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Remote Sensing and GIS for Groundwater Potential Zones Ghagger Watershed, Himachal Pradesh

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Abstract
Groundwater is often referred to as the 'hidden' component of the hydrological cycle because it is not directly observable. However, in many areas, the groundwater resource is huge, and its occurrence and hydrological significance cannot be neglected in water management and planning. Identification of groundwater potential zone is main objective of present work for Ghagger Watershed, Himachal Pradesh. GIS and Remote Sensing is used for identification of groundwater potential zones in the study area. Landsat 8 satellite data is used to generate land use and land cover maps as well as your Geomorphological maps for the study area. Soil maps are used as available. Digital elevation model are acquired using CartoSAT-1 satellite Data. Weighted overlay method of raster dataset for analysis is used to identify groundwater potential zone of study area. The layers landuse, Elevation, slope, geomorphology, rainfall pattern, drainage pattern and soil were considered and the influence and scale values set to different feature according to their importance in groundwater potential areas. After analysis, five zones of groundwater potential are generated as, very poor, poor, moderate, Good and very good were identified for the study area. It estimated is for study area that 49% and 29% part is lies in moderate to good zone of groundwater.

Keywords- Overlay Analysis, GIS Groundwater, Raster Overlay, Watershed Analysis.

1. Introduction

India is the biggest user of groundwater in the world. It is estimated that usage of around 230 cubic km/Year, more than a on forth of the global population with more than 60% of agriculture irrigated and 85% drinking water dependent on it, groundwater is a most demand resource for villages in India (Report on Deep Wells 2010,World Bank). Global fresh water is just 2.5% out of which 1% is available for consumption of humans. Increase in the demand of water for irrigation, industrial and use for domestic activities in few decades is increased and the demand for better quality of water to meet the increasing demands as per World Bank Report, 2002.

Groundwater is water present below the ground surface in soil pore void spaces and in the cracks of rock formations. Groundwater is often referred to as the 'hidden' component of the hydrological cycle because it is not directly observable (Sinha et al., 2012) An aquifer is a unit of rock or an unconsolidated deposit, when it can pass or yield a usable amount of water. The water table is depth at which soil pore spaces/voids and fractures in rock become complete saturated. Groundwater is revived in the long run streams to the surface actually frequently happens at springs and leaks and may shape desert gardens or wetlands. Groundwater is likewise frequently extracted for rural, city and modern use by constructing a well. We can estimate groundwater potential zones with GIS and remote sensing methods. Because groundwater have direct relation with geomorphology, drainage, streams, slope, Stream density, soil, slope, rainfall and geology. Water depth data also used in GIS for creating water depth layer. Water is measured in feet/bgl (below ground level). Digital elevation model defines flow direction and types of streams. Stream order is also useful for identifying streams with maximum water flow (Ballukarya and Ravi, 1999).

A few research papers of GIS applications in groundwater hydrology are present that as in (Raneesh and Thampi, 2013) which shows that GIS has been generally utilized as a tool, for the most part to of standard geophysical procedures. In the current years, present day advancements like Geographic Information System (GIS) has been utilized for different purposes like groundwater examinations, many researchers have endeavoured to depict groundwater potential zones (Jat et al., 2009; Khare et al., 2015). GIS encourage coordination and investigation of extensive volumes of information, while, field investigation considers help to additionally approve comes about data results.

2. Groundwater in Himachal Pradesh

The State basically is uneven territory, involving fissured developments with a less development between mountain valleys having Quaternary alluvial fill. The sub-rocky tract is a piece of Piedmont alluvial fields, which converges with Indo-Gangetic alluvium towards southwest. Kandi belt and the connecting slope inclines are underlain by rocks, rock and clay. The unconsolidated silt, happening in the between mountain valleys and in the sub-mountain tracts constitute the essential groundwater stores. The yield of the tube wells ranges 100 to 120m/hr in valley fills. The yield of bore wells in hard shake is constrained. Groundwater is generally of good quality.

3. Study Area

The Study area Ghagger watershed confined between 30°40’ 10" and 30°50' 20” North latitudes and 76°50' 00" and 77°15' 00" East. Ghagger watershed falls in the foothills of the Shivalik Mountains in the Panchkula, Sirmaur, Solan District of Himachal Pradesh and Haryana (Figure 1). Ghagger is a rainy river it flows during monsoon season. It has estimated catchment area is 400km$^{2.}$ It receives maximum rainfall during monsoon season. Average annual rainfall is between 1080mm to 1465mm.

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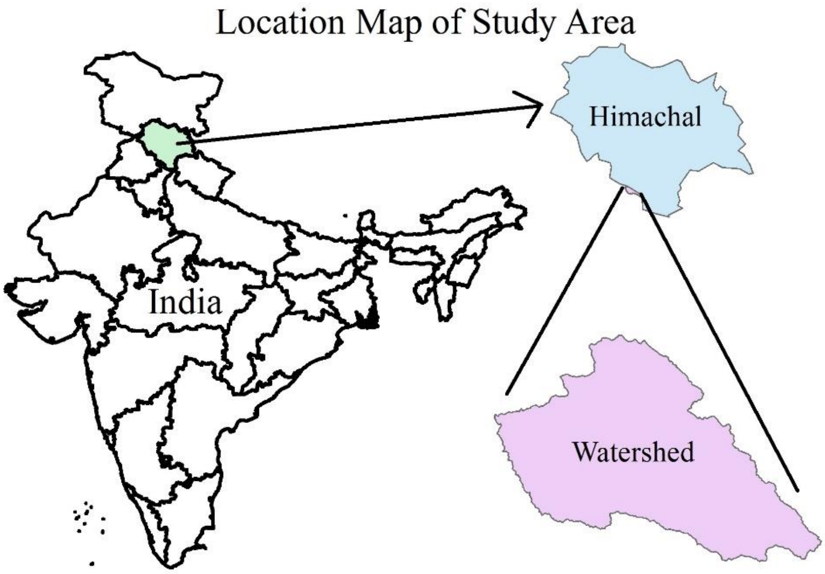

Figure 1. Location map of study area

4. Data Used

Four type of dataset has been used in present study.

- Digital data of India in vector format downloaded from http://www.IndiaRemoteSensing.com.
- Remote Sensing Data: Landsat 8 20-12-2015 has been chosen. It is cloud free and 30-meter spatial resolution.
- Rainfall Data: Rainfall data in grid Download format from "CRU TS 2.1 Global Climate Database" (The CRU TS2.1 Climatic Research Unit (CRU) of University of East Anglia has been produced Climate Dataset, which is available to download).
- Elevation: CartoSAT-1 of ISRO data is used for Digital elevation model.

5. Methodology

A Digital Geo-Database has been created for all features. All feature digitised required for analysis, like Soil, Geomorphology. Raster dataset has been generated for slope, stream density, relief, land use land cover. Supervised classification has been performed. Automatic drainage map is generated by building model in ArcGIS. All vector data converted to Raster and reclassified. UTM projection is used for all analysis. All data vector and point data converted to pixels with integer value for Raster overlay analysis. For evaluation of Groundwater potential in the region raster overlay analysis has been performed by considering property of each layer, like geology, soil, geology water table etc. The procedure included data collection, mapping of various themes, acquit (Farnsworth et al., 1984). Satellite data from NRSC and image processing using ERDAS Imagine, building of

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Geodatabase, development of matrix for assigning weights to various factors and ranking of the hydro-geological units for groundwater potential zones based on integration of all thematic layers. A flowchart has been presented to indicate the methodology used to undertake this work (Figure 2).

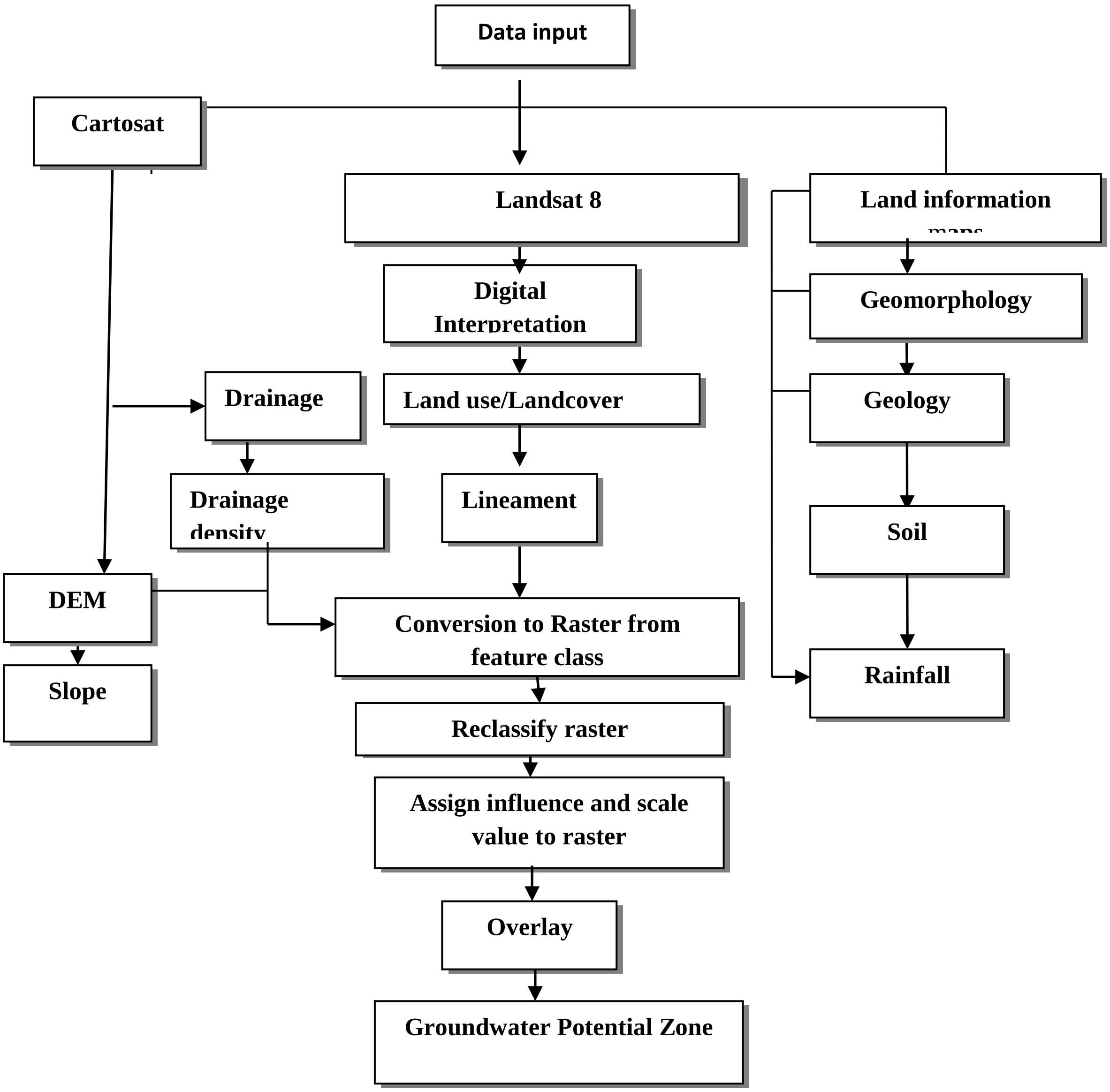

Figure 2. Flow chart of methodology

The Weighted Overlay analysis applies a standout amongst the most utilized methodologies for overlay investigation to take care of multi criteria issues such groundwater models (Li et al., 1999). Similarly, as with all overlay examination, in weighted overlay investigation, we should characterize the issue, break the model into sub models, and recognize the information layers (Jankowski, 1995). Since the input method of analysis for layers will be in various numbering systems with different value of ranges, to set them in a single analysis, each pixel for each class must be reclassified into a single raster with preference scale such as 1 to 10, with 10 being the most favourable. Preference decided how important layer and its class with attribute. The preference values set to relative scale. Which is, a preference of 10 is double as preferred as a preference of 5? The preferred values not only represent relative to each other within layer but should have the same meaning between the layers. As example, if a location for one criteria is assigned as a preference of 5, it will have the same weightage on the phenomenon as 5 in the second criterion. It also calculates result for all pixels (Malczewski, 1996).

6. Result and Discussion

6.1 Land Use Land Cover

It is clear from map that dense forest covers 79% of total area and 8% low dense, remaining is agriculture and settlements. This area has much forest cover more than other land use class and less population density that is why here is very less settlements Figure 3.

6.2 Geology

Geology of the study area is characterized by pre-sequence of pre-tertiary and tertiary groups of rocks. Pre-tertiary composes underlain by slates and Phillies. Seismically the area is also very active and falls in the very high damaging risk zone V of the seismic map of India.

Different region of watershed area contains rocks of various type related to different geologic periods. Some rocks are badly deformed and transmuted while some are recently deposited of alluvium soil that has yet to undergo digenesis. Great varieties of Mineral deposits of are found in this region.

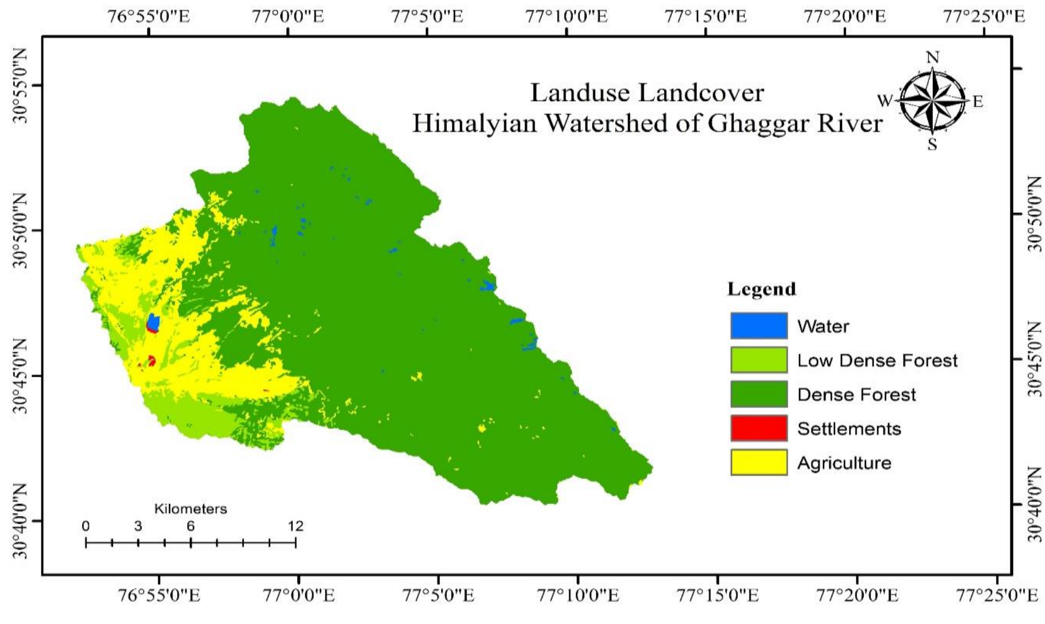

Figure 3. Landuse

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6.3 Soils

Study area has alluvium and loamy soil is 28% and 30% and 41% are is of soft rock surface with mixed soils. These are mostly found in Northern part of watershed. It has almost no settlements in this region.

6.4 Streams

Most of streams are found in upper Dholadhar to Middle Mountain. These streams have fast flow of water at upper hills due to steep slope at upper hills. The path of first order stream is short before it meets to second order stream. Streams length is very less on mountain region. When stream reach to plain 600-900 metre height, length of stream start increasing as stream reach to end of watershed density of stream starts decreasing. In rainy season Ghagger River have maximum of water. There is dam also in this area. These streams are generated CartoSAT-1 digital elevation data. Generated streams are shown in Figure 4.

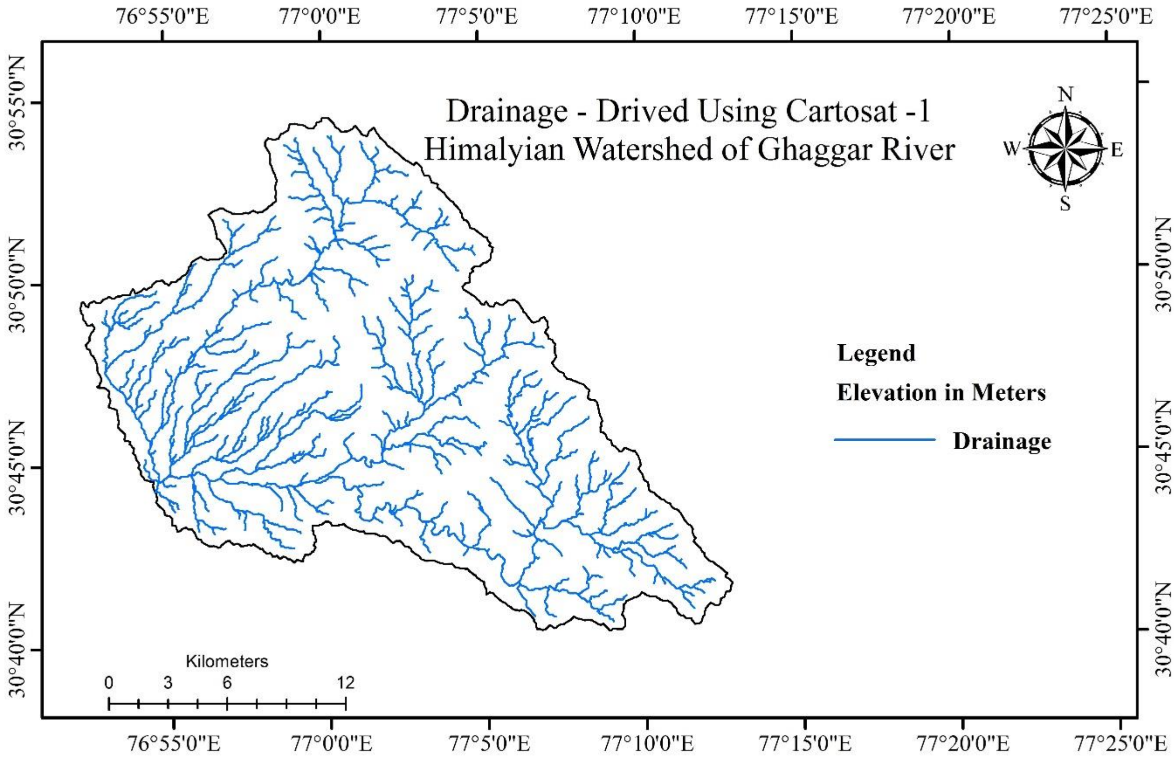

Figure 4. Drainage

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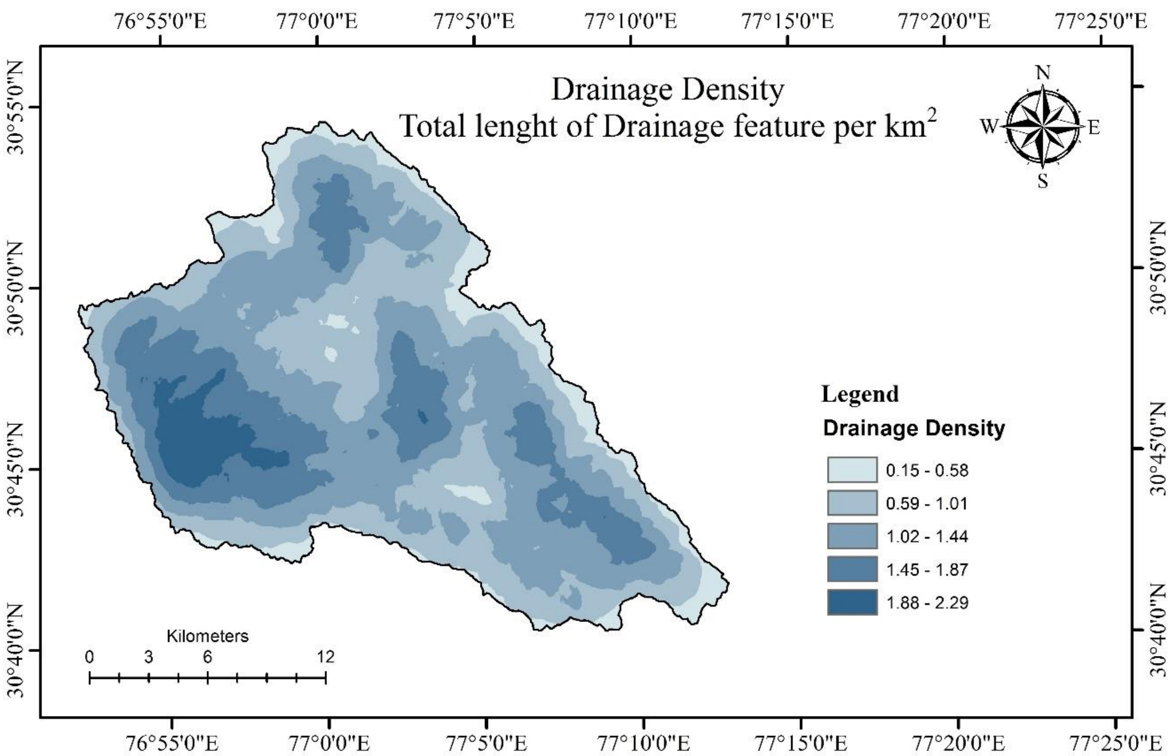

Figure 5. Drainage density

6.5 Stream Density

Streams are lines so line density is used for calculating stream density. Stream Density is used to calculate the drainage density features in the neighbourhood of each output raster pixel. Density is calculated in units of length per unit of area (Figure 6).

6.6 Drainage Density

Calculation of drainage density conceptually explained as, a circle is drawn around every pixel of raster cell centre using the search radius (Xie and Cui, 2011). The length of the portion of every line that falls inside the circle is multiplied by its Population field value. These figures are summed, and the total is divided by the circle's area. The Figure 6 illustrates this concept:

In the example, a raster pixel is represented with its circular neighbourhood. Lines L1 and L2 shows the length of the portion of each line that lies within the circle. The corresponding population field values are V1 and V2. Thus:

Density = ((L1 * V1) + (L2 * V2)) / (area of circle)

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If a population field except “NONE” is used, the length of the line is used to be its actual length times the value of the field for that line (*Source: ESRI*). For Study are search radius of 2 km is considered and drainage density and classes are shown in Figure 5.

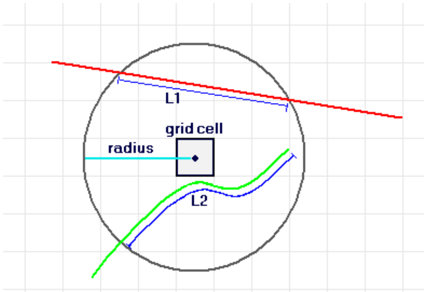

Figure 6. Calculation of density

6.7 Elevation

Study area has maximum elevation of 1871 meters and minimum is 333 meters. Most of area is found below elevation 900meters. Details of elevation are shown in Figure 7.

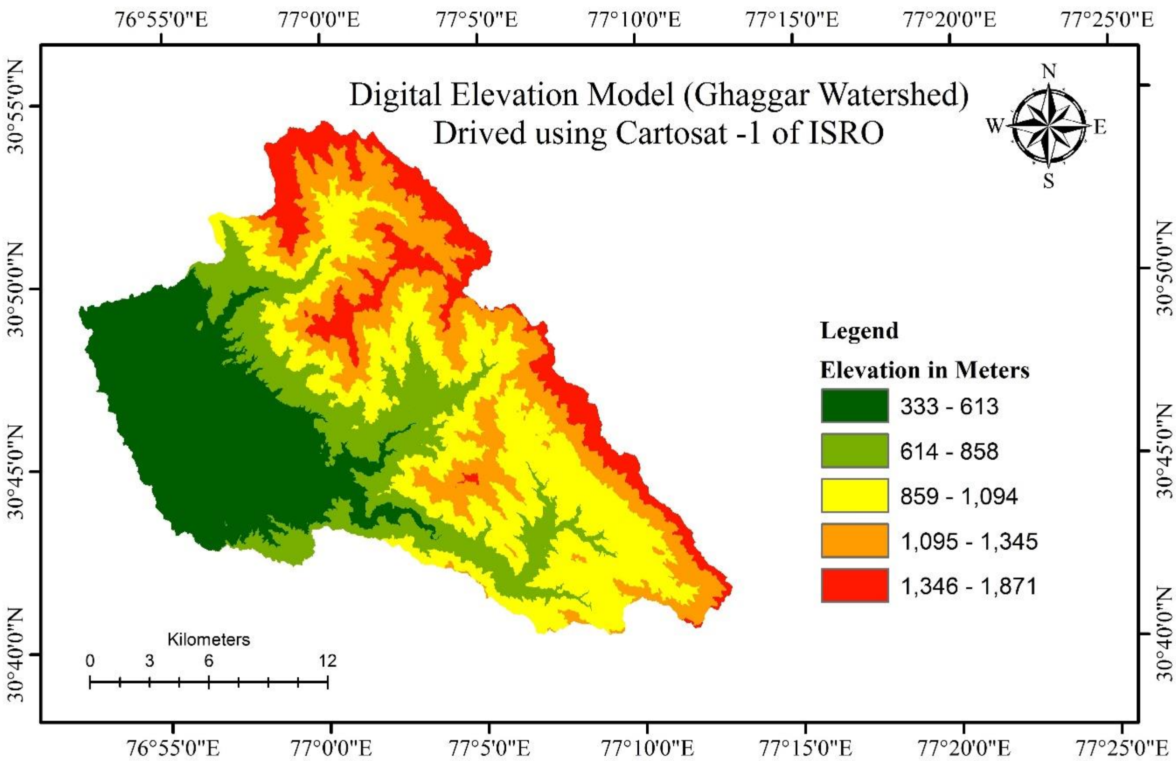

Figure 7. Elevation

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6.8 Rainfall

Average annual rainfall pattern in watershed varies from 1465 of west and 1080 is east of watershed. *(Source: CRU TS 2.1 Global Climate Database).*

The period of July to September months is of rainfall. The whole region becomes green and all the streams and springs are filled again (Dile and Srinivasan, 2014; Fuka et al., 2014). The winter season begins from October to February. Area receives heavy rainfall during monsoon. Rainfall pattern map is shown in Figure 8.

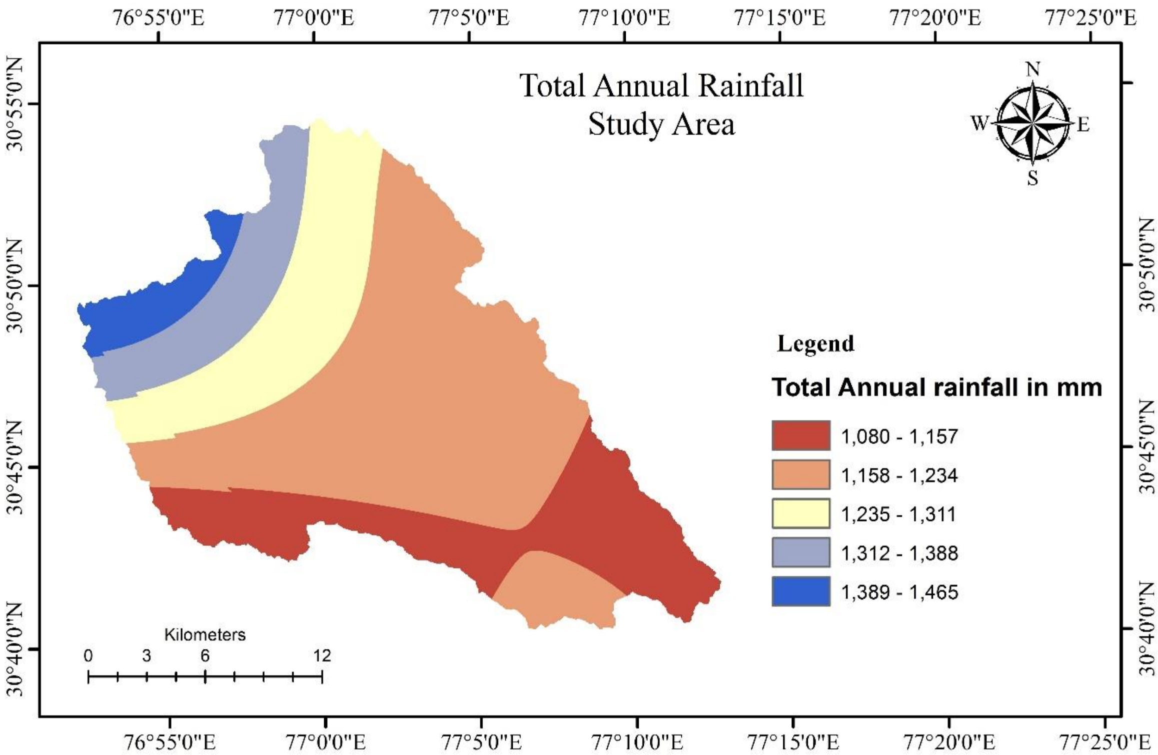

Figure 8. Rainfall pattern

7. Raster Weighted Overlay Analysis (Groundwater Analysis)

Weighted overlay is a digital cell based method for analysis a common measurement scale of values to diverse and unlike input to generate an integrated analysis. GIS problems often require the study different factors. For instance, choosing groundwater potential zones means assessing such things as geology, geomorphology, slope, water table, stream, relief and flood soil etc. The information is present in different raster layers with different value of scales in different units. Moreover, the factors in analysis might not have identical importance. It may be that the landuse is more important in groundwater than the slope (Campbell and Lehr, 1973).

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In a particular raster data layer, usually prioritize values. As example, a value of 1 represents slopes of 0 to 5 degrees, a value of 2 represents elevation of 614 to 858 meters, and a value of 5 represents slopes of 333 to 613 meters. If elevation is a criteria in finding a new site, as example, evaluation scale is from 1 to 5 by 1, give a scale value of 5 to the input value of 1, a scale value of 6 to the input value of 2 (the second most suitable elevation), and a scale value of 3 to the input value of 3 (the least suitable, steepest slope as in cells). It was decided that, all the input values greater than 1871would be assign a scale value of restriction to exclude them, If the elevation greater than 1871 meters would not be considered.

Weighted Overlay only accepts as input the integer dataset, such as a raster of soil types or land use land cover. Floating point dataset is reclassified as an integer prior it may be utilized. Usually, the values of continuous dataset are grouped into ranges, for instance elevation or slope outputs. In the Weighted Overlay analysis tool, a single value must be assign to all range prior it may be used. The Reclassify tool allows such dataset to be reclassified. The output rasters can be weighted by significance and added to create an output Raster. (Influence and Scale Values Table 1).

Table 1. Influence and scale values

Thematic layer	**Influence**	**Individual feature**	**Scale value** (Each have importance 0 to 5)
Landuse	10%	Water	5
		Low Dense Forest	1
		Dense Forest	2
		Settlements	3
		Agriculture	4
Elevation	30%	333-613	5
		614-858	4
		859-1094	3
		1095-1345	2
		1346-1871	1
Drainage Density	30%	0.15-0.58	1
		0.59-1.01	2
		1.02-1.44	3
		1.45-1.87	4
		1.88-2.29	5
Soil	10%	Alluvium	5
		Loamy	4
		Mixed Rock	1
Rainfall	20%	1080-1157mm	1
		1158-1234mm	2
		1235-1331mm	3
		1312-1338mm	4
		1389-1465mm	5

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8. Results of Groundwater Potential Zones

A groundwater potential zone, final map is dived in 5 zones namely: Zone-I as very poor, Zone-II as poor, Zone-III as Moderate, Zone-IV as Good and Zone-V as Very Good as in Figure 9 and Table 1.

Zone – I (Very Poor)

Mainly comprises of area along the Shivalik range from where the main Ghagger river originated. The area only characterised by the secondary porosity which is in the form of fracture only. Thus only groundwater in this parts of study area is expected to be present along the lineaments. Moreover groundwater difficult to tapped in zone this area have steeper slope and can be characterised as high run off zones and this have very low potential.

Areas which come under zone – I have very less possibilities of groundwater. Normally this is high altitude of 1346 to 1871 metre. This area is located at Norther part of watershed. This area covers 3km².

Zone – II (Poor)

Second zone cover area with moderate altitude of 1095 to 1345 metres and slope is 40 to 45 degree this area has stream density 0.59 to 1.01 km. This area also has hill soil. Relief is also hard. So, we can say after combining all factor zone – II also have less possibilities of water. This area covers 93 km². Extent of area is shown in Groundwater map with accurate latitude and longitude in Figure 8.

Zone – III (Moderate)

This zone is between elevations of 859 to 1094 metres. It has city like Pinjore of Haryana. This area covers 218 km². It has suitable groundwater availability for agriculture and other works.

Zone – IV (Good)

This zone has good possibilities of water with low altitude, less slope degree of slope and lowers the water table. This area covers 124km². This area has soft relief and is easily boreable.

Zone – V (Very Good)

This area has everything suitable for occurrence of good groundwater. This area covers 3km². This area is at maximum accumulation points of drainage. Altitude of this area varies between 333 to 613 metres. This area also have valley field. This is very good zone of groundwater.

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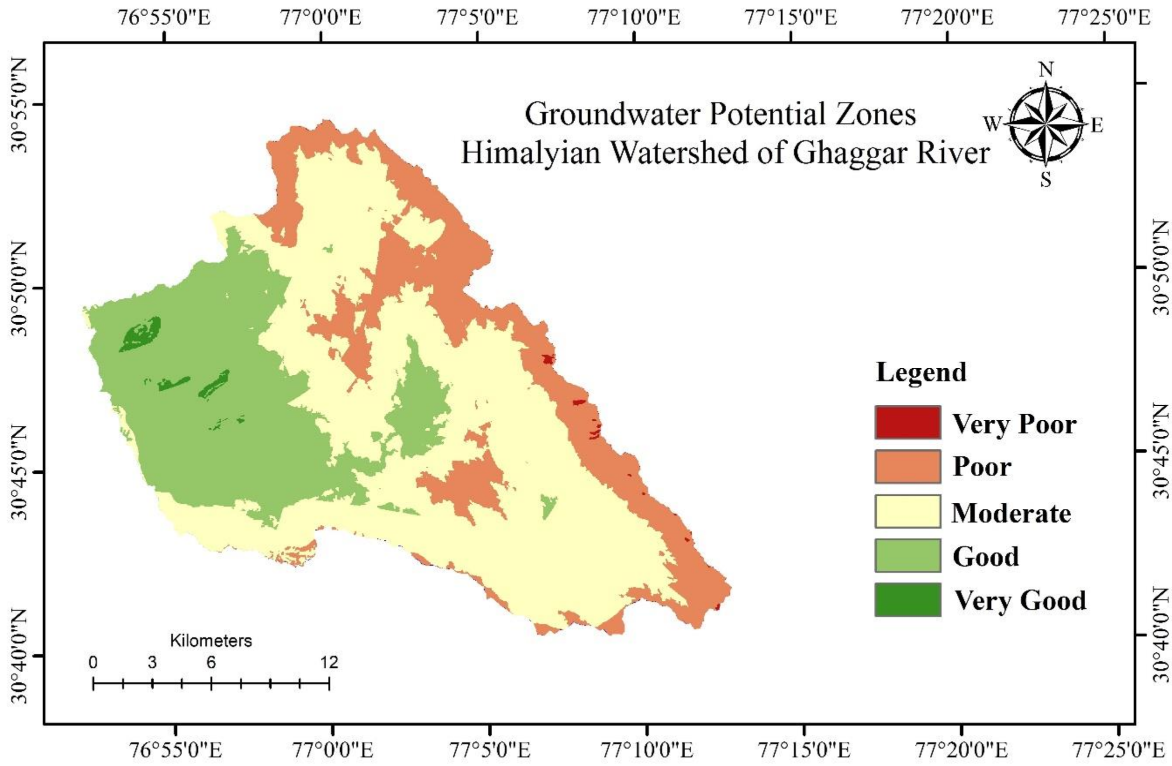

Figure 9. Groundwater potential zones

9. Conclusions

Groundwater in study area mostly find in valley fields and near main river. We cannot aspect good quality groundwater in high range of mountain even below surface of earth here is good groundwater but it is useless for human being due to not reach at bottom, because height of mountains is too much we cannot bore a well. Second main source of groundwater is alluvium plains, where river drop its materials, mostly they are flood plain in valley field. People easily bore well in area in valley field. In study area agriculture not depends on rainfall maximum farmer using electric tube well.

The study area is composed of terrain from mountain to medium height plains, too much fertile land, low population, many source of water and maximum rainfall. However a vast land is un-accessible for cultivation. In village people home are not collapse they are on some metre distance i.e. wall of one home not touch with other.

Maximum population working in Industries in this area. Largest area is cover by valley field all stream flow thru this area and Ghagger river also pass throughout this area. The entire stream collects in middle of valley field. So this area also has maximum possibilities of groundwater. On the other hand Shiwalik.

Geology of the study area is characterised by Pre-sequence of Pre-Tertiary and Tertiary groups of rocks. Pre-tertiary composes of Dhauladhar granite underlain by slates and Phillies. Seismically the area is also very active and falls in the very high damaging risk zone V of the Seismic map of India.

Whereas hill soils are found in north-western part of area, which have medium height mountain and dense forest are found in this area. The study area reveals large number of lineaments, normally a manifestation of different structural features like folds, faults and fractures. With the help of a lineament filter map, different types of lineaments were differentiated.

Remote Sensing and Geographical Information System (GIS) is used for this work all possible layer are created which are important for water.

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