatial Analyst and Arc Hydro tool extensions were loaded from the tools in Arc Map and then following steps of Arc Hydro tool extension were followed to delineate the main watersheds and sub watersheds of Southern Haripur Tehsil.

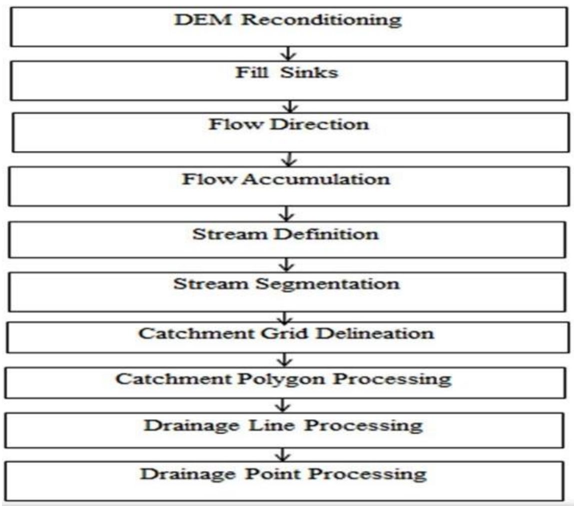


Figure-6: Flow process of watershed delineation

First DEM reconditioning was done to check whether the Haro River was superimposed on the DEM based Haro River (Step.1 in figure 7).

Fill sinks function was applied to fill the sinks of the DEM so that the flow direction of water is identified. Fill Sinks function created a depression less DEM (Step 2 in figure 7) (Khan, K. *et al.*, 2012).

Flow direction: Best key of identifying the hydrology of any surface was to

determine the direction of water flow from each raster cell. This can be performed by using Flow Direction function. Flow Direction function was applied in this step which shows the flow direction from each cell (Step 3 in figure 8).

Flow Accumulation: The accumulated flow was calculated by the Flow Accumulation tool as the accumulated weight of all raster cells flows into every down slope cell in the output raster (Step 4 in figure 8).

Stream Definition: gives the total count of streams and identifies their patterns. Stream networks were generated by using the output raster data derived by performing the Flow Accumulation function. The threshold value was given 100 to Study area (Southern Haripur Tehsil) to identify the detailed Stream definition so that continuity of streams could be easily seen. Using this function streams were defined in raster form on the basis of pixel count (Step 5 in figure 9).

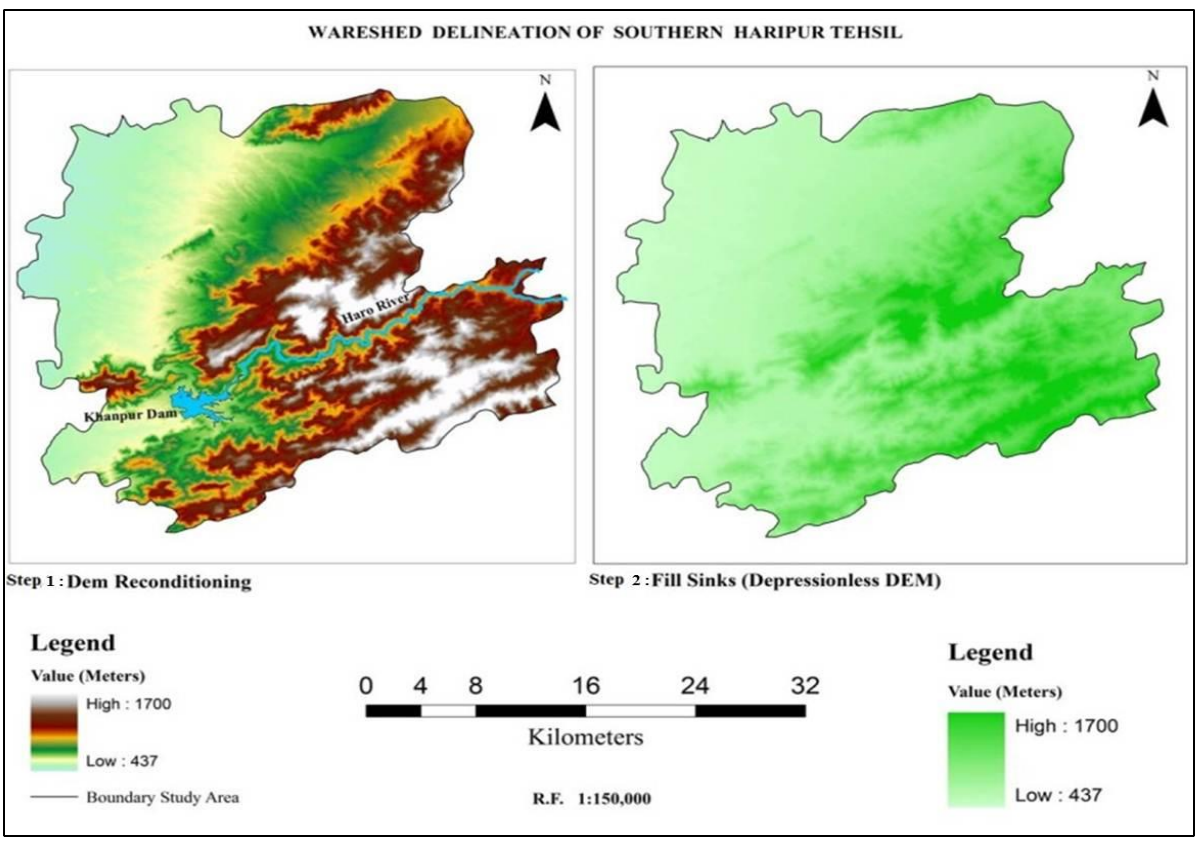


Figure-7: Shows DEM Reconditioning and Depression less DEM

Stream Segmentation: shows the unique identification of streams hierarchy e.g. the Primary, secondary and tertiary links of the streams which help to identify the contributing streams in watershed (Step 6 in figure 9).

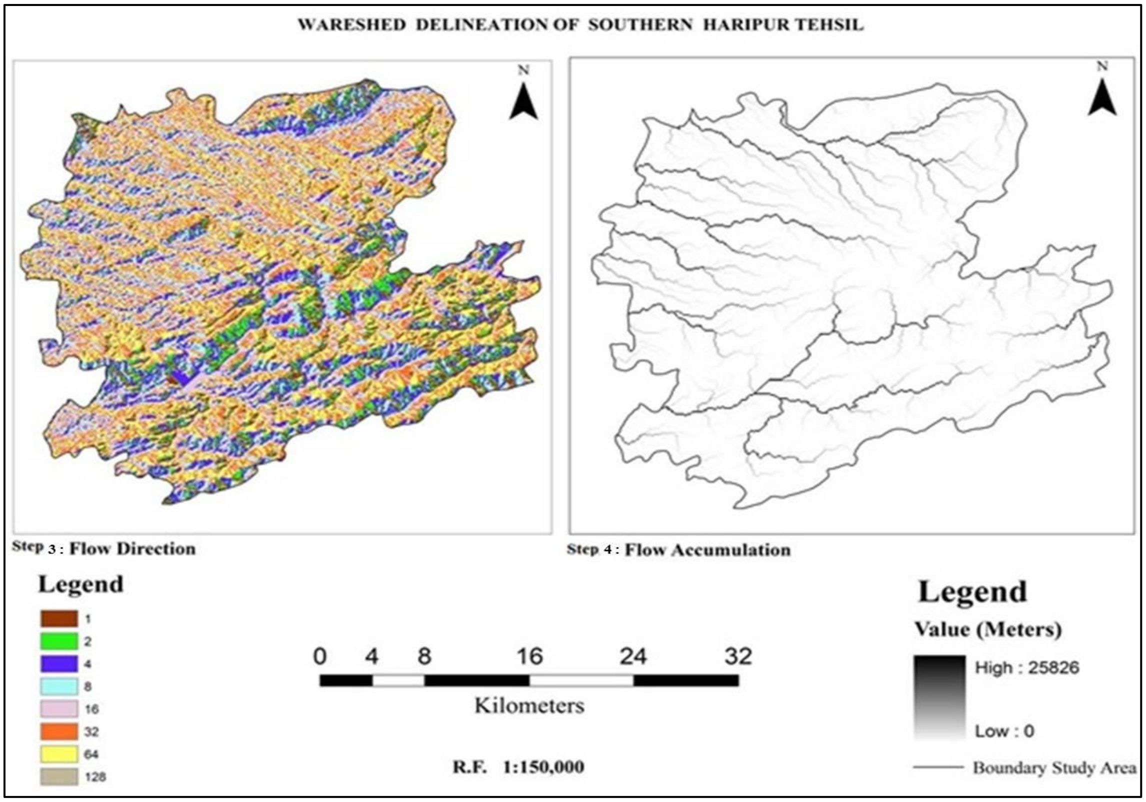


Figure-8: Flow Directions and Flow Accumulation

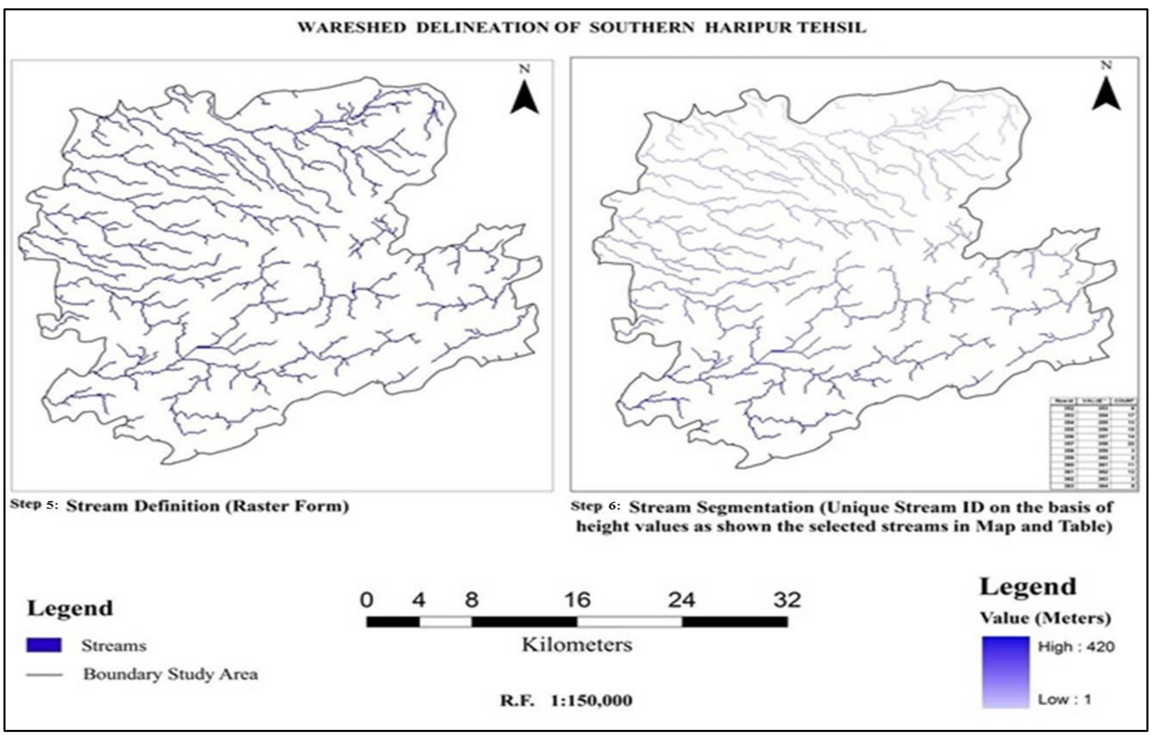


Figure-9: Stream Definition and Stream Segmentation

Catchment Grid Delineation: This function was applied to delineate the catchments in raster form which shows the Catchments Grids according to the elevation (Step 7 in figure 10).

Catchment Polygon Processing: A Catchment Polygon is the high slope area contributing water flow to a given location. This high area is also called basin, catchment, sub watershed, or contributing area. Catchment Polygon processing function was applied to delineate the watersheds after computing flow direction. Catchment Polygon processing tools used a raster data of flow direction to find catchment area. By applying this function Raster Grid data of step 7 was converted into vector polygon data (Step 8 in figure 10).

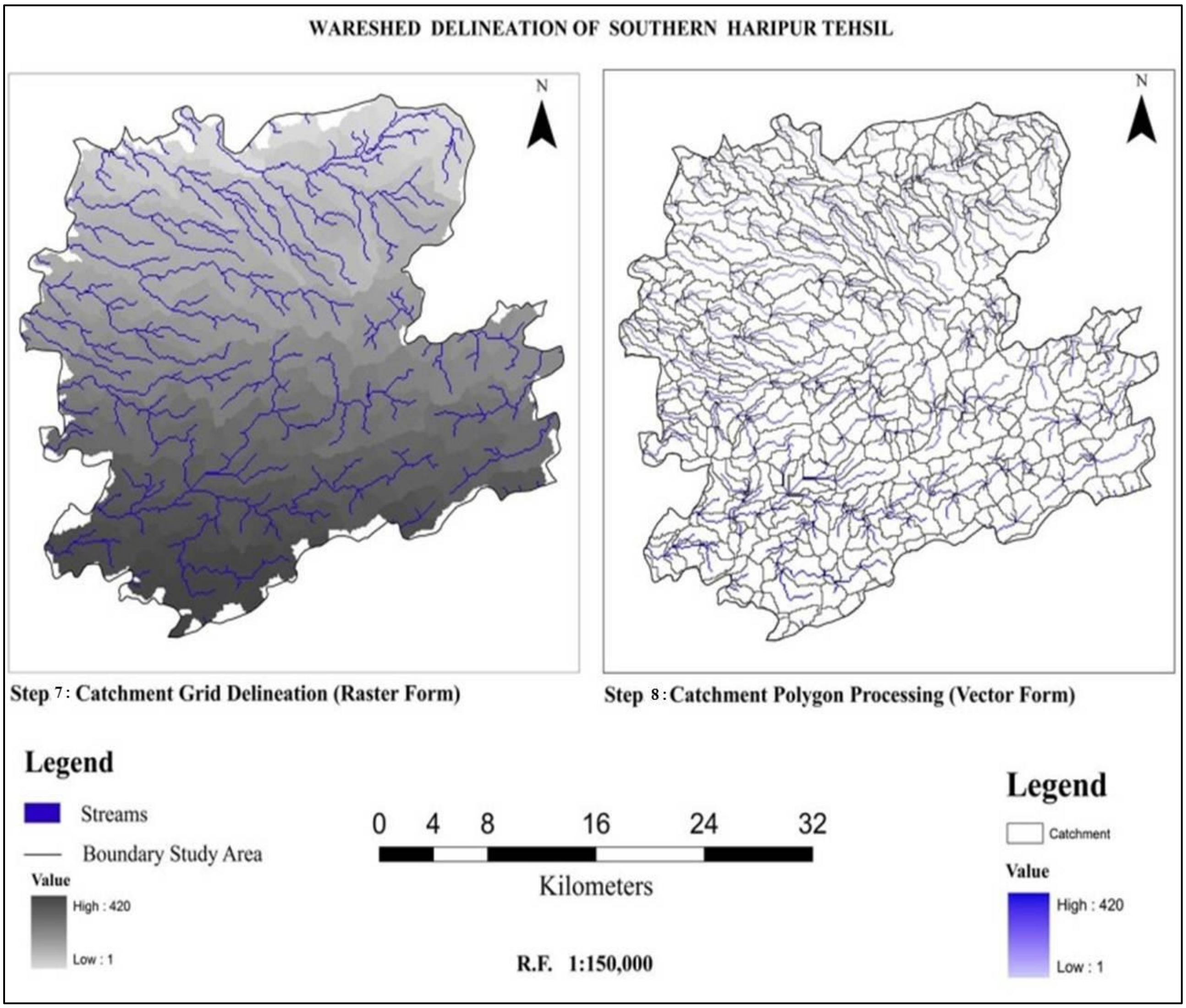


Figure-10: Catchment grid delineation and catchment polygon processing

Drainage line processing: Raster linear network was changed into features (Vector Data) by using this function (Step 9 in figure 11).

Drainage point processing: was applied to identify the drainage points of the watersheds. Drainage Points of the watershed are the junctions of a stream network generated after performing flow accumulation function. So, flow accumulation raster depends upon the threshold value (minimum number of cells that constitute a stream) Drainage Points are shown in Step 10 in below figure 11.

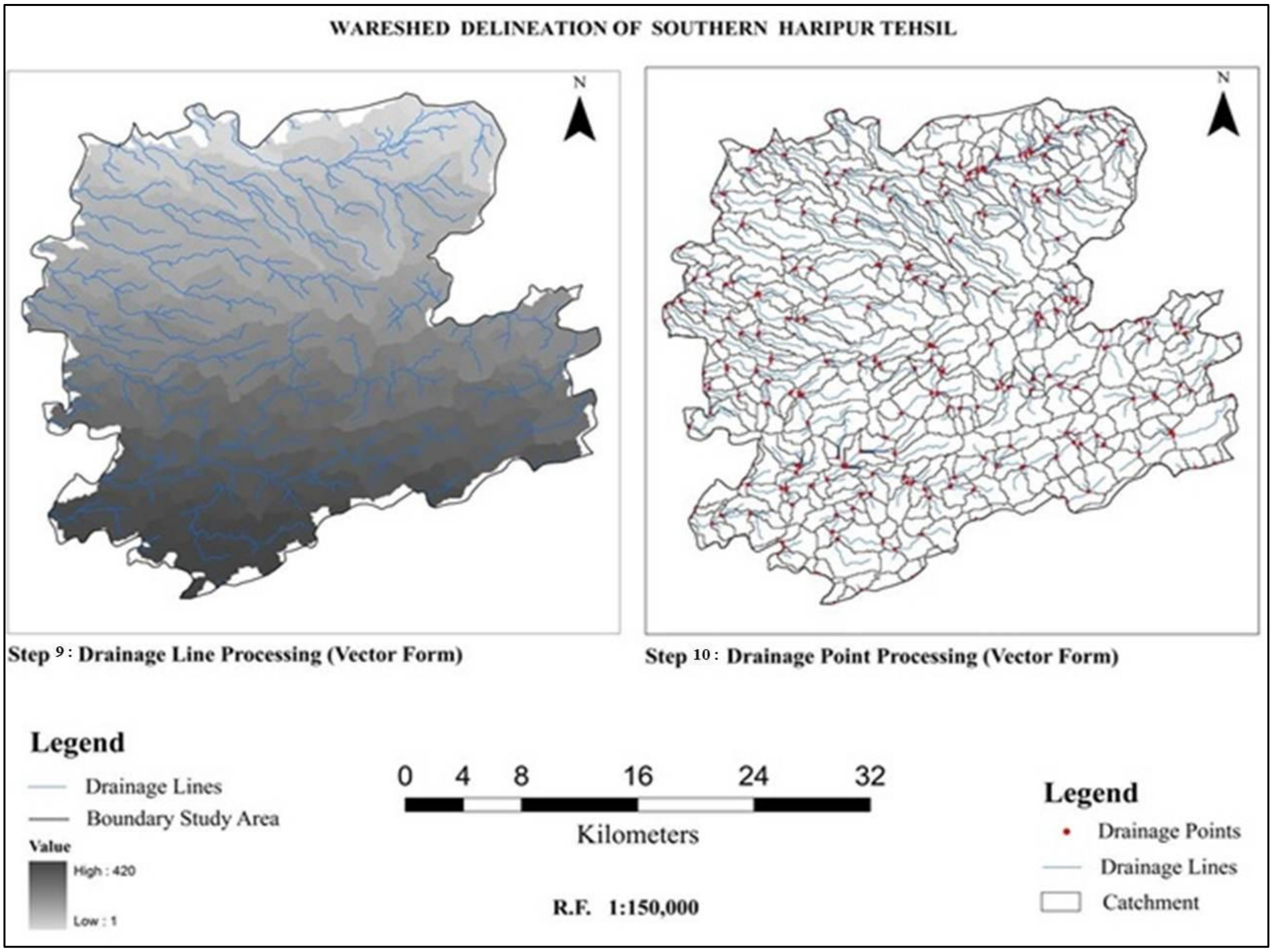


Figure-11: Drainage line processing and drainage point processing

RESULTS AND DISCUSSION

In this research watershed delineation of Southern Haripur Tehsil was performed in the Arc GIS 9.3 software and following procedure was followed as shown in figure 12.

It was found in this study that the Southern Haripur Tehsil was comprised of seven main watersheds. The largest watershed (WS-Id 2) having 249.72 Sq.Km area was located to the west of study area. The smallest watershed (WS-Id 7) having 59.60 Sq. Km area was located to the west of spillway of Khanpur Dam. There were 60 drainage points and 55 trace origins found in this study area. It was found that the area of Khanpur Dam was 5646 Sq. m/5.646 Sq.Km. There were three small dams found named Rehana dam (Area: 83.8 Sq. m/0.0838 Sq. Km), Kahal dam (Area: 121.8 Sq. m/0.1218 Sq. Km), and Mang dam (Area: 87.8 Sq. m/0.0878 Sq.Km).Two islands found in Khanpur dam bigger island (East Island) having area 27.3 Sq.m/0.0273Sq.Km to the east and small island (West Island) having area 9.8 Sq.m/0.0098Sq.Km to the west in Khanpur dam as shown below in figure 13 and14.

There were 33 sub watersheds found in Southern Haripur Tehsil. The largest watershed having Id. 17 and area of 83.94 Sq. Km was contributing water to Tarbela Dam. The Dor River is the main river flowing through this watershed originating from Barin Gali, a union council of Abbottabad district having its source at height of 2139 meter. The smallest watershed having Id.13 (Figure14) and area of 4.37 Sq. Km is located to the north of study area and contributing to Dor River.

Following graph 2 indicated that the area of watershed No.17 was largest and of watershed No.13 was smallest.

It was found that there were 357 streams. The length of smallest stream was 0.16 Km and stream of maximum length was of 9.41Km as shown below in figure 15. It was found that the length of Haro River from the confluence of its two tributaries in watershed 1 to its mouth of Khanpur was 37 Km and from the spillway of Khanpur Dam to the west border of study area was 8 Km. So the total length of Haro River in the study area was 45 Km.

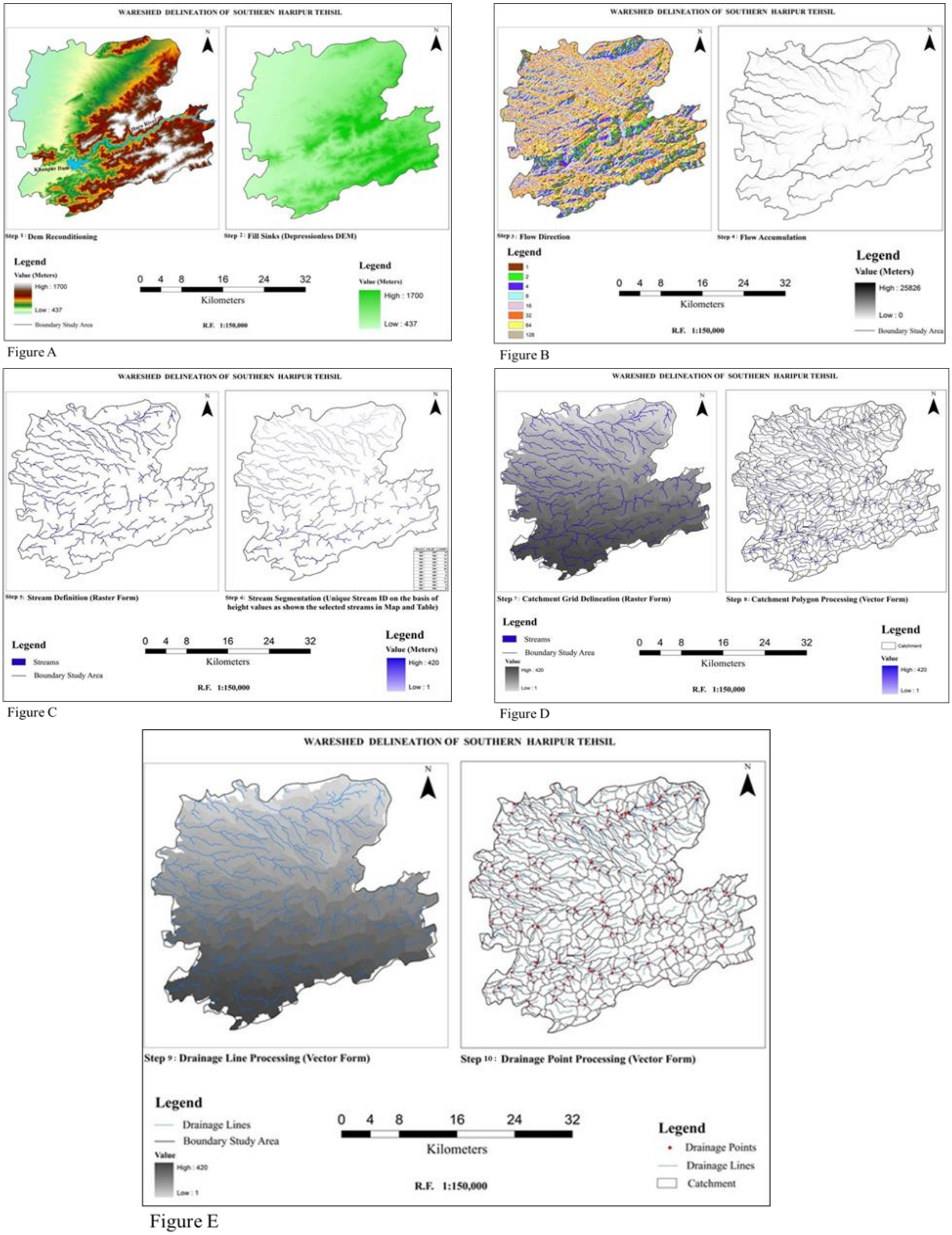


Figure-12: Watershed delineation process

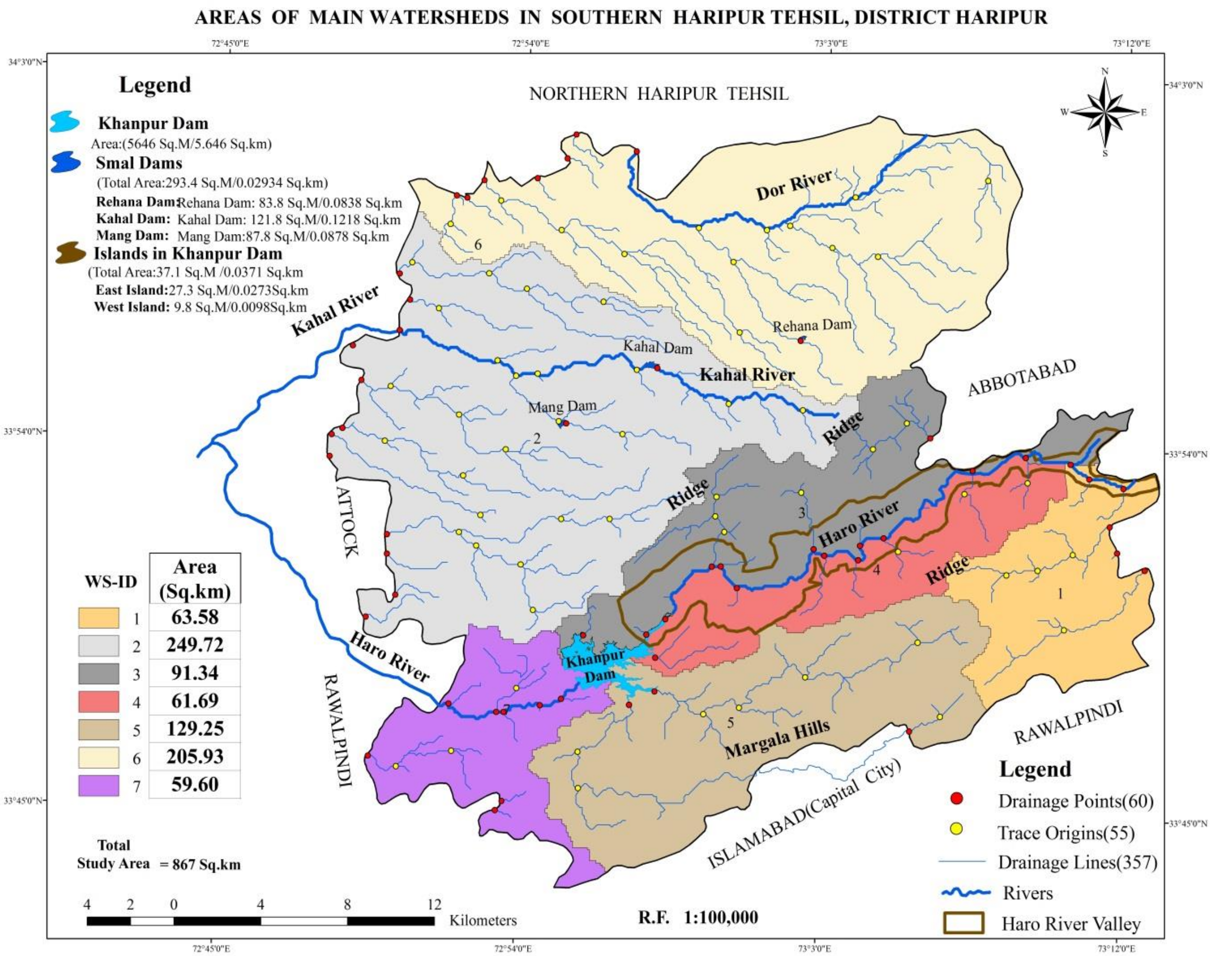
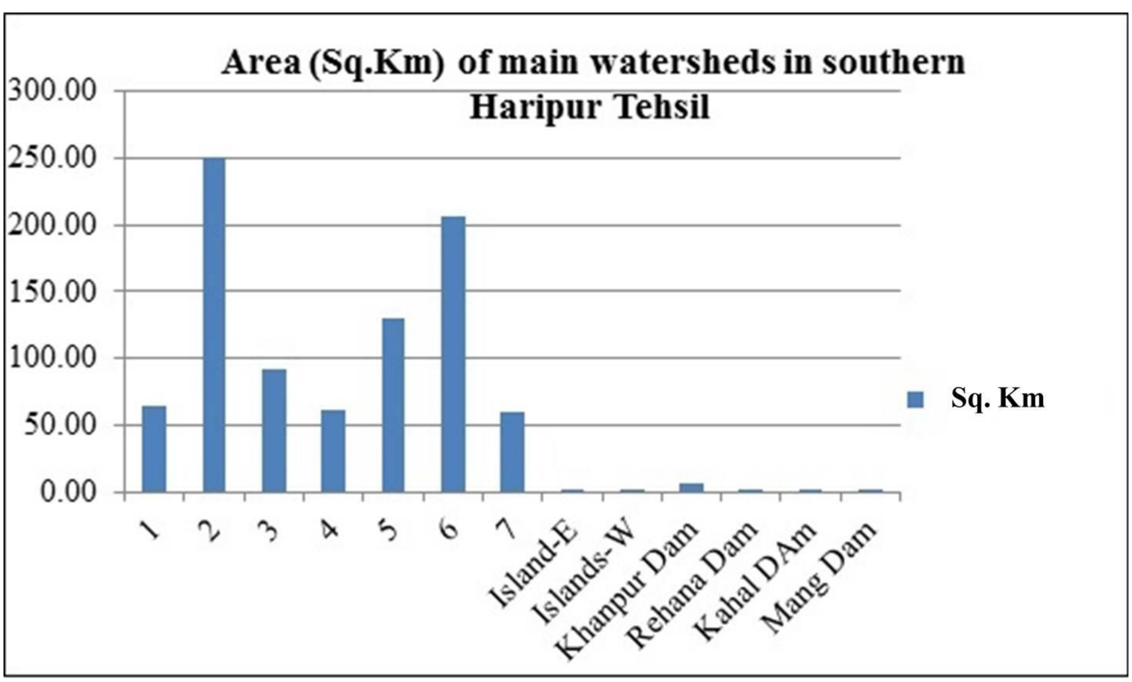


Figure-13: Main watersheds of the study area



Graph-1: Shows the areas of main watersheds of the study area

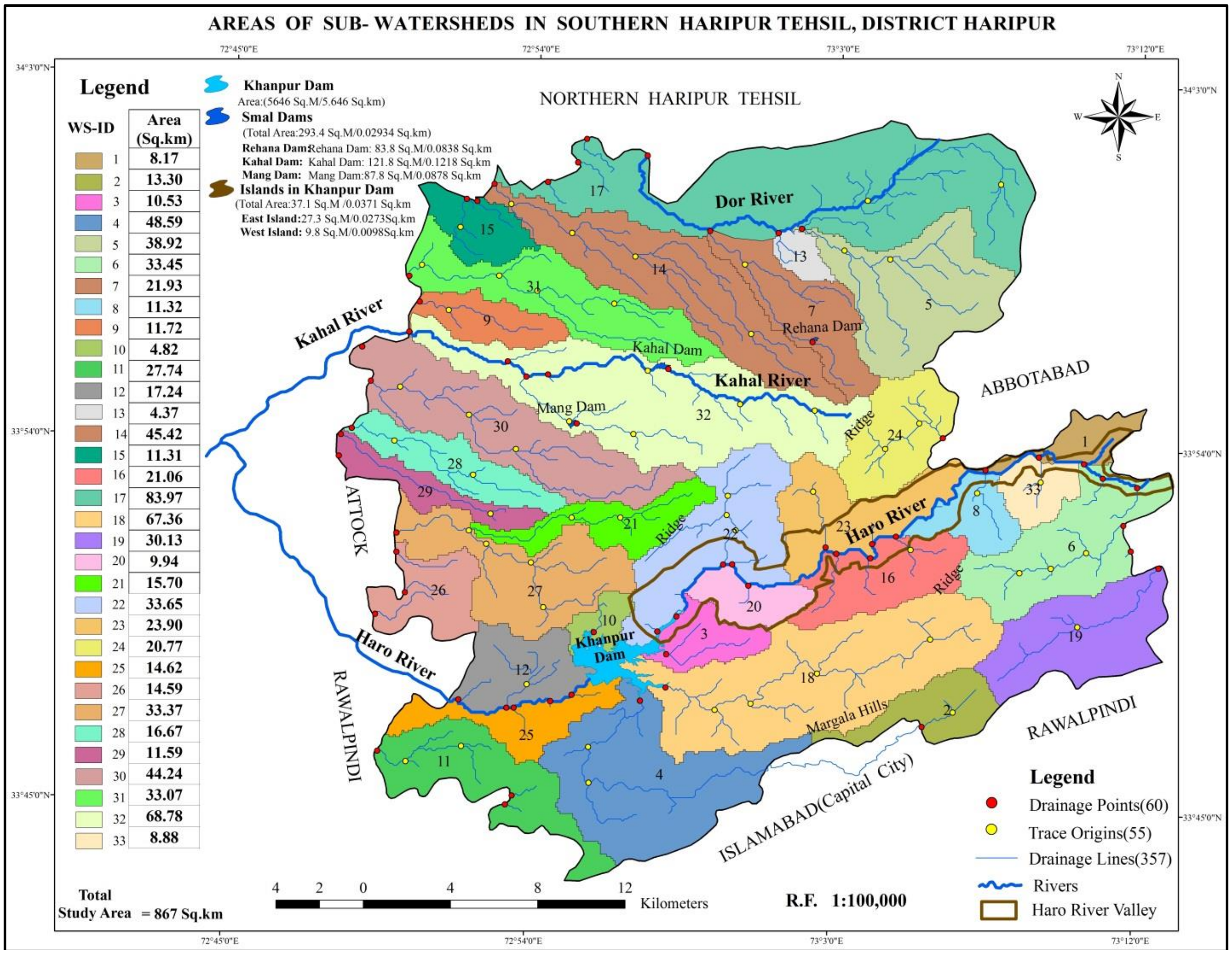
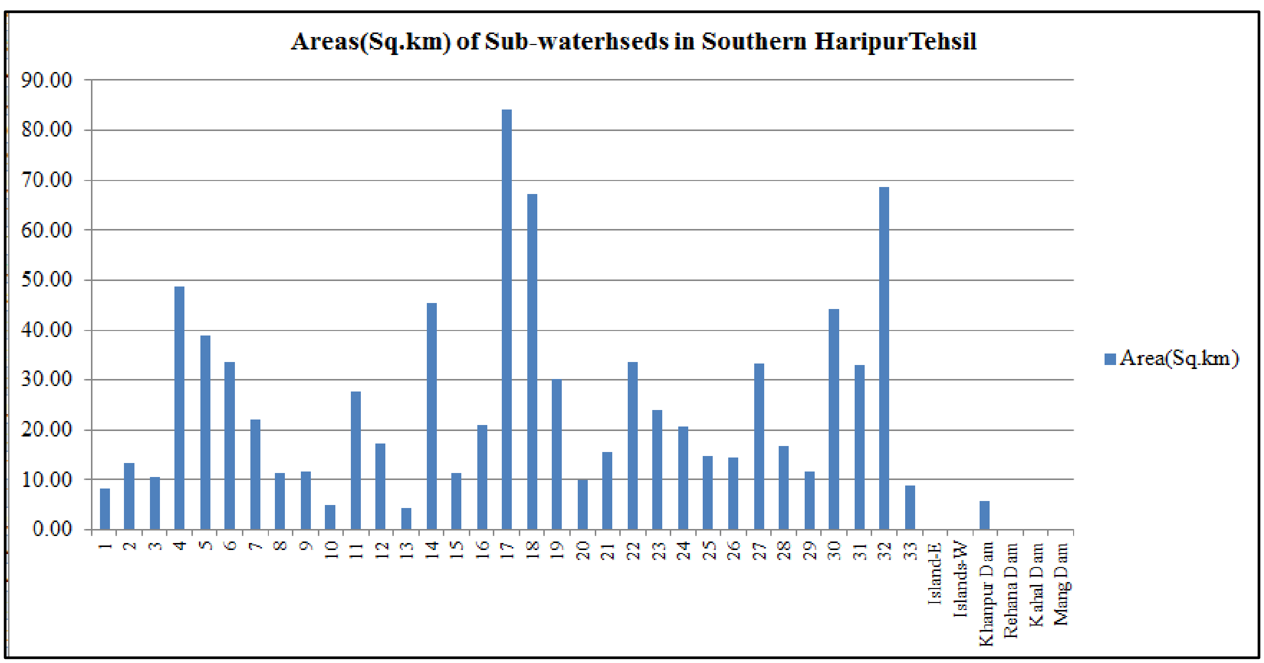


Figure-14: New map Shows sub watersheds of the Study area



Graph-2: Shows the sub-watersheds of study area

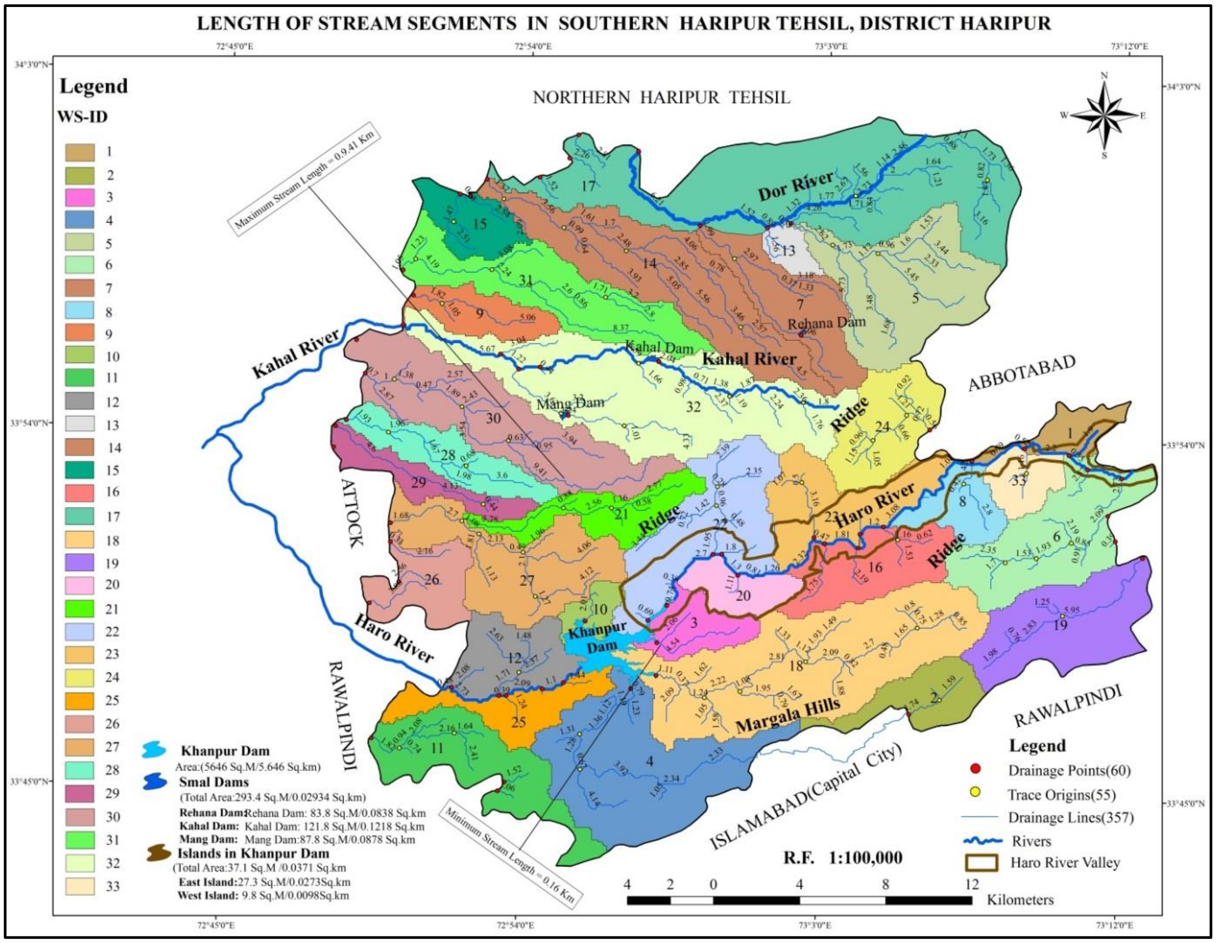


Figure-15: Shows the stream length of all sub-watersheds in study Area

Conclusion: In this study the remotely sensed SRTM DEM data of USGS having 90 * 90 meter resolution of Southern Haripur Tehsil was used in Arc GIS software 9.3. It was found 7 main watersheds. Out of them largest was 249.72 Sq.Km and smallest was 59.60 Sq.Km. It was also found 33 sub-watersheds. Out of them largest was 83.97 Sq.Km and smallest was 4.37 Sq.Km. There were 60 drainage points and 55 trace origins were found in the study area. It was concluded that GIS techniques were very helpful to perform the watershed analysis.

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