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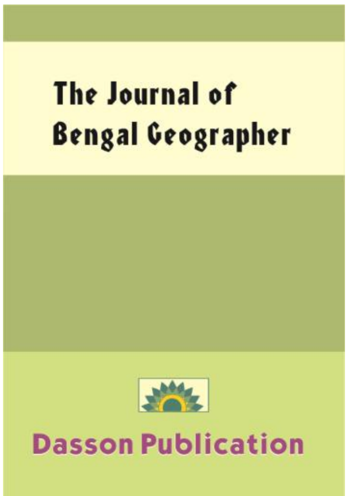

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Ground Water Potential Zone management in Rohru Community Development Block of Himachal Pradesh, India using Remote Sensing and GIS

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Abstract: *In the world of geospatial technology, characterisation of groundwater potential with the help of Remote Sensing data and Geographic Information System has become a breakthrough for ground water management. In the present Study a GIS based physical resource database was constructed to have physical based information of the Rohru Community Development Block and out of that resource base an attempt have been made to find out the ground water potential in the Rohru Community Development Block, Shimla, Himachal Pradesh, India, with an aerial extent of 305.57 km^2. Thematic maps such as geomorphology, geology, soil, drainage, land use and land cover and slope have been used to access ground water potential zone of the study area. High resolution 12.5 meter DEM (ALOS PALSARA DEM) was used to generate Slope layer. All thematic layers influencing ground water potential have been analysed and overlaid using GIS based overlay analysis. Final outcome of ground water potential have been categorised into five different ground water potential category viz., very high, high, moderate, low and very low potential for ground water. The study shell be useful for further planning and can be used as quick guide for further studies.*

Keywords: *Geospatial technology, Geographic Information system, Ground water potential, Remote sensing*

Introduction

Land and water are two importantresources for human progression. These resources are essential requirements for their social wellbeing and economic progression. (Jain, 1998; Das and Gupra 2018; Das 2017).Groundwater is also one of the most important portable water supplies for both rural and urban duelling (Sar *et al*. 2015). It provides water for various sectors like agricultural, industrial and domestic purposes (Agrawal*et al.* 2013). During last few decades, scarcity water has been observed by most of the country in the world. In India situation is more precarious as every year many people lost their lives because of water scarcity. It has been seen that there is significant spatial imbalance in the demand and availability of water resource available.

The groundwater at any place is the interaction of climatic, geological, hydrological, physiological and ecological factors, so it is important to locate correct influencing indicators and evidences which affect ground water (Antony *et al.* 2012;Biswas *et al.* 2012). Geological structure and its characteristics play an important role in ground water potential of any area. Over these geological stricter geomorphic feature act as additional elements which together controls water permeability and porosity. The slope, vegetation, soil lineaments and drainage, they all together influence the ground water of any area. Like higher the drainage density higher will be the water run-off and lower will be water potential. Overall it can be said that hydro-geomorphic feature plays an important role in ground water recharge. Geospatial techniques like Remote Sensing and Geographic Information System is one the most efficient tool which can be used for such analytical studies like delineate of ground water potential in any region (Muthamilselvan 2017; Waikar and Nilawar 2014; Rajkamal*et al.* 2014). Various studies in the field have been done by different researches using Remote Sensing and GIS like (Jain, 1998; Das and Gupra 2018; Das, 2017; Muthamilselvan 2017; Waikar and Nilawar 2014; Rajkamal*et al.* 2014;Antony *et al.* 2012;Biswas *et al.* 2012; Reddy *et al.* 2000).

Himachal Pradesh is a mountainous state and the abode of many rivers that originate here yet it is facing water scarcity due to terrain and hard rocks in most of the district of state which results in low ground water potential (Government of India, Ministry of Water Resources,Central Ground Water Board. 2013). Even in villages most of natural water sources are vanishing due to fall down in ground water. It is essential to develop a suitable ground water management schemes for the proper utilization of groundwater. Hence before developing a proper management of groundwater it is important to delineate groundwater potential zone. In the present study an attempt has been made to delineate ground water potential zone using information from village information system and geospatial techniques.

Study Area

The study area constitutes Rohru Tehsil and Tikar Sub-Tehsil of Shimla district of Himachal Pradesh. This area is situated in the eastern part of the district Shimla. The study area lies between 31º6′39″ and 31º17′32″ N and 77º40′15″ and 77º55′35″ E. The eastern parts of the study area share the boundary with Chirgaon Block. The western boundary is formed by Kotkhai Block of district Shimla. In the north part, it makes boundary with Nankhari and Rampur block and in the southern part it share boundary with Jubbal block of district Shimla. Community Block Rohru spread over the area of approximately 324 sq. km. Rohru block of Shimla district (Himachal Pradesh) comprises eastern part of Shimla district and fall in lesser Himalayan region. Rohru community block covers south eastern part of Shimla which is a water divide of two major river system of India. This area has complex physiographic mosaic of hilly valleys and snow clad peaks. The relief of this area ranging between minimum of1378 meters to maximum of 3409 meters. This area is drained by Sai Khad and Dogra khad that are tributaries of Pabar River. Pabbar River drains the Rohru region and it rises from Chandra Nahan north of Rohru and joins Tons river near Uttaranchal-Himachal Pradesh border. The study area has total 188 number of villages out of which 170 are inhabited and 18 villages are uninhabited. Rohru community development block have total 12,480 households. Total population of the study area is 56,421 people out of which 29.050 are male population and 27.371 are female population (Fig 3).

Objective

- ❖ To assess and demarcate ground water potential zone through various thematic maps of Community Development Block Rohru.

Methodology

To demarcate the ground water potential zones in the study area, different thematic maps such as Slope, Drainage (Drainage Density), Lineaments (Lineaments Density), Geomorphology, Land use / land cover and Geology have been prepared using database from different sources (Fig.1). The base map is prepared using Survey of India Topographic sheet (53E-10, 53E-11, 53E-15 and 53E-16 geo-coded with UTM projection and datum WGS 1984) on 1:50,000 scale. The thematic maps were overplayed and Weighted Vector Overlay Analysis has been incorporated in order to find out the ground water potential areas.The suitability maps have been ranked and grouped in order to identify the zones that for best areas of ground water potential. Because of the different scales on which the criteria are measured, multi criteria equalization (MCE) method is used that the values contained in the criterion map are converted into comparable units. Maps are re-classed into three comparable units i.e. suitability classes namely; 3 {(high suitability), 2 (medium suitability), and 1 (low suitability)}. The suitability classes then have been used as base to generate the criteria maps (one for each criterion). Figure 1 and Figure 2 shows the methodological flowchart of the study area and GIS based model run in ArcGIS model builder to get final output.

Model Builder application in ArcGIS is used to create models for the current study. Models are workflows that string together sequences of geo-processing tools, feeding the output of one tool into another tool as input. Figure 2 shows the model and different sequences of process. The effect of each influencing factor may contribute to delineate the groundwater potential zones. Moreover, these factors are interdependent.

Table 1:

Data used in present study

Sr.No.	DATA TYPE	SCALE/RESOLUTION	SOURCE
1	Survey of India Topographic sheet	1:50000	Survey of India
2	ALOS PALSARA DEM	12.5 Meter	http:search.asf.alaska.edu/
3	Google Earth Images		Google Earth Online portal

4	Lithology map	1:50000	Geological Survey of India
5	Geomorphology and Lineaments	1:2,50,000	Geological Survey of India
6	India Administrative boundary	1:50000	Census

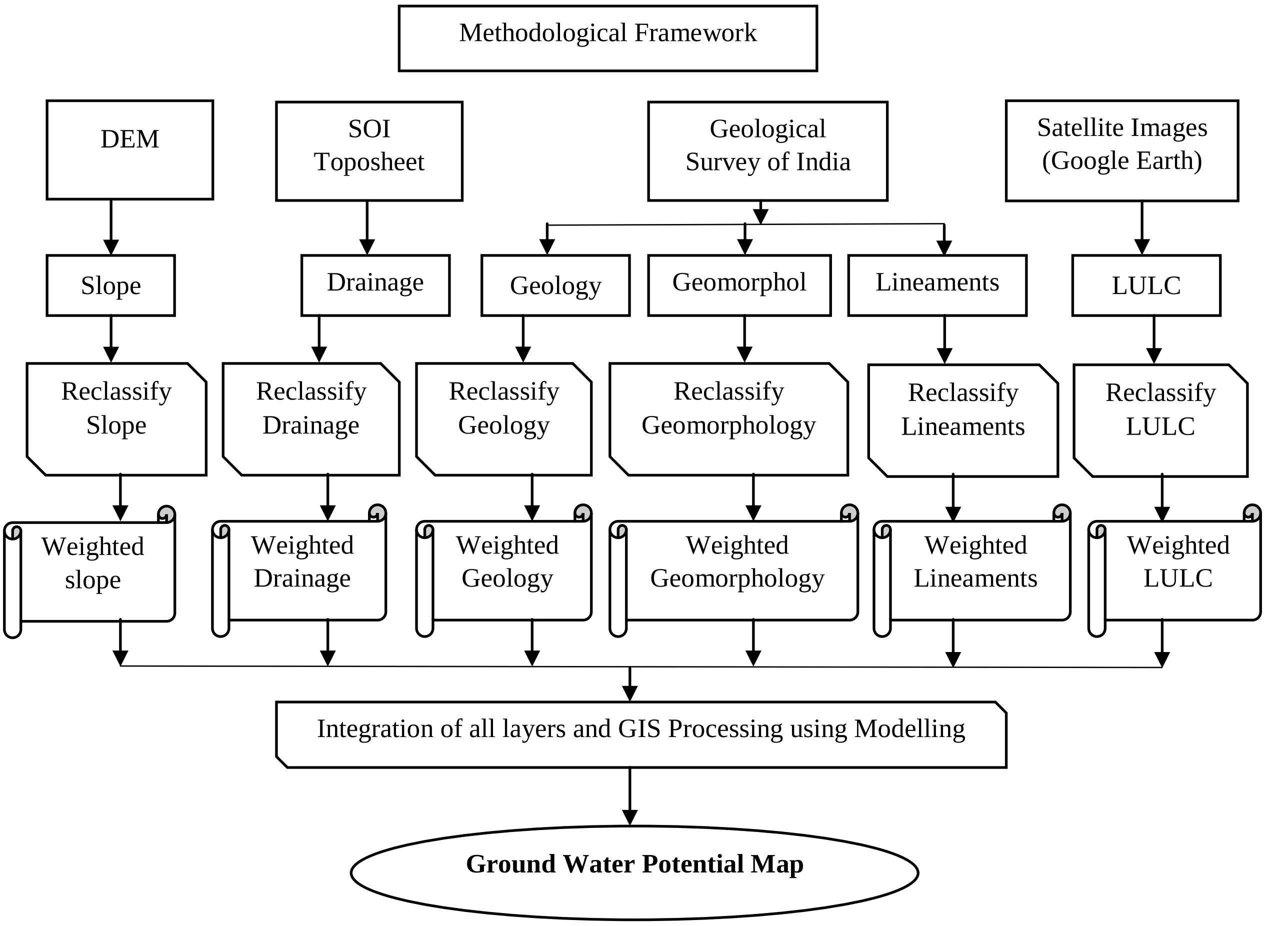


Figure 1

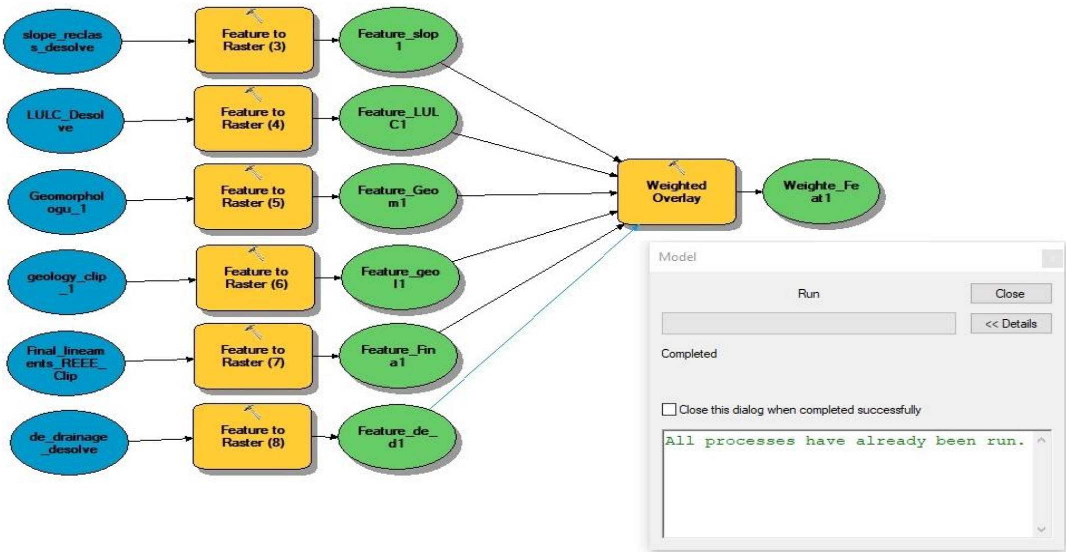


Figure 2

Result and Discussion

Different criteria for different layers have been used for the current study and different layers have given weight according to their importance towards ground water potential. Table 2 shows the different criteria taken for the final overlay output and weight given to particular layer.

Table II:
Criteria for identifying Ground water potential zone

Sr No	Criteria	Classes	Weight
1	**Geomorphology**	Water Body, Flood Plain, Sedimentary plain	3
		Buried piedmonts (shallow, deep)	2
		Penment complex	1
2	**Geology**	(Jutogh Formation) (Proterozoic Era)	1
3	**LULC**	Water Body, River bed	3
		Agricultural land and Plantation	2
		Dense Forest, Open forest, Scrub land, Grass land, Fallow land and Built-up land,	1
4	**Lineaments Density**	High density (1.08–2.96 km^2)	3
		Moderate density (0.37–1.08 km^2	2
		Low density (0–0.37 km^2)	1
5	**Slope**	Below 5	3
		5 – 20	2
		Above 20	1
6	**Drainage density**	Low density (0–0.75 km-1)	3
		Moderate density (0.75–2.39 km-1)	2
		High density (2.39–5.08 km-1)	1

Slope

Slope is an important factor for the identification of ground water potential zones. High degree of slope result in rapid surface runoff and an increased erosional rate with feeble recharge potential (Rokade *et al.* 2007; Magesh *et al.* 2012;Gumma and Pavelic 2012; Selvam *et al*. 2012, Das. 2017; Lokesha *et al*. 2005). Areas having gentle slope will have low water runoff and high water percolation while areas having high degree of slope resist to water percolation due to high runoff. Areas having slope less than 5 degree classified into higher potential for water due to the nearly flat terrain and relatively high infiltration rate. Slope between 5 to 20 degree classified under moderate category and covers only 6.07 sq. km of the total geographical area of Rohru block.Areas having sloped higher than 20 degree are kept under low water potential areas and covers 243.33 sq. km. of total area (Fig. 3).

Drainage Density

Rohru block falls under Pubber sub-watershed of Tons watershed of Yamuna catchment. It falls in the western part of the Pubber sub-watershed. The drainage pattern observed in the study area is dendritic in nature. Drainage is digitized using Survey of India topographic sheet no 53E-11, 53E-12, 53E-15 and 53E-16. Drainage helps to delineate micro-watershed. Drainage network helps in the identification of watersheds and three micro watersheds have been identified in the study area. For calculating drainage density line density tool of ArcGIS have been used. Drainage density has a positive relation with water runoff and inverse relation with water permeability. Higher the drainage density in any area higher will be water runoff and lower will be the drainage density higher lower will be water runoff. Lower drainage density will allow more water to percolate and improve underground water. Drainage density suggests various water harvesting structures and soil conservation measures. Since the drainage density can indirectly indicate the ground water potential of an area due to its relation to surface run-off and permeability, it was considered as one of the indicator of ground water occurrence. The drainage pattern of the study area is dendritic in nature and the drainage density is moderate which flows on a homogenous rock type, which is volcanic (Fig.5).

Land Use and Land Cover

Land is a dynamic canvas on which human and natural systems interact (Dawn *et al.* 2003). Land-use activity contributes to climate change, and changes in land-cover patterns are one way in which the effects of climate change are expressed (Dale 1997). Land use land cover is also one of the parameters which control the occurrence and development of groundwater (Patle and Awasthi 2019).Land use involves the management regime humans impose on a site and modification of natural environment or wilderness into built environment such as settlements and semi-natural habitats. It also has been defined as "the total of arrangements, activities, and inputs that people undertake in a certain land cover type. Land cover is the physical material at the surface of the earth and is the descriptor of the status of the vegetation at a site. Ten different type of land use and land cover type have been identified in the study area as; agriculture land, planation land, dense forest, open forest, shrubs, grass land, built up (roads and settlement), waste land, river bed and water body. Agriculture including horticulture is the prime activity in the study area. Agricultural land and horticultural plantation area together covers of near about half of the total geographical area 138.04 sq. km. (45.59 %). Forest are covers both dense forest and open forest. Dense forest and open forest both accounts for 37.31 % (112.97 sq. km.), wasteland account for 14.51 % (40.93 sq.km.) and built up account for 2.29 % of study area (Fig. 6).

Geomorphology

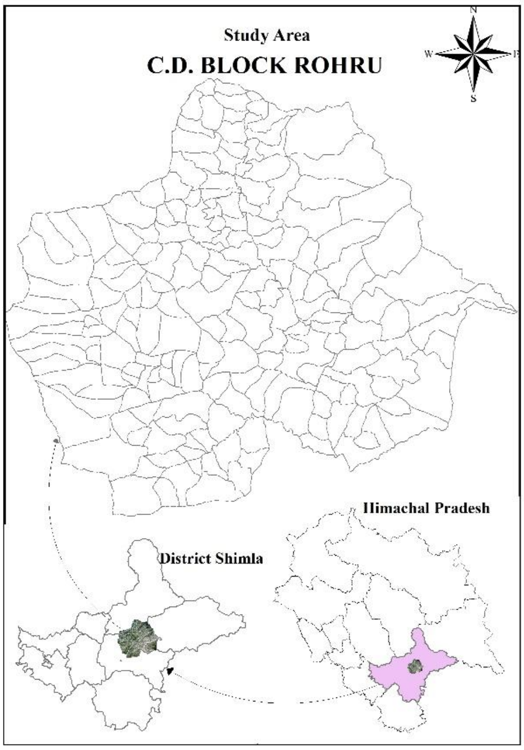
The relationship between geomorphic feature and lineaments help in delineating the recharge and discharge sites (Jain 1998). So it is important to study landform and geomorphic features in the study area for characterization of ground water potential. Some of these features are good for ground water recharge. Different type of geomorphic feature has been identified in the study area. Moderately dissected hills and valley, highly dissected hills and valley, flood plains, alluvial plain and water body. Highly dissected and moderately dissected hills and valley covers 96 % of the study areas and most of parts except flat river bed and old alluvial plane belt in the study area. These areas exhibit high degree of slope and have high drainage density. These areas have poor potential for water recharge. Low lying flood plain, water body andflat valleys cover only 4 % of the study area. These areas have high potential for ground water recharge. Soil in these areas belongs to coarse-loamy to fine-loamy having higher depth and fine texture which also have higher potential of water holding (Fig 7).

Geology

It is a well-established fact that geological set up ofan area plays a vital role in the distribution and occurrence of groundwater (Krishnamurthy and Srinivas 1995: Kumar *et al.* 2008). The geological setup of the study area is very complex dominated by igneous and sedimentary rocks. Metamorphic rocks are also found at some places of the study area. Geological layer have been taken from the Geological Survey of India map of 1:2,50,000 scale published by Geological Survey of India Hyderabad. Figure 8 shows the spatial distribution of different geological structure in Rohru Block. Rocks of Rohru block is mainly of Jutogh Group formed in Undifferentiated Proterozoic era. These older rocks are devoid of any primary porosity. Secondary porosity (fracture & fissure) in these rocks, topographical set up coupled with precipitation in the form ofrain and snow, mainly govern occurrence and movement of ground water and formaquifers of low yield prospect. In the terrace deposits along the major rivers, porespaces between sand, gravel and talus material also form the avenue for ground watermovement. Ground water potential in such areas is very low due to its hydro-geomorphic set up (Govt. of India. Ministry of Water resource. Central Ground water board. 2013) (Fig.8).

Lineaments Density

A lineament is defined as a large scale linear structural feature. Such features may represent deep seated faults, master fractures and joints sets, drainage lines and boundary lines of Different rock formations (Kumar*et al.* 2008). Lineaments provide the pathways for groundwater movement and are hydro-geologically very important (Sankar 2002). Lineaments density have been calculated using lineaments layer downloaded from bhukosh Geological Survey of India portal. Line density tool is used to generate drainage density. Higher will the lineaments density high fracture and joints in any region providing opening for water percolation. Lineament Density more than1.08 km^2 is categorised as good areas for ground water potential. And areas with drainage density lesser than 0.75 km^2 is categorised under areas having low potential for ground water potential (Table 2) (Fig. 9).



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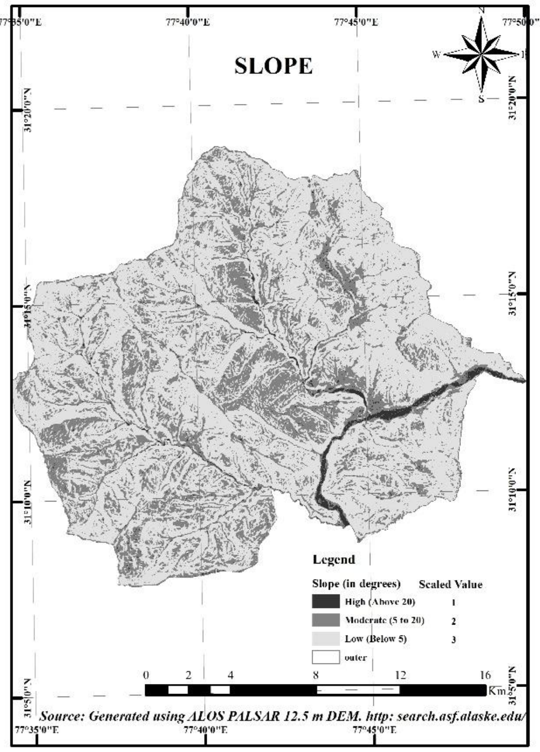

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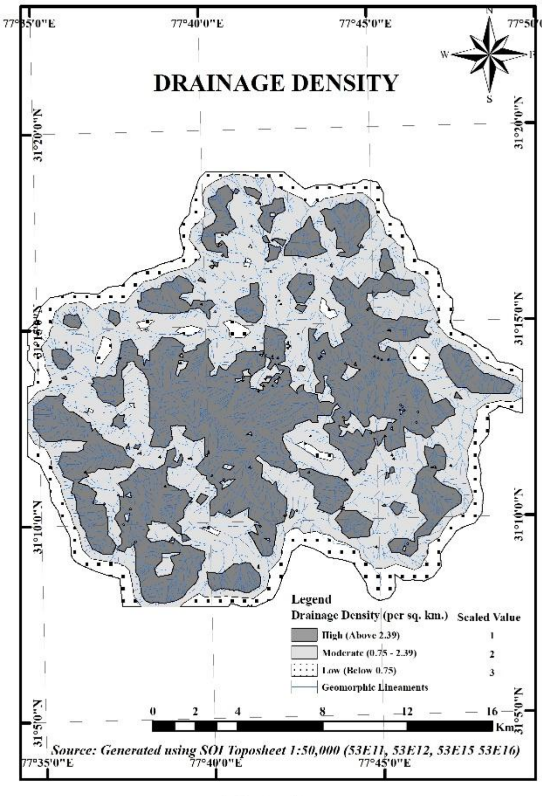

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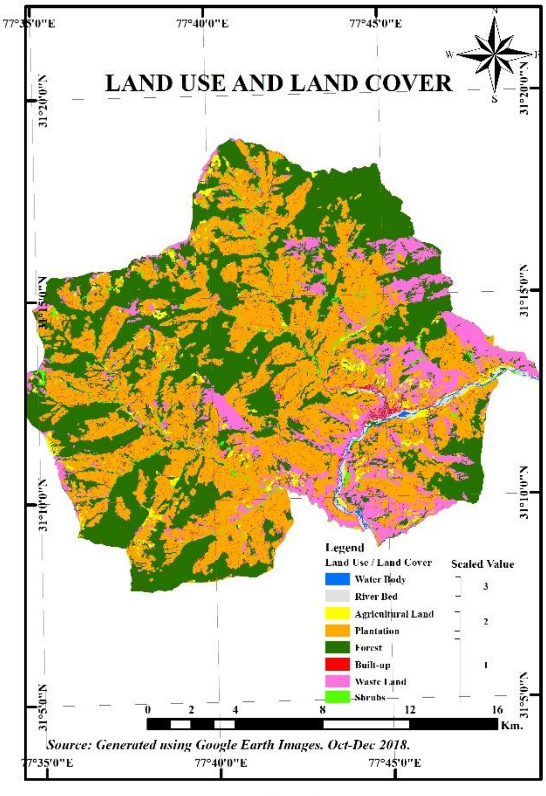

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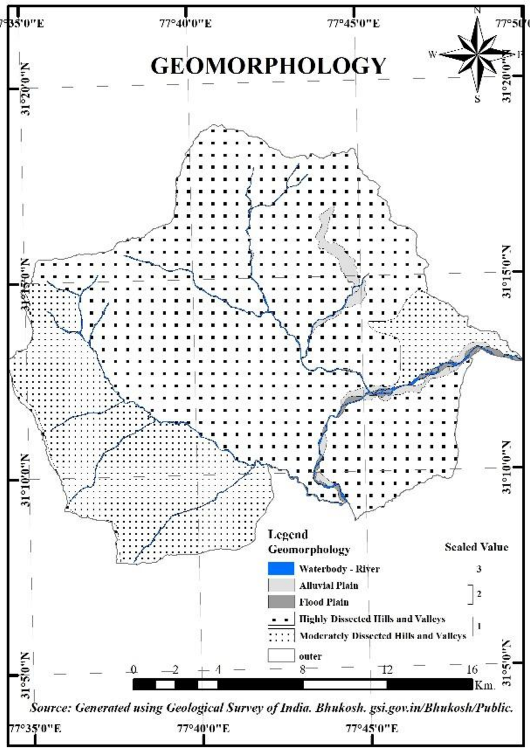

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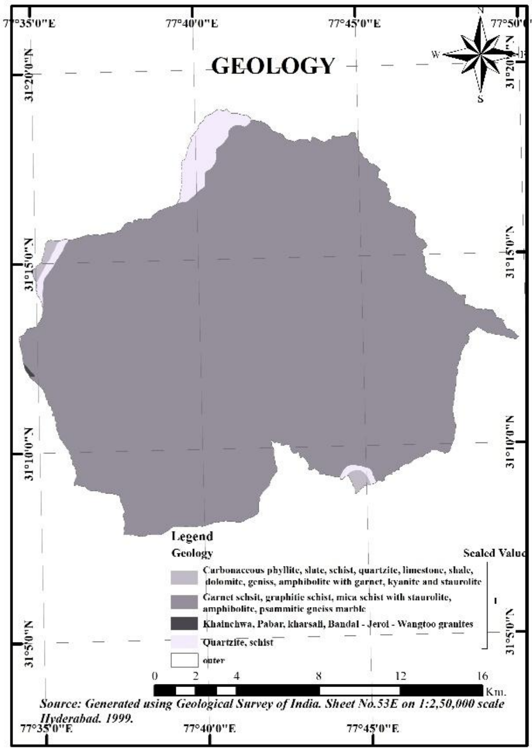

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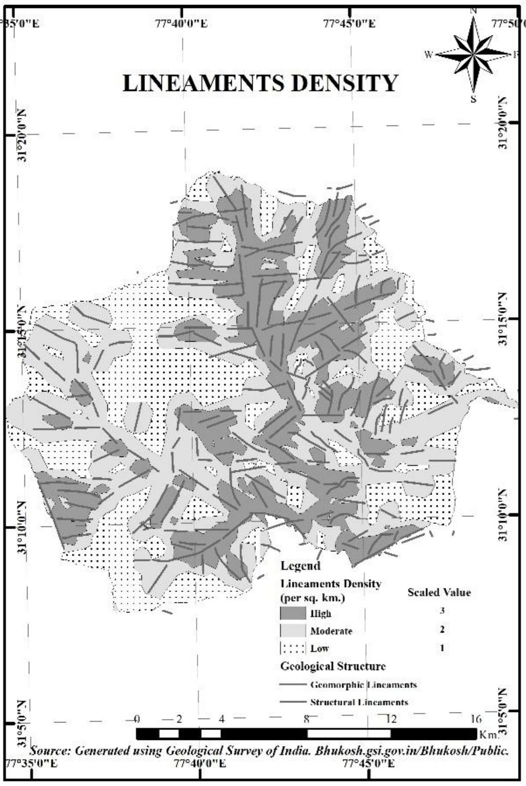

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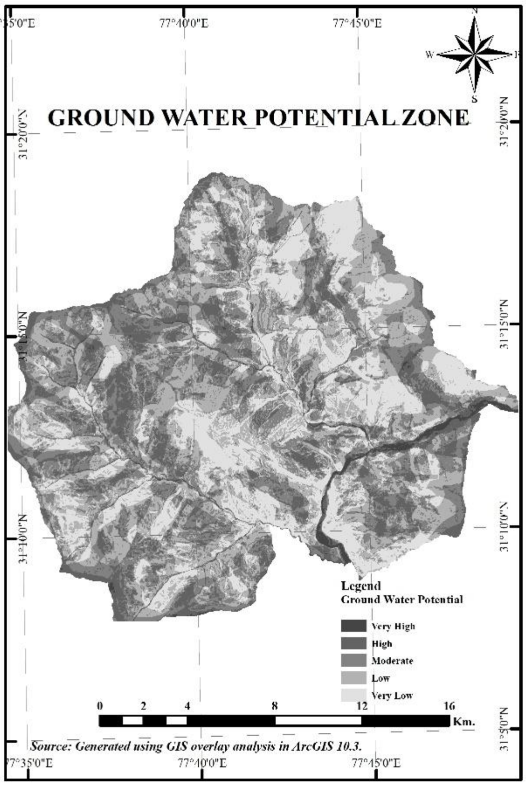

Figure 10

Ground Water Potential Zone

The study identified major factors influencing ground water potential, namely, elevation/slope, geomorphology, lineaments, landuse / land cover, drainage density and lithology. Drainage density, lineaments density, geology, geomorphology, slope and land use / land cover layer and overlaid and final output is generated. The resultant intersected areas are marked as potential zone in the study area map (fig. 10). The lineaments and hard rocks can store surplus amount of water and the analysis of the different parameters have clearly brought out the ground water potential zone in the study area.

Areas with very high ground water potential have been witnessed only in 4.47 sq. km. that accounts of only 1.48 % of the total geographical area of the study area. Figure 2.15 shows that the upper region of Dogra Khad bed, Shikdi Khad bed and Pubber River bed of Rohruregion have very high water potential. The majority of the areas with very high to high suitability have slopes between 2 to 8% and with an intensively cultivated land cover at some places. The major soil type in the very high suitable area is loamy and coarse loamy with fine and medium texture, have deep soil and very high drainage density (Fig. 10).

A small proportion of 2.49 % of the study area has been witnessed in high water potential zone category. The spatial distribution of the suitability map shows that River bed of Pubber river in southern, southeaster region and low lying area along the river bed of Dogra and Shikdi Khad have shown high site for good water potential. The majority of the areas with high potential have slopes between 2º and 5º and with mostly wasteland and shrubs region. The major soil type in the very high suitable area is loamy skeletal and coarse loamy with fine and medium texture and have medium deep and deep soil with very high drainage density (Fig. 10). The study reveals that one fourth of the study areas have moderate potential for ground water. These areas are distributed in the western, south-western, southern, south-eastern and in small patches on northeaster part of the study area. These areas have moderate to high drainage density relatively higher slope. Coarse loamy, loamy-skeletal and sandy-skeletal soil with medium texture, soil with medium depth and highly dissected hills to moderately dissected hills characteristics have been witnessed in these areas (Fig. 10).

A very high proportion about 51.21 % of the study area has been witnessed under low suitability for ground water potential. Figure 2.15 shows that these areas are distributed all over the study areas. Brooder river valleys and moderately sloppy hills on northern, northeaster, south-eastern, south-western, western and north-western part of study area have relatively low potential for water potential (Fig. 10). Around one fifth of the area total geographical area of Rohru development block have witnessed very low/poor suitability for the ground water potential in the study area. This area covers the central, north-eastern and south-eastern of study area. These areas have relatively higher slope, low vegetation cover, high drainage density. Soil of this area has coarse loamy and sandy skeletal texture with shallow and medium deep soil. Geomorphological these areas have witnessed highly dissected hills to moderately dissected hills characteristics (Fig.10).

Conclusions

Delineation of ground water potential zone using Geospatial techniques and information from village information system are found to be effective and efficient to minimize the time, labour and money and provide quick decision-making for sustainable water resources management. Data pertaining to the study area collected from different sources stacked together with their relevance to groundwater potential provide a final output in the form of different potential zones. Hydro-geomorphologic, geological and topographical elements layers like drainage density, geomorphology, geology, lineaments density, land use/ land cover and slope layers used in the study to identify ground water potential in the study area. The results of the present study can help planners and serve as a guide for future planning. It can help the planner as a guide for drawing a suitable plan for ground water development at local and micro-level. This further can be used for micro-watershed planning and ground water recharge by constructing micro level check dams.

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