International Journal of Geology, Earth & Environmental Sciences ISSN: 2277-2081 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jgee.htm
2015 Vol. 5 (3) September-December, pp. 1-10/Ankana and Kumar
Research Article

REMOTE SENSING AND GIS APPLICATION IN GROUND WATER RESOURCES IDENTIFICATION AND MAPPING: A CASE STUDY OF CHAKIA TAHSIL, CHANDAULI, UTTAR PRADESH

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ABSTRACT
Surface water and ground water are the two major domains where human being fulfills his needs of water, but ground water is a subsurface phenomenon. Hence, its identification, delineation, mapping requires other secondary sources of information like land use/land cover, geomorphology, drainage, slope, lineaments, soil, etc. Remote sensing and geographic information system has undoubtedly provided a solid platform for information and so helps in targeting the ground water prospects in the area of interest. The present study takes into account of hydro-geo-morphological features, slope, drainage, lineaments and land use/land cover in ground water targeting and their mapping. This study also highlights the ground water potential of the study region through GIS mapping that may be further utilize for planning purpose of utility of ground water resources.

Keywords: *Hydrogeomorphology, Land-Use/Land Cover, Lineament, Groundwater Potential, Slope, Lithology, Remote Sensing*

INTRODUCTION
Integrated approach of remote sensing and Geographic Information System (GIS) has considered as a quite powerful tool in identification, delineation, mapping, modeling and conservation of ground water resources. Ground water and surface water are the two reservoirs mostly used by man. Fresh ground water is about 100 times more plentiful than fresh surface water, but we use more surface water because it is so easy to find and use (Fitts, 2013). Geological structure and geomorphological aspects are the major controlling factors of groundwater storage, occurrences and movement in hard rock terrain. These features can be identified through satellite remote sensing (Boutaleb *et al.*, 2008). Hydrogeomorphological features largely influence the ground water occurrences. In the hard rock terrain, lineament is the most important structural feature through which ground water zones can be targeted. With the use of visual image interpretation techniques and image elements like tone, texture, color, pattern etc, lineaments can be easily identified on the imagery while they are not visible by naked eyes in the field. As the ground water occurrences is a subsurface phenomenon, so their identification and delineation are done on the basis of secondary sources like land use/ land cover, geomorphology, lineaments, soil, lihology etc. The present case aim is to identify and delineating the ground water prospects by analyzing hydrogeomorphic features, land use and land cover (LU/LC), slope, drainage and lineament study. This study also aims to observe the ground water fluctuation occurring in the region due to existing hydrogeomorphological features.

Aim and Objectives
The main aim is to monitor the water table fluctuation in pre and post monsoon periods and to identify and mapping the groundwater potential zones in Chakia tahsil, Chandauli District. The specific objectives are,

- To preparation of thematic maps of lineament and lineament density, hydrogeomorphology, land use/land cover, slope and drainage;
- To observe the water table fluctuation by using pre-monsoon and post-monsoon water table; and,
- To preparation of ground water potential map based on findings of above prepared thematic maps and data.

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MATERIALS AND METHODS

Database and Methodology

The study is based on the information derived from the data sources like topographical sheets (Survey of India) and satellite data of IRS P6, LISS-III (2014) obtained from NRSC, Hyderabad. The visual image interpretation technique has been applied for the identification and delineation of objects of interest in various different thematic maps. Linear contrast image enhancement technique has been applied in the case of lineament. The digital file of lineament was again brought into the grid of 1×1 Sq Km. Length of lineaments per unit has been calculated and isopleths were drawn and accordingly lineament density was classified. Hydrogeomorphological features were delineated by using again visual image interpretation technique and kept into two major categories, namely, alluvial plain and Vindhyan upland. For LU/LC, supervised classification using maximum likelihood classifier is done for the LU/LC categories of urban, rural, dense forest, open forest, scrub forest, water bodies, sandy/rocky waste, fallow land and cropland.

Slope map was generated under GIS environment, whereas drainage map was prepared by digitizing the drainage using SOI toposheets 630/4, 630/8, 63P/1, 63P/2, 63P/5, 63P/6 at a scale of 1:50,000.

Finally, all the thematic layers were integrated and the total factor scores for each pixel were calculated through raster addition process in Spatial analyst extension of ArcGIS 9.3. Based on the derived scores, the final integrated map was classified into five categories of groundwater prospect zones as (i) Very good (ii) Good (iii) Moderate (iv) Moderately Poor and (v) Poor.

Study Area

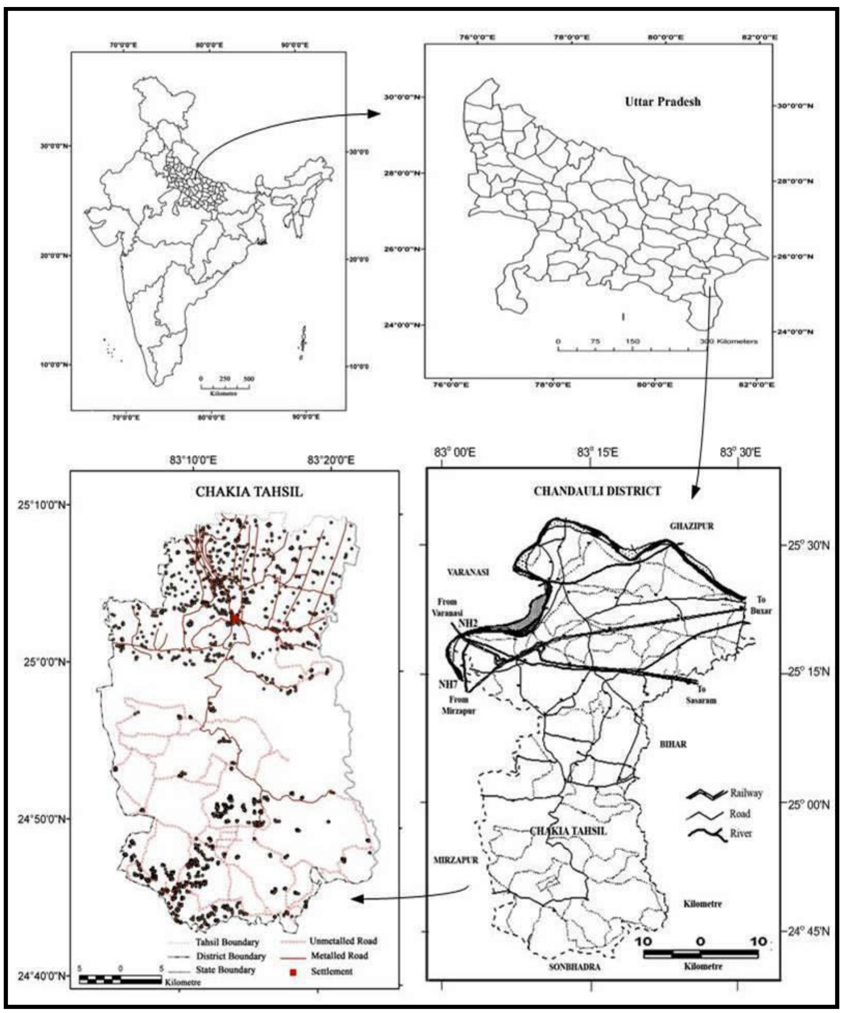

Figure 1: Location Map of Study Area

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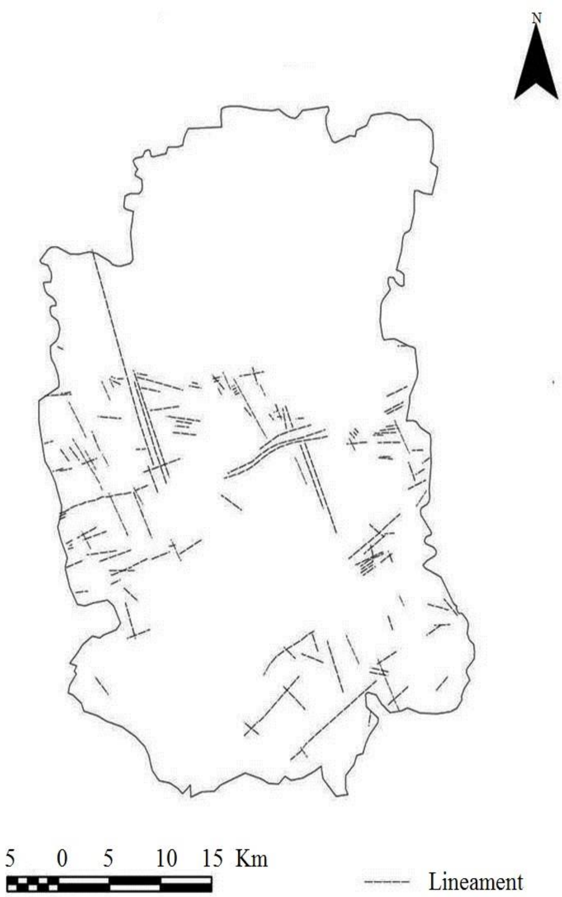
Chakia Tahsil of Chandauli District (Uttar Pradesh) is the study area of the present case. This region imbibes the two contrasting features, namely, Alluvial plain in the north and Vindhyan upland in the south. The region extends between 24º 4' N to 25º 3' N and 83º 3' E to 83º 24' E (Figure 1).
Geologically, alluvial plain shows the sediments of Quaternary age, including sand, silt and clay, whereas the Vindhyan Super group consists of a stratified unmetamorphosed group of rocks, presented by sandstone, shale, sandoquartizite and limestone. This region is characterized by '*monsoon*' with seasonal variations in the weather. The soil of alluvial plain has consisted of sandy, sandy loam or clay loam. These soils are deep to moderately deep and well drained. The soil of Vindhyan plateau, are characterized by sandy loam with stones. These soils are associated with moderate erosion, moderately well drained and lying on gentle slopes.

RESULTS AND DISCUSSION

Lineament

Lineament mapping was used long before this work in other geological applications and the first usage of the term lineament in geology is probably from a paper by Hobbs (1904, 1912). This was later used by O' Leary *et al.,* (1976) as a basis for developed definitions. Lineaments have been defined as extended mappable linear or curvilinear features of a surface whose parts align in straight or nearly straight relationships that may be the expression of folds, fractures or faults in the subsurface. This interest has grown most rapidly in geological studies since the introduction of aerial photographs and satellite images. The studies revealed a close relationship between lineaments and groundwater flow and yield (Mabee *et al.*, 1994; Magowe and Carr, 1999; Fernandes and Rudolph, 2001, Prabhu and Rajgopalan, 2013).



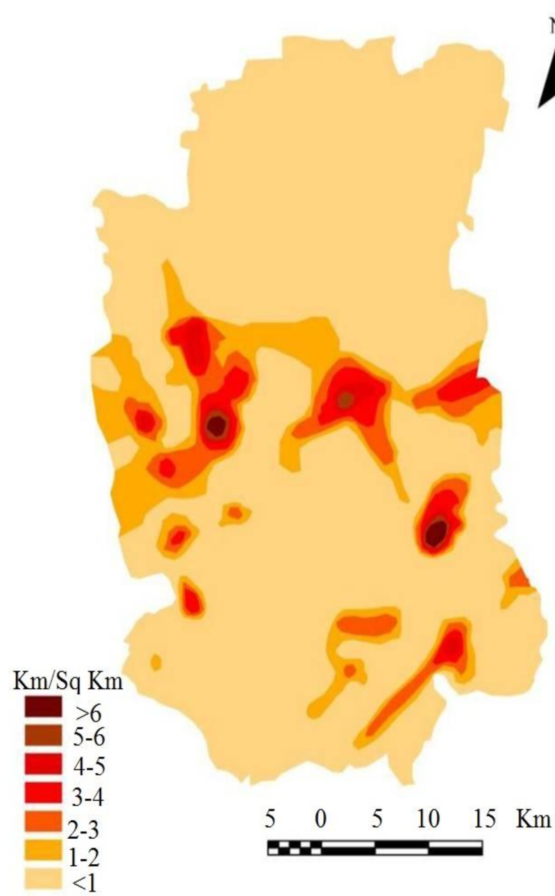


Figure 2: Lineament Based on IRS P6, LISS-III **Figure 3: Lineament Density**
Figure 2 and 3: Chakia Tahsil

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Figures 2 and 3 reveals that middle scrap zone of the area reflects zone of high lineament density. Northern portion reflects the very low lineament density. Southern portion exhibits some patches of high lineament density.

We can expect ground water potentiality good in areas of high lineament density. In hard rock areas, the surface water enters below the surface/subsurface through these lineaments and because of such facts, the junctions of lineament intersection prove very promising for rich aquifer.

Hydrogeomorphology

The Hydrogeomorphology is the specific description of applied geomorphology that includes three interrelated themes (hydro+geo+morpho). Hydro means water, including both surface and ground water; Geo-means the earth (lithology) and morphology expresses the features in the form of land forms.

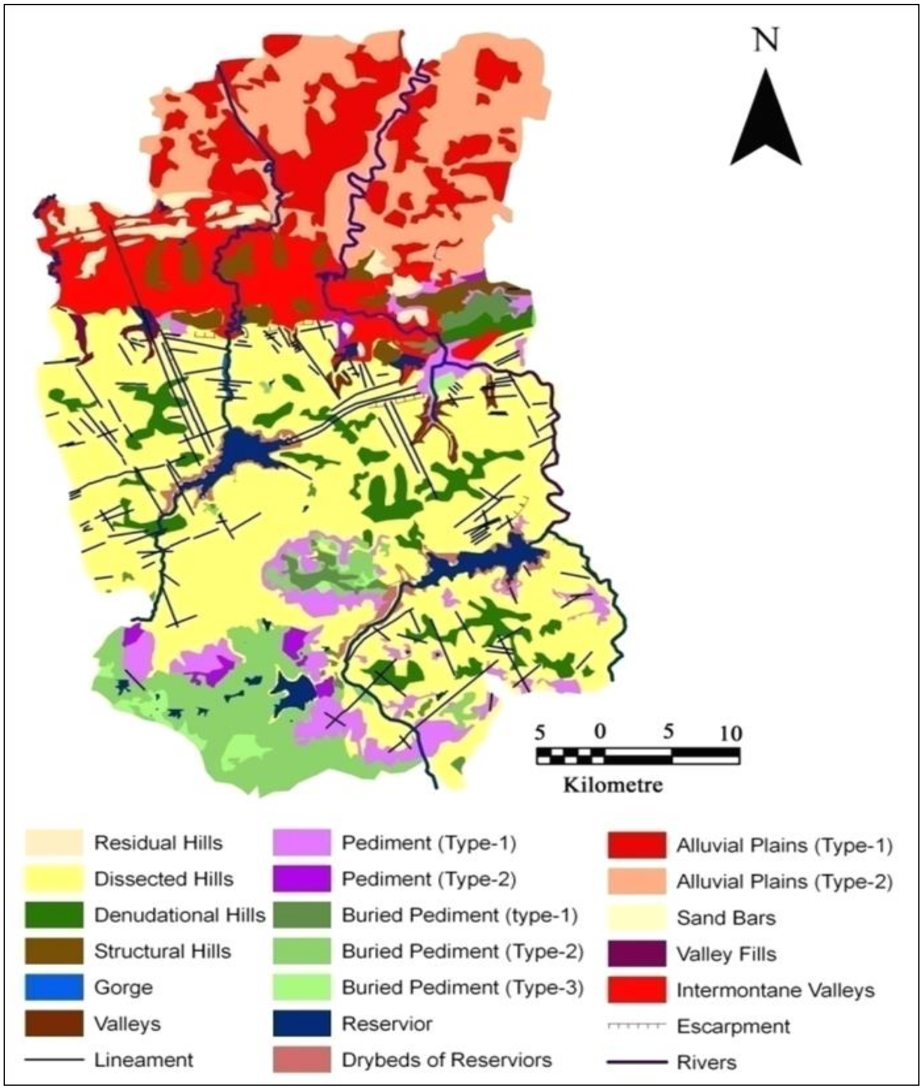

Figure 4: Chakia Tahsil, Hydrogeomorphic features

Figure 4 shows delineated hydrogeomorphic features and Table 1 describes ground water prospects with the image description. Alluvial plain, intermontanne valley, buried pediment and valley fills indicates a good scope for ground water potential, whereas hydrogeomorphic features like pediments, dissected plateau, structural hills, denudational hills and residual hills in the region offers moderate to very poor ground water prospects.

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Table 1: General Characteristic of Hydrogeomorphic Features and Ground Water Prospect

S. No.	Hydrogeomorphic Unit	Image Description	Lithology	Ground Water Prospect
1	**Alluvial Plain**	Light to dark red tone with coarse to smooth texture,	Sand, silt, clay	Excellent
2	**Intermountanne Valley**	Medium red tone with patches of dark red tone, Coarse texture, Identified as depression between escarpment and residual hills	Colluvial deposit of varying lithology	Good to Moderate
3	**Pediment**	Light to moderate greenish tone, Characterized by scrub	Thin soil cover	Poor to very poor
4	**Buried Pediment**	Weathered material, good cultivation	Weathered rock, alluvial/colluvial materials	Good to Moderate
5	**Valley fill**	Medium to smooth texture	Gravel, sand, silt and alluvium	Good to excellent
6	**Dissected Plateau**	Marked various lineaments, covered with dense and open forest, associated with various landform features like gorge, valleys, hills	Various litho units	Good to moderate
7	**Structural hills**	Dense and open forest, structurally controlled unit.	Thin soil cover, rocky surface	Very Poor
8	**Denudational hill**	Dense forest, dark red/ brownish tone with moderate to smooth texture.	Thin soil cover	Very poor
9	**Residual hills**	Covered with scrub forest, bright tone with coarse to smooth texture	Sandstone and calcareous material	Very Poor

Land Use / Land Cover

Figure 5 shows that the entire northern portion including intermontanne valley and valley fills of cultivated portion has excellent prospects of ground water resources.

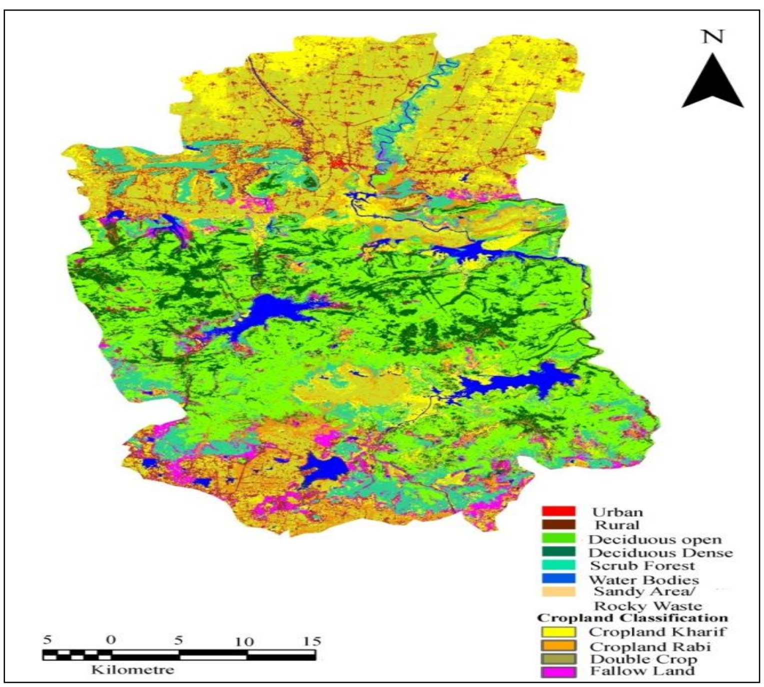

Figure 5: Land use/Land cover, Chakia Tahsil

Dense forest of Denudational hills and land with scrubs and fallow lands indicate moderate condition of ground water. Land without scrub including residual hill, structural hills, etc. have poor prospects of ground water occurrences.

Slope

The degree of slope controls the amount of runoff, velocity of river, erosion, transportation and deposition and plays an important role in the development of the drainage network (Bibby and Mackney, 1969). The slope of the area reflects more than 69.93% under level to gentle slope (15° and below) covering northern and southern portion with some variations. Nearly 19.98% of the area are categorized under gentle to moderate slope (15°-30°). Moderate slope (30°-45°) consists nearly 5.01% of the area. Nearly 4.98% and 0.10% of the area is under moderate to steep (45°-60°) and very steep (60° and above) category respectively (Figure 6 and Table 2).

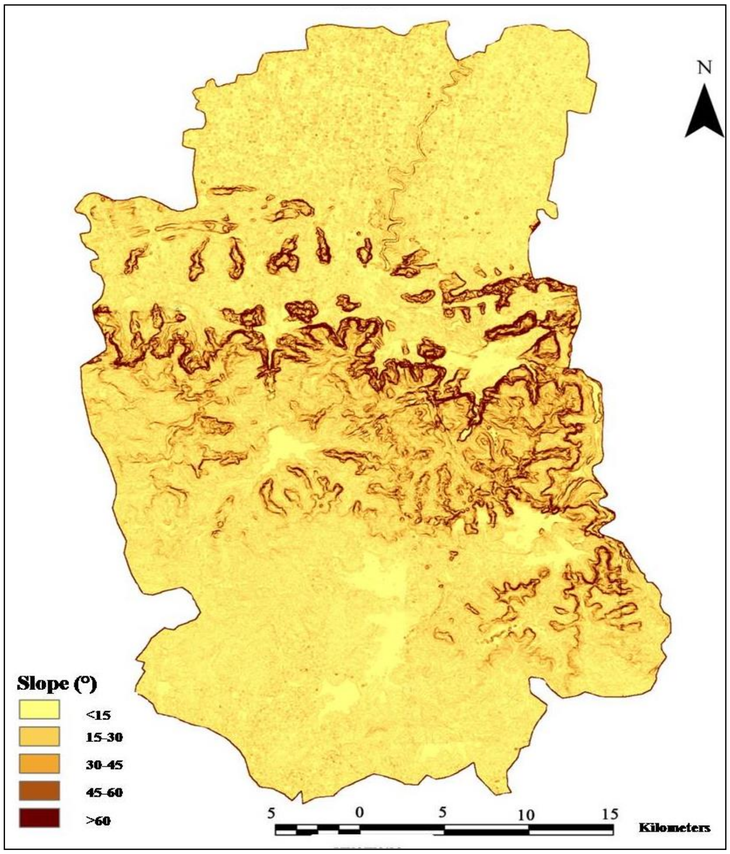

Figure 6: Slope, Chakia Tahsil

Table 2: Slope and Area Covered (%)

Slope Category (Degrees)	Area Covered (%)	Nature
< 15	69.93	Level to Gentle
15-30	19.98	Gentle to Moderate
30-45	5.01	Moderate
45-60	4.98	Moderate to Steep
>60	0.10	Steep

Source: *Based on GIS computation*

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Drainage

Figure 7 shows the drainage map of the area. Karmanasa, Chandraprabha and Garai River are the major stream flowing in this study area. Latif Shah, Munsakhand, Bhainsora, Chamer, Shamsherpur, Chandraprabha, Naugarh, Muzaffarpur dam are the other important sources of water in Chandauli district. Nakoiya, Baburi, Chandauli, Lehra Disty and other their tributary canals also play their role in the productivity and prosperity of this region.

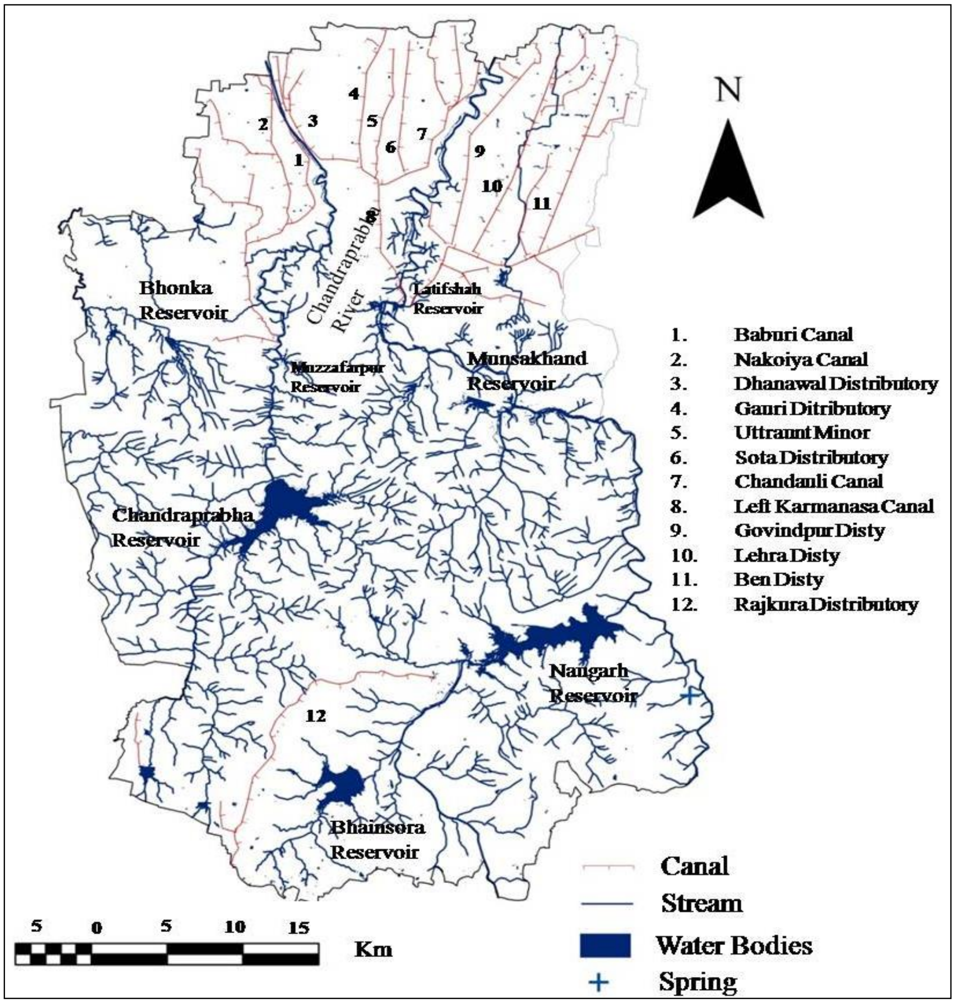

Figure 7: Drainage of Chakia Tahsil

Ground Water Delineation and Prospect

Figure 8 and Table 3 show the location of selected hydrological stations for pre and post monsoon water table and their average fluctuation (2005-2008) for the selected hydrological stations. *Maghgain* shows highest fluctuation of 6.30 m, whereas with 1.90 m, lowest fluctuation is shown by *Jaimohini*. The highest fluctuation in the water table is observed in the plateau region, ranging on an average 6m and above. Lowest fluctuation is seen in the middle zone, alluvial plain region and extreme southwestern part of the region (Figure 9).

According to Karanth (1989), many aspects of ground water occurrence and yield prospects can be drawn from geomorphology and geology of the area and the structure of the formation. Based on visual interpretation by using the standard FCC of IRS P6 (LISS III, 2014), the potential zone is categorized into five *i.e.*, very good, good, moderate, poor, very poor (Table 4 & Figure 10) for the ground water potential map.

Table 3: Pre-Monsoon and Post Monsoon Water Table Fluctuation in Chakia Tahsil, (Water Table in *m b.g.l*)

		2005			2008			2005-2008
Sr. No.	**Station**	**Pre-Monsoon**	**Post-Monsoon**	**Fluctuation**	**Pre-Monsoon**	**Post-Monsoon**	**Fluctuation**	**Average Fluctuation**
1	Balia Kala	7.12	3.67	3.45	6.00	4.00	2.00	2.73
2	Mawaia	7.40	1.70	5.70	7.00	2.00	5.00	5.35
3	Raghunath	4.98	1.43	3.55	4.00	1.00	3.00	3.28
4	Sherwan	4.91	0.81	4.10	4.00	2.00	2.00	3.05
5	Tilori	8.93	2.73	6.20	5.00	2.00	3.00	4.60
6	Utraut	5.10	1.45	3.65	5.00	2.00	3.00	3.33
7	Amritpur	9.43	4.99	4.44	9.00	4.00	5.00	4.74
8	Jaimohini	3.83	2.03	1.80	4.00	2.00	2.00	1.90
9	Majhgain	8.39	0.79	7.60	7.00	2.00	5.00	6.30
10	Naugarh	7.69	1.79	5.90	8.00	2.00	6.00	5.95
11	Tiwaripur	9.22	3.37	5.85	9.00	3.00	6.00	5.93
12	Ghandhinagar	9.38	5.38	4.00	7.00	2.00	5.00	4.50
13	Illiya	4.90	1.50	3.40	5.00	2.00	3.00	3.20
14	Khilchi	7.32	4.37	2.95	5.00	4.00	1.00	1.98
15	Mubarakpur	4.49	1.39	3.10	3.00	2.00	1.00	2.05
16	Shahabganj	10.09	6.79	3.30	9.00	6.00	3.00	3.15

Source: *UP Ground water Board, Lucknow*

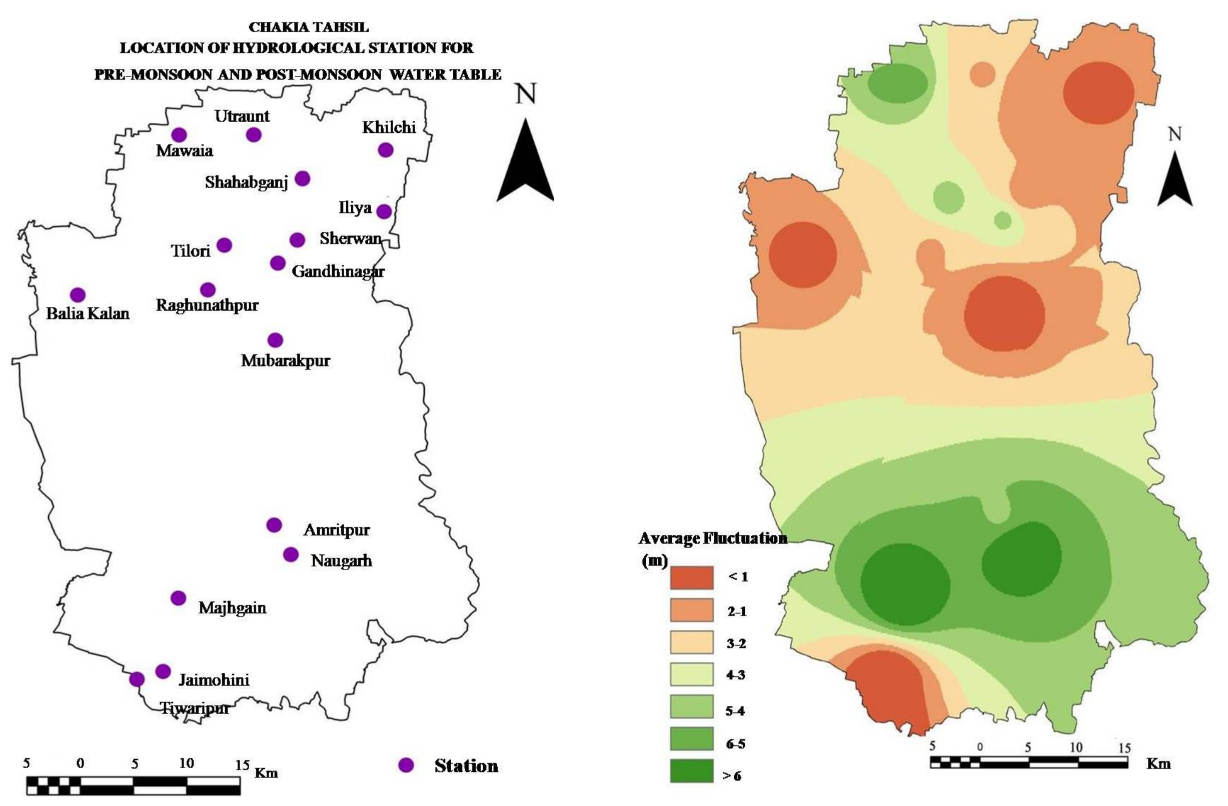

Figure 8 and 9: Location of Hydrological Station and Ground Water Fluctuation in Chakia Tahsil

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Table 4: Pre-Monsoon and Post Monsoon Water Table Fluctuation in Chakia Tahsil,

Ground Water Potential	Area (%)
Very Good	9.78
Good	16.94
Moderate	17.65
Poor	38.77
Very Poor	16.86

Source: *Image interpretation and GIS based computation*

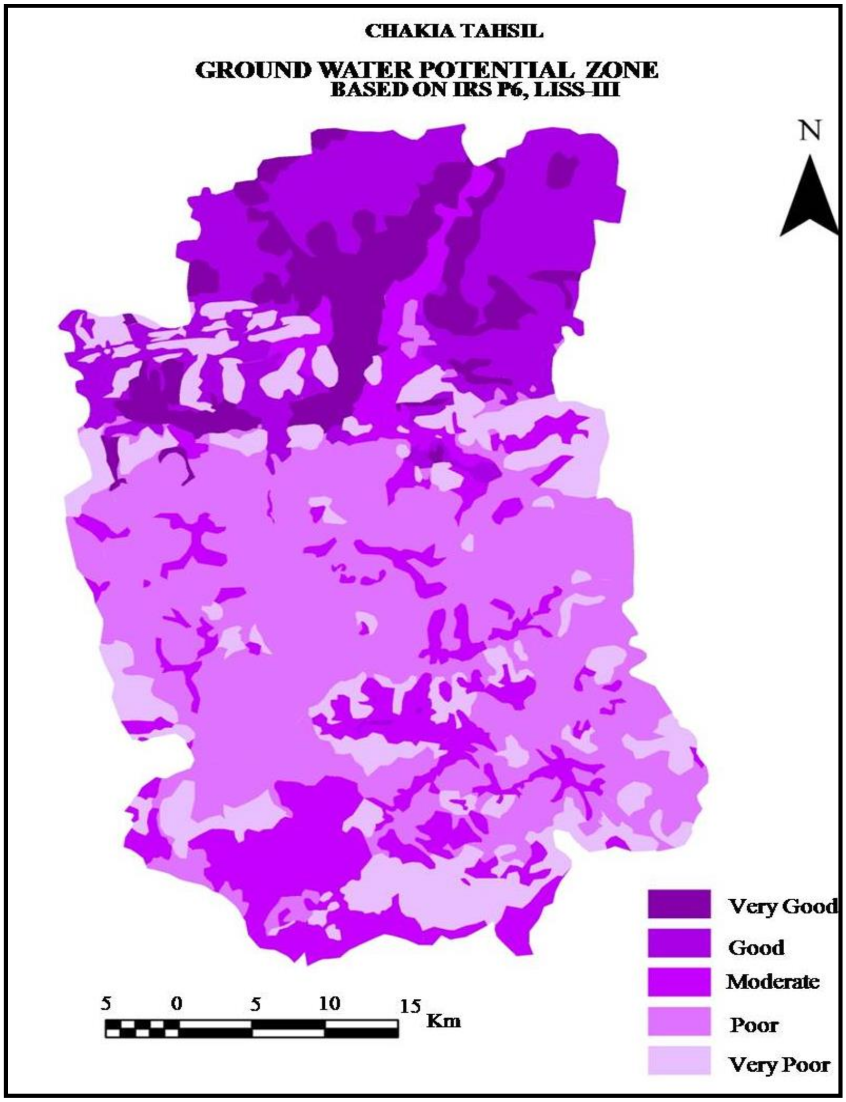

Figure 10: Ground Water Potential Zone

Good Potential Zone

This includes a region of red tone on imagery, almost covering 16.49% of the total area of the region. This prominently occupies the northern alluvial plain and intermontanne valley.

Moderate Potential Zone

This category embraces the zones of denudational hills located in the form of patches in the plateau region and buried pediment zones. It accounts for the total area of 17.65% and appears with bright reddish and grayish tones on the imagery.

Poor Potential Zone

Almost all the southern dissected plateau region comes under the poor zone category. Presence of lineaments in this region offer the water potentialities in a few places, though it is located nearly in the middle zone, i.e., just above the northern portion of poor zone category. It covers around 38.77% of the total area of Chakia *tahsil*.

Very Poor Potential Zone

The areas of very poor potential zones are marked with very bright grayish tone on the imagery and constitute 16.99% of the total study area. Hydrogeomorphic features associated with this unit are pediments and hills.

Conclusion

Two diversified physical units of the area under study, *i.e*., alluvial plain and Vindhyan upland have been marked with contrasting nature of water resources availability and utilization. Presence of lineaments, nature and extent of hydrogeomorphological features, land use/ land cover, slope and drainage etc. largely influences the ground water resources. High lineament density prospects for excellent ground water resources. Cultivated land in alluvial plain, valley fills and intermontanne valleys are promising region for this purpose. Slope and drainage present in the region largely influences the occurrences.

Overall, alluvial plain have excellent to good prospect, whereas Vindhyan upland has spatially varying nature with moderate to poor condition of availability of ground water resources.

ACKNOWLEDGEMENT

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