Integrated GIS and Remote Sensing Techniques for Geospatial Analysis of Groundwater Potential Zones of Bilate River Catchment, Main Ethiopian Rift Valley

Anirudh Bhowmick, Jai Ram Ojha

Abstract: As the demand and needs of the population for water is growing, the value of water is felt in all sectors. Therefore, groundwater resources needed to be mapped properly to exploit. The present study has been taken to delineate and classify the groundwater potential zones of the Bilate River catchment basin using overlay of themes in GIS environment. The consideration of thematic layers in the study are geology, geomorphology, drainage density, lineament density, rainfall, soil, slope and land use/ land cover and groundwater potential zones were delineated by using Weighted Overlay Analysis in Arc GIS 10.1 software. In the thematic overlay analysis, individual parameters is assigned with ranking considering the more or less their influences towards groundwater prospects. The integration of thematic layers finally is done using ArcGIS software to demarcate the groundwater potential zone map. Thus, three groundwater potential zones are categorized viz., good, moderate, and poor.

I. INTRODUCTION

Among various natural resources the groundwater is the most significant because of its uses in our daily life and activities. Due to the frequent failure of monsoon, rapid urban development, industrialization and lacking awareness in water resource management techniques, there is a great increase in the demand of groundwater resources. Depending upon the lithological assemblages, geology and soil qualities the availability of water shows a spatial variation and such variation may due to long retention period, slow movement, less storage volume. Therefore, reliability of information and timely prediction about the occurrence and movement of groundwater has prima facie importance for its uses in different sectors. The demand of groundwater for the sustaining human population and its growth never going to be cease therefore, technique and its suitability to predict the occurrence of groundwater resources in time and space is of great importance. Therefore groundwater delineation attaining grounds in local as well as regional scale for sustainable development of human societies is the need of hour. The groundwater supply is the main source of water to fulfil the demands of domestic, industrial and agricultural sectors. It has estimated that more than 80% of total demand is supplied from groundwater reserves, close to 90% of domestic and 95% of industrial demand fulfilled by the groundwater resources.

To reduce the supply demand gap and to target the areas of groundwater resources the Remote sensing (RS) and Geographic Information System (GIS) proven to be very useful tool in present decade. In recent years satellite remote sensing data with integration of GIS techniques has been widely used for the delineation of groundwater resources. The integration of thematic maps is proven to be solved the puzzled question of groundwater availability much accurately and in comprehensive manner. The application of this technique has been used widely used in locating the potential zones of groundwater. Though remote sensors in space born platforms cannot detect groundwater directly, but different image enhancement techniques and inferring of various features from remotely sensed images can throw light on various mineral assemblages, linear features, geomorphology, land use etc. and these can be used to decipher as indicators of groundwater potential zones. Remote Sensing and GIS use for preparation of various thematic maps after analysis of the base map, ancillary data and images of the concerned area and then the overlay operation in GIS suite with assigned weightage value for different variables can help to prepare a cumulative map showing contribution of different variable in the potential zones of groundwater availability map. The various thematic maps were created with help of Geographical information system (GIS) and remote sensing techniques then integration is done by applying Weighted Overlay Technique. For overlay purpose the pixel values is matched. In overlay technique can use weight factors depending upon their potentiality on the groundwater recharge scale.

For basin or watershed it is very difficult to find out recharge amount of groundwater directly. The groundwater prospect is dependent upon variables or factors which influence the groundwater recharge and potential zones. It also dependent upon influence these variables. The highest score weight point will contribute more for recharge. These factors can be weight positively or negatively for the purpose of groundwater recharge. Therefore, in the Bilate River basin five major descriptive ranks are classified with a range from very good to very poor. Proposed weighting of theme coverage of these ranks starts from maximum 5 points to the minimum level of 1 point.

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Anirudh Bhowmick, Faculty of Meteorology and Hydrology, Arba Minch Water Technology Institute, Arba Minch University, Ethiopia.

Jai Ram Ojha, Department of Geology, Arba Minch University, Ethiopia

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II. LOCATION

Location and Physiography: Bilate River catchment is situated in South Western Escarpment of the Main Rift valley and it is about 130 Km North West of the town Hawassa.

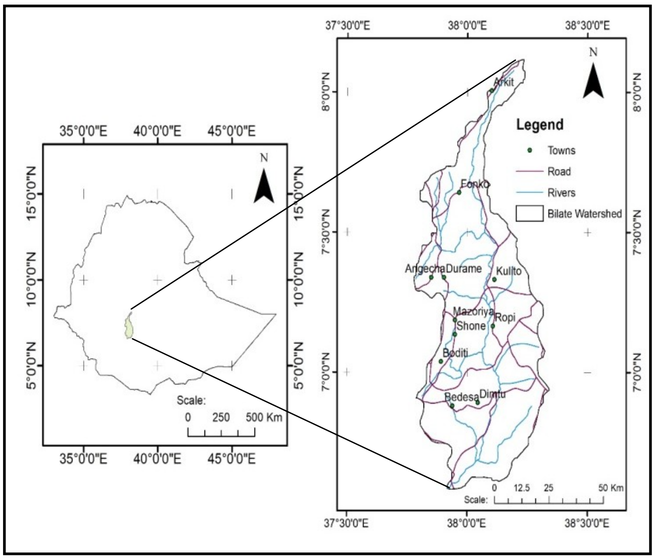

Figure 1. Location map of the study area

It covers an area of approximately 5625 square kilometer. It is bounded with geographic coordinates of 37° 46' 41.6" W to 38° 20' 26.8" E, at Abaya Lake in southern part Wolayita Zone to 6° 34' 55.9" S to 8°6' 58.2" N at Gurage and Silte zones border the Northern part. Physiographically the Bilate River basin is a tectonic valley. Along its length much of the valley is bounded by fault scarps or steep slopes on either side. The floor of the valley is mostly flat plain and appears to be as a part of a remnant of the depositional floor of an ancient large water basin. The study area is part of the western rift margin which is characterized by chain of ridges, hills, deep and wide valleys of small and large streams, and narrow flat lands and between the valleys having gentle slopes. It is due to the upliftment and subsequent rifting phenomena that created localized and regional fractures and faults. The rift floor and escarpments are highly faulted. The geomorphological features is caused by erosion, deposition processes, and land use practices. The lowest altitude of the catchment is 1180 meter at the point where river Bilate meet with Lake Abaya and the highest altitude is at Mt. Ambaricho situated in Alicho Wiriro Wordea area from mean sea level. The change in height can be depicted as the area is highly rugged with elevated mountains and with elevated terrains. Towards the center and the South, the morphology of the terrain changes to gentle slopes though there are hilly features and steep slopes along the river courses are observed. The catchment is bounded by Omo – Gibe basin to the south west, Ziway – Abijata – Shala, Lakes basin to the east and Lake Abaya to the south.

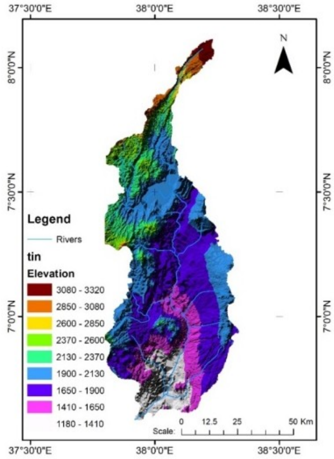

Figure 2. Triangulated Irregular Network (TIN) map of the study area

The Bilate River is a perennial river like Gidabo and Gelena which flows into the Lake Abaya. The tributaries of Bilate River also brings large volume of water in the catchment area and most of the tributaries originates from Hadiya, Silte, Gurage, Wolyita and Kambeta high lands. The amount of flow in the downstream could be influenced by the high evapotranspiration, availability of rainfall relatively and thermal springs that join the river downstream. The drainage density is generally high in the plateau and escarpment area and found to be very low in the rift valley floor. The disappearances of small streams can be associated with intensive faulting and volcanic activities in the area. In several places small stream disappears in the floor, before reaching to the major drainage system.

In general, the area is characterized by dendritic and at some places rectangular drainage pattern. The variability in precipitation, climate, and rainfall variability intensity in the catchment follows a humid to semi- arid tropical bimodal distribution precipitation pattern. Variability is caused by alternating dry and rainy seasons, as well as long-term influences, which is overlapping with regional orographic effects The climate of the area is humid to sub – humid in the highlands and semi-arid to arid in the rift valley.

III. METHODOLOGY

The groundwater evaluation in the study area involved the creation of thematic map in GIS environment and their integration through GIS. Thematic maps were prepared with a spatial resolution of 30-meter pixel size of the satellite imageries. The maps were developed in GIS using input parameters that indicate groundwater potential. The main factors responsible for groundwater resource development are rainfall/precipitation, geological assemblages, geomorphology, land use/land cover, drainage density, slope, soil, lineaments etc. For the purpose of this study Landsat-8 Operational Land Imager (OLI) images of nine spectral bands with a spatial resolution of 30 meters for bands 1 to 7 and 9 is used. The resolution for band 8 (panchromatic) is 15 meters (Landsat-8 metadata file) is used for creation of lineament and LULC thematic maps.

Table 1. Showing path and row and date of acquisition

Path	Row	Date of Acquisition
169	055	2017-03-11
169	054	2017-03-11
168	055	2017-03-11

A total of three Landsat scenes needed to cover the study area. Band 8 (0.50 - 0.68 micrometers); panchromatic band is used for the extraction of linear features present in the study area. On the images directional and Sobel Kernel filter were applied, then manually lineaments are traced through ARC GIS and to validate wrap over image topographic relief.

Weighted Overlay: The Weighted Overlay tool is implemented within a single tool in several steps in the general overlay analysis process. The tool consist of several stages which combines the following steps:

- Reclassifies values in the input rasters into a common evaluation scale of suitability or preference or some similarly unifying scale
- Multiplies the cell values of each input raster by the rasters' weight of importance
- Adds the resulting cell values together to produce the output raster

The tool only accepts integer rasters as input of a raster of land use or soil types. Continuous (floating-point) rasters are reclassified to integer (ArcGIS 10.1). The weighted overlay tool is used for suitability modeling (to locate suitable areas). The higher values result of overlay generally indicate that a location is more suitable. The weighted overlay tool scales the input data on a defined scale and weights of the input raster's, added together. Weighted overlay assumes that more favorable factors result in the higher values in the output raster, therefore identifying these locations as being the best is considered. To differentiate groundwater potential zones, scored maps of all the thematic layers after assigning weights were integrated (overlaid) step by step using spatial analyst tool of ArcGIS 10.1 software. ARC GIS 10.1 and Arc Hydro tools ERDAS imagine 2015 were used for image preprocessing and thematic map generating.

RESULTS AND DISCUSSION

Drainage Density: Usually represents sum of all the streams lines divided by the total study area, which shows drainage density in values.

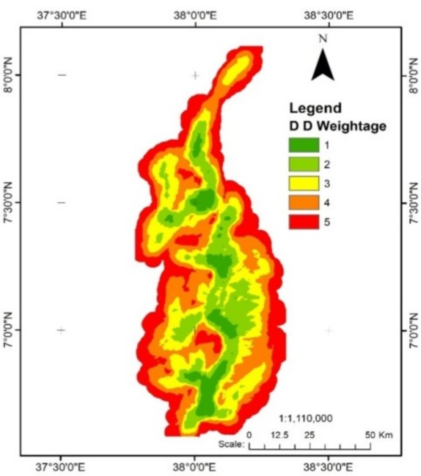

Figure 3. Weight Map of Drainage Density of Bilate Watershed

The total length of drainage in the watershed is 5625.12 km. For the purpose of overlay operations we need to show drainage density as map which can help us easily to show the area in a map spots having higher drainage density which is given in the unit of square kilometers. The drainage density of the watershed basin is 0.6134 per square kilometer which is considered fairly good. The drainage density map is then going to be reclassified and assign weight for the theme. The higher density will be given lower weightage.

We reclassify drainage density weight map based upon five classes as very low density (5), low density (4), moderate (3), high (2) and very high density (1) weight. In case of water resource management high density area for the purpose of cropping may be suitable for the plant needs more water. The area coverage of total watershed 5625 sq. km. The drainage density zone wise are 421, 1150.97, 1524.47, 1733.54, and 794.82 sq.km for class 5 to 1 respectively. But in case of groundwater potentiality higher drainage density is having poor prospects of subsurface groundwater recharge. The reclassified weight map of drainage density is shown in figure 3.

Geology and Lithological Assemblages: The geology of Ethiopia constitutes stratigraphic sequences from Archean up to Holocene sediments. The Ashangi group is the earliest by age exposed in Bilate basin, constituting Alkali olivine basalt and tuffs very rare are the rhyolite of Paleocene-Oligocene Miocene age.

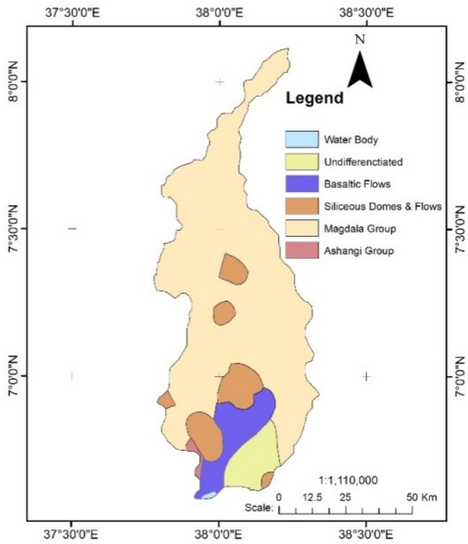

Figure 4. Geological Map and Geological Map with Assign Weight

Mineral composition of olivine rich basalt use to be weathered easily. Geologically the Magdaa group overlain the Ashangi Group, constitute rhyolite, trachytes, rhyolitic and trachytic tuff; ignimbrites agglomerates and basalts. The age of this group is Upper Miocene-Pleistocene. Magdala group is moderately permeable, therefore in the weight given a weightage of three. Magdala Group is overlain by Siliceous domes and flows constitutes Pantellerites, obsidians.

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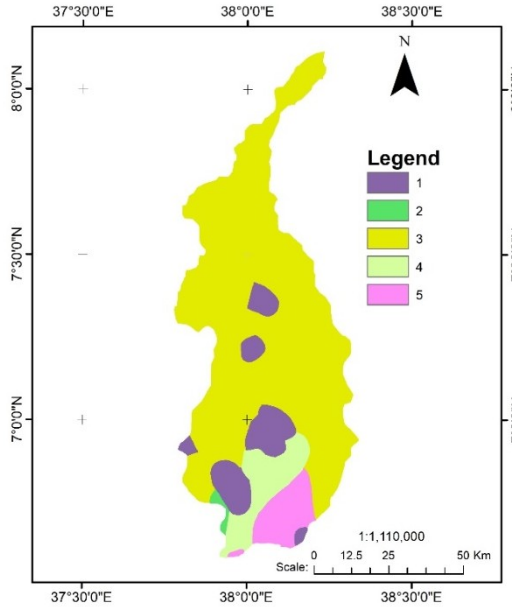

Figure 5. Geological Map with Assign Weight

This group is complex of volcanoes having andesite-trachyte-rhyolitic composition. The Siliceous Domes are overlain by Basaltic flows which are related with spatter cones mainly constitute Alkaline olivine basalt.

Table: 2. Geology, its coverage area and assigned weight.

S. N.	Classes	Coverage (Sq. Km.)	Percentage Coverage	Assign Weight
1.	Undifferentiated	329.76	5.86	5
2.	Basaltic Lava Flow	463.94	8.24	4
3.	Siliceous Domes & Flow	565.97	10.06	1
4.	Magdala Group	4250.72	75.56	3
5.	Ashangi Group	30.06	0.53	2
Total Coverage		5625.00		

This group is weathered easily and due to presence of secondary porosity this group is assigned good in the weightage assignment. Undifferentiated group is constituting sediments of Pleistocene Holocene age.

The assigning of weightage for varying geology, (Cherenet T., 1993) the alluvial deposits, recent basalts and lacustrine sediments, volcano - sedimentary rocks are highest weightage due to their higher porosity. The impermeability of Ignimbrites of rift floor, Pyroclastic deposits and Pleistocene basalt were assigned moderate value because they are generally well jointed and therefore having moderate permeability, siliceous domes are less affected by faulting and fracturing, given lowest weightage (Table 2).

Geomorphology: Geomorphology of Bilate watershed is created with shaded relief developed from SRTM data. The Bilate watershed has variety of geomorphic features area in which more than half area is geomorphologically termed as undulated area.

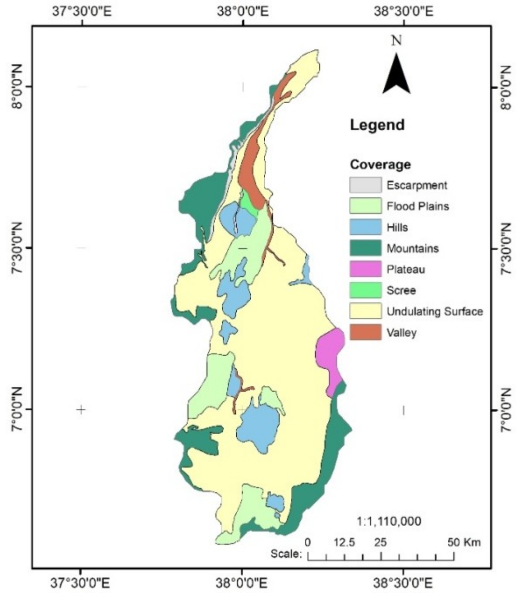

Figure 6. Geomorphological map and Geomorphology map with assigned weight

These areas are dominated by agriculture with sufficient amount of anthropogenic interventions to stabilize slopes locally up to some extent. These undulated area are mostly area of intermittently higher slopes. But still in broader respects it is a sloppy area. Rest coverage of geomorphology dominated in the area is mountains, isolated hills and flood plains. The undulated area is given a weight of three. A small portion is having valley mainly in the northern part of the watershed and escarpment is also present in the area though it covers only a small part and given a weight value of four. Escarpment are steep slopes along the fault plain and generally very low groundwater recharge prospects, therefore given a weight value of one. Plains are with gentle slope which account only nine percent in the area of the total watershed basin. This area lies in south west part of the basin.

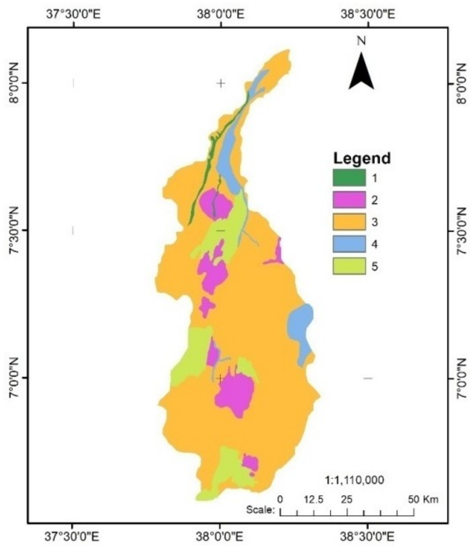

Figure 7. Geomorphological map and Geomorphology map with assigned weight

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Table: 3. Geolomorphological features coverages area and assigned weight.

S.N.	Geomorphologic Classes	Coverage (Sq. Km.)	Percentage Coverage	Assign Weightage
1.	Hills	499.24	8.87	2
2.	Flood Plains	495.84	8.81	5
3.	Mountains	794.21	14.12	3
4.	Valley	185.78	3.30	3
5.	Plateau	133.58	2.73	4
6.	Scree	28.00	0.49	3
7.	Escarpment	62.33	1.10	1
8.	Undulating Surface	3268.45	58.10	3
Total Coverage		5625.00		

These areas are predominantly having low slope and occupied for agricultural farm lands and for urban settlements. Flood plains are located close to hilly area as well as when slope of valley stabilizes. Flood plain is fertile land and profusely occupied with farming, hence given a weightage of five. Close to hills when slope stabilizes the weathered material under the influence of gravity deposited known as scree and it has given a weight of three. The weightage table (3) is given above.

Soil: The types of major soil found in the study area, as extracted from soils map of Food and Agricultural Organisation of the United nations (FAO), are Mollic and Vitric Andosols are young soils formed from volcanic deposits. The physical properties of MollicAndosols are conditioned by a fine texture, although the clay content does not usually overpass 20 to 25%, they are poor in sands when more higher the evolution. The study area is having EutricVertisols have dominantly vertic properties and they are clay soils.

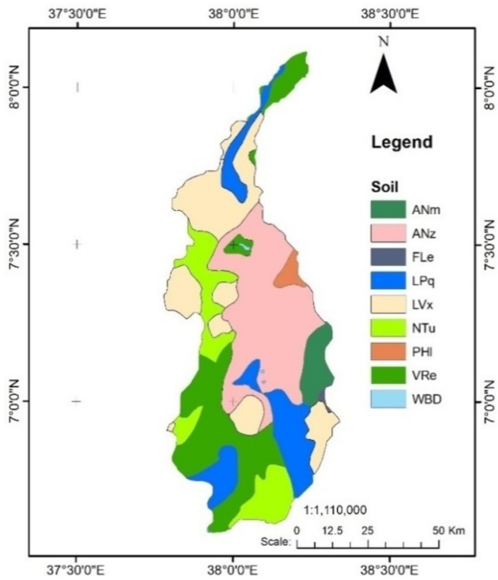

Figure 8. Bilate watershed Soil Map

According to FAO (1988) Vertisols are characterized by their high clay content and saturated soon also have water holding capacity but poor in permeability. According to FAO (1988) Vertisols type soils are characterized by their high clay content. They are often dark colored. Due to their semitite clay mineralogy, they are very hard and crack when dry, but becomes sticky and plastic (often impassable) when wet. These are chemically rich soils, they may develop on an undulating relief. Vertisols have great agricultural potential, but special management practices are required.

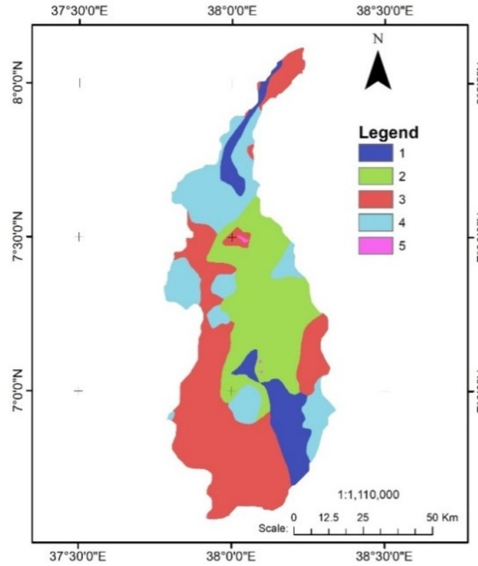

Figure 9. Bilate catchment Soil weightage Map

Table 4. Soil classes and assign weight of Bilate Watershed

S. N.	Soil Classes	Coverage (Sq. Km.)	Percentage Coverage	Assign Weight
1.	MolicAndosols	248.58	4.41	3
2.	Vitric Andosols	1749.39	31.10	2
3.	EutricFluvisols	14.81	0.26	4
4.	Lithic Leptosols	652.56	11.60	1
5.	HumicNitisols	78.99	1.40	3
6	LuvicPhaeozems	83.42	1.48	4
7.	EutricVertisols	1477.01	26.25	3
8.	Chromic Luvisols	1311.91	23.32	4
9.	Water Body	7.55	0.13	5
Total Coverage		5625.00		

Very shallow soils over hard rock or the unconsolidated consist of gravel material, therefore not much important for infiltration. Eutric Fluvisols are young alluvial soil and mostly covered with natural vegetation cover. The Bilate watershed has HumicNitisols which are deep, dark red brown to yellowish clay soil having a pronounced shiny, nut shaped structure. Luvisols are soils that have higher clay content in the subsoil than in the topsoil as a result of pedogenetic processes. They are most common in flat or gently sloping land and the parent material constitute a wide variety of unconsolidated materials including glacial till, and aeolian, alluvial and colluvial deposits. Since most luvisols are fertile soils therefore very suitable for a wide range of agricultural uses in the area. Luvisols with a high silt content are susceptible to structure deterioration where tilled when wet or with heavy machinery (FAO, 2006). Phaeozems are dark soils developed on eolian (loess), consist of glacial til and other unconsolidated parent material and are rich in organic matter Environmentally, they are mostly found in

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flat to undulating land in the Bilate basin tropical highland regions. In humid condition allows some percolation of the soil, but also with periods of time the soil dries out. Phaeozems are fertile soils; they are planted to irrigated cereals and pulses or are used for cattle rearing and fattening on improved pasture (FAO, 2006). The classes of soil types are given in the Table (4). Soil image for the purpose of overlay is reclassified in to five weightage zones. The area given weightage very poor is covering an area of 579.36 square kilometer. Weight rank two poor area, covers an area of 1553.15 sq. km., the area termed as moderate in reclassified image covers most of the watershed area constitute 2233.34 sq. km, area termed as good covers area of 1251.98 sq. km. and very good for infiltration purposes are covering only 6.71 sq.km. The reclassification of soil is mainly based on clay, sand, silt and organic matter content.

Lineaments: Lineaments are structural lines such as faults,

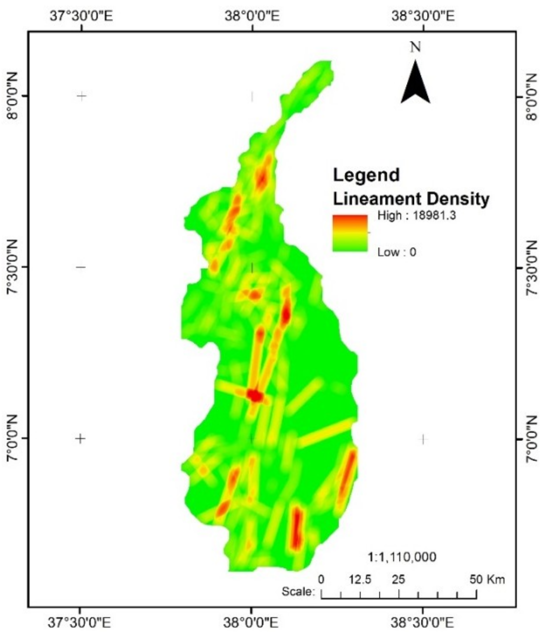

Figure 10. Lineament Density Map and Lineament Density weight reclassified Map

which often represent zones of fracturing and increased secondary porosity and permeability, and therefore of enhanced groundwater occurrence and movement. To delineate lineaments panchromatic band of Landsat 8 OLI image is taken as input image. The image is enhanced radiometrically with histogram equalization. The Sobel 1 and sobel 2 kernels as well as directional (left and right) kernels were applied to find out lineament directions of NE-SW, E-W, N-S and NE-SW. For lineament delineation shaded relief map is also taken in to consideration. The lineament extraction were made with visual interpretation. The cutting of lineaments with secondary lineaments are very important for groundwater potential zone. From the lineament map, lineament density map is produce and lineament density map is taken as a theme for groundwater potential variable. Lineament density map is prepared with spatial analyst tool in Arc GIS. The lineament density map is created with a grid of a square kilometer.

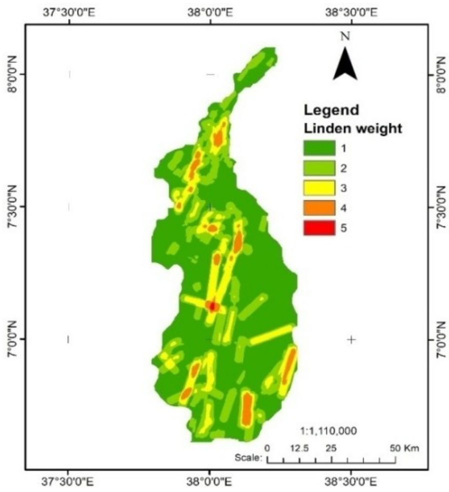

Figure 11. Lineament Density weight reclassified Map

For refinement of lineament map the shaded relief map is taken as assistance to make a final delineation of linear features. The lineaments mostly have a trending NE-SW direction. Though few are having NW-SE trend. Few lineaments are having EW trends.

In reclassified map the poor weightage is for 1, moderate is for 2 and good is assign for three. Area wise the zone of weightage one covers an area of 3255.52 sq.km, weightage two covers an area of 1406.30 sq.km and weightage three covers an area of 682.16 sq.km. The weightage four in the area is considered as good promising zone for groundwater recharge as second generation lineaments are cross cutting the prevailing lineaments. Fourth zone covers an area of 214.20 and the best area for infiltration only 4.6 sq.km.

Landuse Landcover Classification: The Landsat 8 image has been downloaded. The False Colour Composite (FCC) is prepared after stacking band 5, band 4 and band 3. The images shown that the shadow of hills in the area has similar signature with water body. Therefore ratio images/indices are prepared. The determination of indices taken into account of three elements, namely built-up land, vegetation and open water bodies.

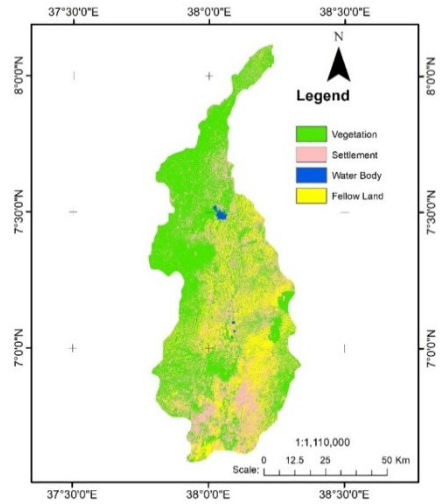

Figure 12. Supervised Classified Image

The study area consists of urban built-up land features, water bodies and water courses imbedded in vegetation. The study explore three indices, namely Normalized Difference Built-up Index (NDVI), Modified Normalized Difference Water Index (MNDWI) and Soil Adjusted Vegetation Index (SAVI) to represent main barren soil with sporadic urban land-use classes, fellow lands prepared for showing, open water body and vegetation covered area with crop and natural vegetation.

The indices are prepared using modeler in ERDAS Imagine 2015 The Model Maker tool palette was used to draw the model to be used in calculation, the input raster was declared as float and Nearest Neighbour interpolation method was selected. After preparation of these three indices the multi-band image created using layer stack process, thus three-band image composed of MNDWI, NDBI and SAVI images. The conversion through indices of Landsat 8 seven-multispectral band image into three-thematic-band image reduced significantly correlation among the bands. After preparation of FCC layer stack image the image is classified using training sites. The classified image is shown in the figure (12). The area of coverage is given in table (5). After reclassify of land use/cover map the watershed is divided in the four classes and 2-5 weightage is given for settlement and barren land, fellow land, forest and vegetation area and water body respectively. The barren land and settlement covers 1692.95 square kilometer area.

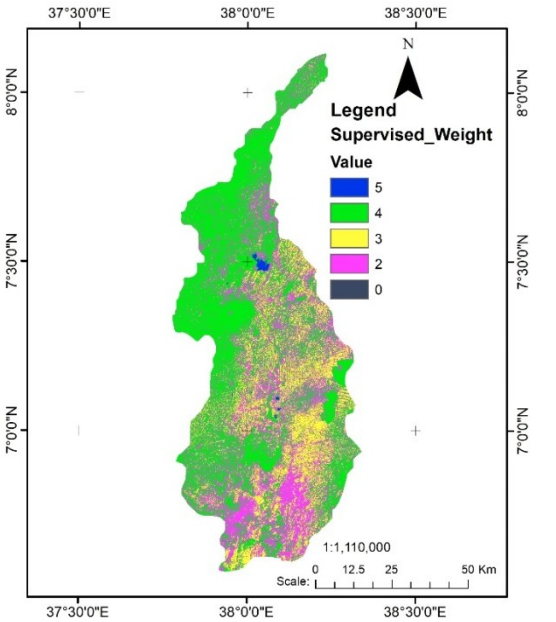

Figure 13. Supervised Classified Image Weightage

Table 5. Showing LULC coverage with assigned value and area of coverage

S. N.	Coverage Classes	Coverage (Sq. Km.)	Percentage Coverage	Assign Weight
1.	Forest and Crop	2882.62	51.20	4
2.	Fellow Land	1032.99	18.39	3
3.	Water Body	17.70	0.31	5
4.	Settlement & Bare Soil	1691.95	30.08	2
Total Coverage		5625.00		

The second class having weightage of 3 is composed of fellow land covers an area of 1034.99 square kilometer. The third class of LULC having weightage of 4 and composed of 2882.62 square kilometer area composed of forest and vegetation area. The fourth group composed of water bodies and constitute the highest weightage covers an area of 17.70 square kilometer area (Table 5).

Slope: Slope is derived with 90m DEM by clipping with Bilate watershed polygon. In the study area the maximum slope is approximately 44.2^0.

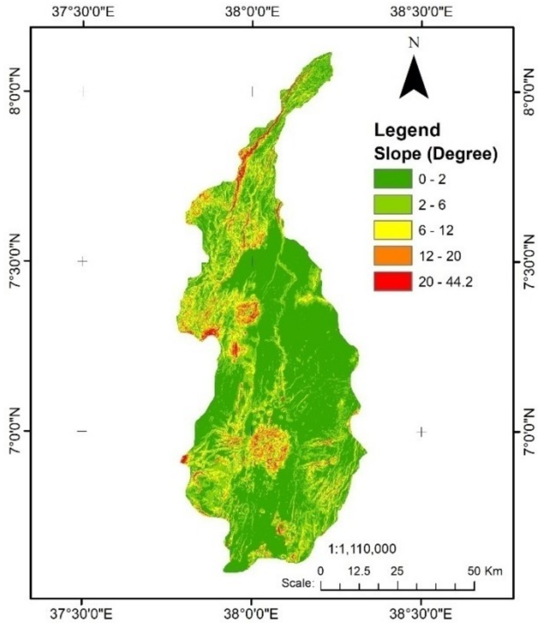

Figure 14. Slope Map of Bilate Watershed

Slope is very important theme which can assess the amount of infiltration and also plays an important role for settlement, agricultural activities and in general workability in the area.

Table 6. Showing Slope zone coverage in Bilate watershed

S. N.	Slope Re-Classes	Coverage (Sq. Km.)	Percentage Coverage	Assign Weight
1.	1	63.03	1.10	1
2.	2	234.73	4.17	2
3.	3	825.35	14.67	3
4.	4	2138.30	38.01	4
5	5	2363.17	42.01	5
Total Coverage		5625.00		

The slope percentage of the study area varies between 0-42.2^0. On the basis of slope degree the study area has been classified into 4 slope classes: 0-2^0, 2-6^0, 6-12^0, and 12-$20^0$and 20-44.2^0. Accordingly, the topography of the watershed is characterized by undulating terrain constituting plains to steeply sloping hills. From higher weightage towards the lowest, close to majority of the study area falls under the slope class of 0-2%, which covers 42.01% of the total study area, and weight 4 covers 38%, and the rest 3, 2 and 1 respectively 14.67%, 4.17%, and 1.1%

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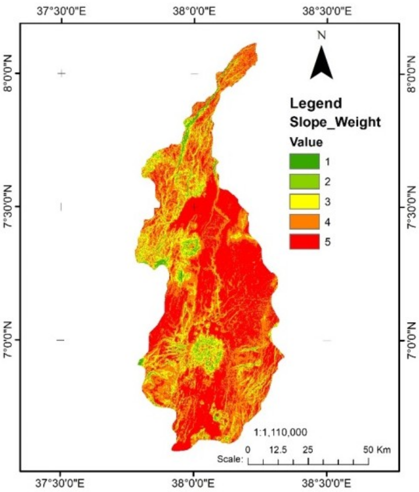

Figure 15. Bilate Watershed Slope map showing weightage

Rainfall: The sensitivity of groundwater system to rainfall is

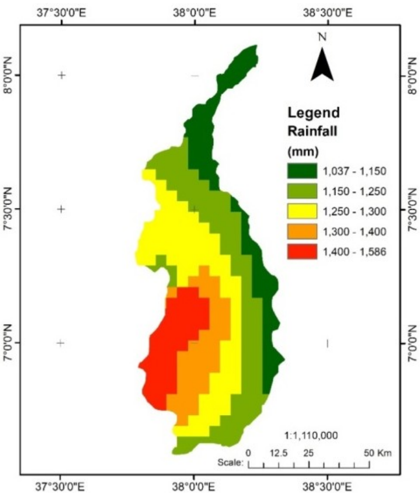

Figure 16. Rainfall Divisions (mm) and Rainfall Assigned Weightage

well established fact. In the region the average rainfall measure constituting rainfall data is plotted and rainfall zones are created with a difference of 40 mm range. The 1037 to 1150 mm is kept as lowest weightage and the maximum weightage is given to 1400 – 1586 mm per year.

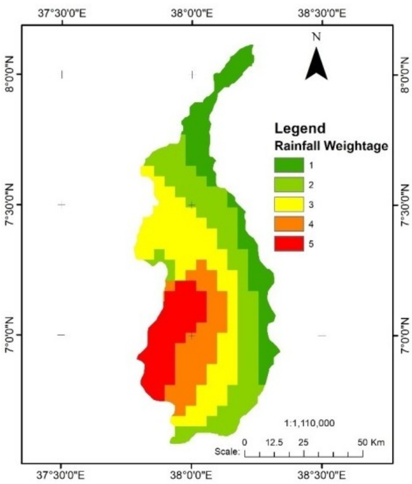

Figure 17. Rainfall Divisions (mm) and Rainfall Assigned Weightage

The South East part of watershed basin gets maximum amount of rainfall while, the northern and eastern periphery of the Bilate basin receive lowest rainfall. The zone one covers 983.21 sq.km area, second zone weightage wise covers 1582.87 sq.km., third zone covers 1532.71 sq. km, fourth zone covers 783.78 sq.km and the fifth zone the highest weightage covers 742.26 sq.km. area. All raster weightage themes are resampled at similar size for weightage overlay operations.

IV. CONCLUSION

The overlay of several rasters are done using a measurement scale of very poor, assigned as 1, poor prospect is assigned as 2, moderate is assigned as 3, good is assigned as 4 and very good is assigned as 5. After preparation of the themes and reclassification of the themes, all themes are given an equal pixel size before apply for weighted overlay operation. The weights are kept close to similar and themes influences are not differentiated on the basis of theme. All input were given in rasters as integer. A floating-point raster as in the case of composites of indices for land use/cover theme, converted to an integer raster before it can be used in weighted overlay. Each value class in an input raster is assigned a new value based on an evaluation scale. These new values are reclassifications of the original input raster values. Each input raster is weighted more or less with equal importance as during theme reclassification values are given with the experiences and rational decisions made by the researcher.

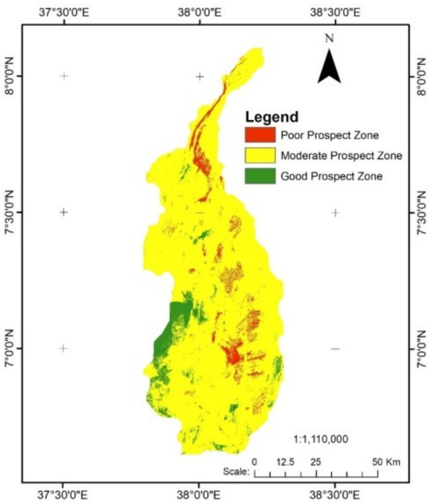

Figure 18. Groundwater Prospect Map of Bilate Watershed

The weight is a relative percentage, and the sum of the percent influence weights brings with some minor adjustment to 100. Changing the evaluation scales or the percentage influences the results of the weighted overlay analysis.

The result shows in Bilate watershed 295.09 sq. km area is having poor groundwater prospect, the area of poor groundwater are in patches and especially in escarpment area. The moderate zone covers an area of 4899.12 sq. km.

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area in the Bilate watershed area. The moderate zone covers almost entire watershed. The moderate zone contribute 88.4% of the total area. The area comes under good prospect of ground water availability covers an area of 347.78 sq.km. There is no area comes under very poor or very good prospect according to the weighted value for all themes. The area mostly in central part of the watershed is having poor prospects. The western region of the watershed account for the most part of good groundwater prospect area.

In this present study, the result of groundwater potential zones by using GIS and remote sensing techniques were identified and delineated based on the influential factors for groundwater potential zones. In this research, eight parameters were selected which have more affects the occurrence of groundwater potential zone prior to overlay analysis. The parameters in the area for groundwater potential are rainfall, slope, geomorphology, lineament density and drainage density, Geology, soil, Land use land cover indicate that all parameters are significant. The delineated Groundwater potential zones were classified into five zones namely; very poor, poor, moderate, good and very good. Very Poor zone shows the low suitable area for groundwater recharge and prospect, whereas very good zone indicates the most suitable area for groundwater recharge and prospect. Most of the area covered by moderate potential zones with an aerial extent of 4899.12 sq. km (88.4%) followed by good groundwater zones with an area of 347.78 sq.km(6.26%) and 295.09 sq. km(5.32%) area is having poor groundwater prospect. According to the weighted value for all themes, there is no area comes under very poor or very good prospect. The area mostly in central part of the watershed is having poor prospects whereas, the western region of the watershed account for the most part of good groundwater prospect area. It can be concluded that Integrated GIS and remote sensing techniques are very efficient and useful, time and cost effective tool for the delineation of groundwater potential zones. From the study it was also concluded that, for any implementation of groundwater management system and watershed conservation strategies, identification of groundwater potential zones plays a major role.

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BIOGRAPHIES

Dr. Anirudh Bhowmick, completed his Ph.D. degree in Geology from Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya of Satna, M.P. in 2010. Author's area of specialization is in the field of advanced GIS and remote sensing application in ground water prospecting and in mineral exploration. Author also worked as a Geologist in Niger for uranium exploration. Presently author working as Associate Professor in the Faculty of Meteorology and Hydrology, Arba Minch Water Technology Institute, Arba Minch University of Ethiopia, East Africa.

Dr. Anirudh Bhowmick may be reached at bhowmick.anirudh@amu.edu.et

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