# ASSESSMENT OF GROUND WATER CONDITIONS USING REMOTE SENSING AND GIS IN NORTH THINGDAWL RURAL DEVELOPMENT BLOCK, MIZORAM, INDIA

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***Abstract:*** The demand of water supply increases rapidly due to growth of human population and urbanization. Surface water alone is often insufficient to meet this escalating demand. The present study deals with the assessment of ground water conditions both in terms of prospect and quality in North Thingdawl Rural Development block of Kolasib district in the state of Mizoram, India. The study makes use of geo-spatial technology to identify the potential locations for ground water availability. Important spatial aspects which are responsible for the presence of ground water within the area were identified. Accordingly, three thematic layers viz., geomorphology, and lithology, geological structures like faults and lineaments were generated. These thematic layers were then integrated using ArcGIS software to form the hydrogeomorphic units which are the aquifers. Different classes of the aquifers determine the ground water condition in terms of prospect for development. Ground water samples were collected from 25 locations during the field survey to determine the ground water quality. The major parameters namely pH, Total Dissolved Solids, Total hardness, Alkalinity, Iron and Chloride of the samples were analyzed. Spatial interpolation technique through Inverse Distance Weighted (IDW) approach has been used in the present study for generating spatial distribution of the ground water quality. The final maps show the ground water conditions of the area in terms of prospect and quality. Advent of scientific techniques for identifying ground water prospective areas and analyzing its quality enables us to save time and money. The final output can be utilized for exploration, development and management of ground water resources.

***IndexTerms* - GIS, Ground water, Remote Sensing, North Thingdawl block.**

## I. INTRODUCTION

Ground water is the largest reachable source of fresh water and one of the most important natural resources for supplying the ever-increasing demand caused urbanization and growth of population (Sharma and Kujur, 2012; Neelakantan and Yuvaraj, 2012; Kumar, 2013). Therefore, finding ground water potential areas, monitoring and conserving ground water has become highly necessary (Rokade et. al., 2004; Kumar and Kumar, 2011).

Mizoram is blessed with high amount of annual rainfall. However, geology of the state comprises ridges with steep slopes and narrow intervening synclinal valleys, faulting in many areas have also produced steep fault scarps (GSI, 2011). Hence, most of the water available is lost as surface runoff. Therefore, Majority of the population suffered shortage of water especially in the post-monsoon season. The age-old method of fetching water from springs is still prevalent within the state. Springs, the main sources of water also get depleted during the post monsoon period (CGWB, 2007).

North Thingdawl block of Mizoram also experienced acute shortage of water. Therefore, ground water prospective areas have to be identified so as to adopt proper measures for its development.

Few efforts were made to study ground water prospect zones within the state of Mizoram using geospatial technology. These include mapping of groundwater potential zones in Serchhip district (Lalbiakmawia and Lalruatkima, 2014) and mapping of groundwater potential zones in Aizawl district (Lalbiakmawia, 2015).

Spatial technology like application of Remote Sensing and GIS techniques allow swift and cost effective survey and for management of natural resources (Ramakrishna et. al., 2013). Hence, these techniques have wide-range applications in the field of geo-sciences including ground water prospecting (Jeganathan and Chauniyal, 2002; Anirudh, 2013). Interpretation of satellite data in combination with adequate ground truth information makes it possible to identify and outline various ground features such as geological structures, geomorphic features and their hydraulic characteristics that may serve as indicators of the presence of ground water (Raju et al., 2013)

Therefore, many researchers have utilized these techniques successfully in ground water studies (Saraf and Jain, 1994; Krishnamurthy and Srinivas ,1995, Krishnamurthy et. al., 2000). The same techniques have been proved to be of immense value not only in the field of hydrogeology but also in water resources development as well. (Saraf and Choudhury, 1999; Sharma and Kujur, 2012).

The main purpose of the present study is to make use of geo-spatial layers in delineating ground water prospective areas in North Thingdawl block, to create vital database for future development and management of ground water within the rural development block.

## II. STUDY AREA

North Thingdawl block is located in the north western part of Mizoram between 23° 55.205' to 24° 19.977' N Latitudes and 92° 32.222' to 92° 54.270' E Longitudes. It is bounded to the north by Kolasib block, on the east and southern side by Aizawl district, to the west by Mamit district. The total geographical area of Zawlnuam block is approximately 879.50 sq. km and it falls in the Survey of India Topo sheet Nos. 83 D/12, 83 D/15, 83 D/16, 84A/9 and 84A/13. The study area enjoys a moderate climate owing to its tropical location. It is neither very hot nor too cold throughout the year.

## III. MATERIALS AND METHODS

### 3.1 Data used

Indian Remote Sensing Satellite (IRS-P6) LISS III data having spatial resolution of 23.5m and Cartosat-I stereo-paired data having spatial resolution of 2.5m were used as the main data. SOI topographical maps and various ancillary data were also referred in the study.

### 3.2 Thematic layers

Thematic layers generated using remote sensing data like geomorphology, geology and lineaments can be integrated in a Geographic Information System (GIS) environment and can be utilize for delineating ground water potential zones (Kumar and Kumar, 2011). The present study utilized three thematic layers to identify ground water potential zones of the study area. The different layers are as follows-

**3.2.1 Geomorphology:** Geomorphology is one of the most important features in evaluating the ground water potential and prospect. It can also be utilized in managing ground water resources and highly helpful for selecting the artificial recharge sites as well (Kumar and Kumar 2011; Valliammai et al., 2013, Raju et al., 2013; Ghayoumian et al., 2007). The study area comprises geomorphic units like intermontane valley, alluvial plain, fractured valley, less dissected structural hill, moderately dissected structural hill and highly dissected structural hill.

All the geomorphic units occurring in the study area are mapped as polygon features. While demarcating the geomorphic units, toposheets were consulted to comprehend the relief variations and other topographic features. The geomorphological map showing assemblage of different landforms is prepared based on the lithological map so that each rock type is classified into different geomorphic units. Apart from dissection in the hills, slope-form also plays an important role in ground water occurrence and flow in the hilly/ mountainous terrain (RGNDWM, 2008). Geomorphological map of the study area is shown in Figure 2.

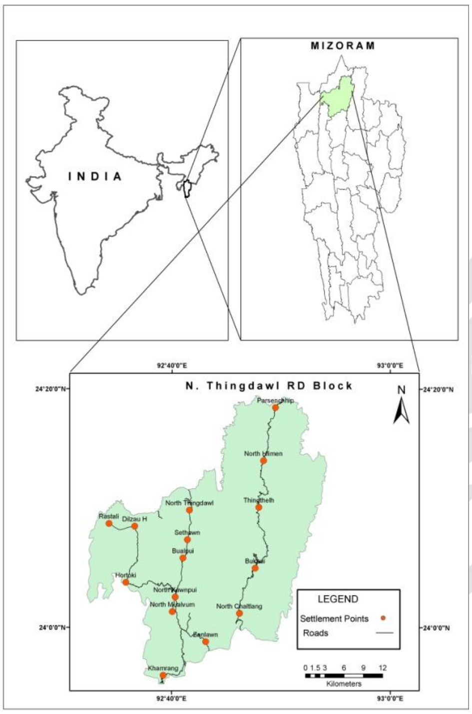


*Figure 1: Location map of the study area*

**3.2.4 Lithology**: Detailed knowledge of lithology is an important factor in ground water exploration and in particular, the features to be considered are geological boundaries, porosity, etc (CGWB 2000). All the rock formations occurring in the study area are mapped as a layer. Existing geological and literature are consulted which helps in knowing general geological setting of the area and different rocks types that occur or likely to occur in the area (RGNDWM, 2008).

The study area lies over rocks of Lower Bhuban, Middle Bhuban, Upper Bhuban and Bokabil formations of Surma Group of Tertiary age. Recent unconsolidated sedimentary materials are also found in the low lying areas. Lower Bhuban and Upper Bhuban formation comprises mainly of arenaceous rocks while Middle Bhuban and Bokabil formations consist mainly of argillaceous rocks (GSI, 2011). The lithostratigraphical map of the study area is given in Figure 3.

**3.2.5 Geological Structure:** Lineaments like faults, fractures and joints can be delineate and analyse using Remote sensing data (Kanungo et al., 1995). They are the most obvious structural features that are important from the ground water point of view (Bhatnagar and Goyal, 2012). The geological structures occurring in the area are treated as conduits for the movement of ground water and provide potential for ground water recharge (CGWB, 2000; Sankar, 2002; Sharma and Kujur, 2012). It was observed that the rocks exposed within the study area were traversed by several faults and fractures of varying magnitude and length (MIRSAC, 2006). The geological structures are mapped as line features.

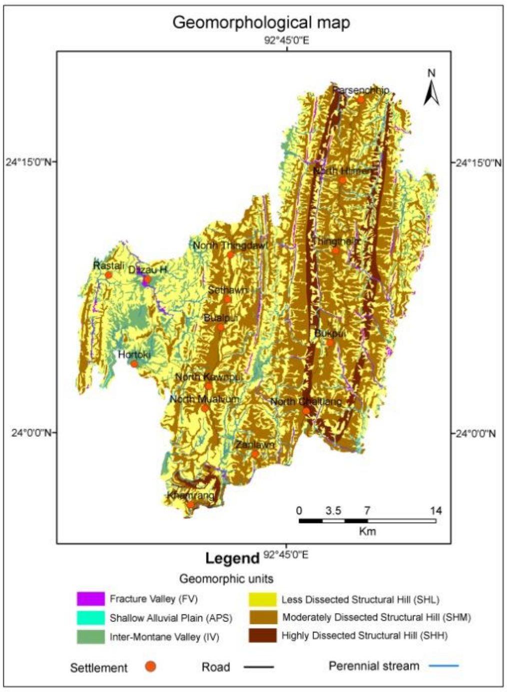


*Figure 2: Geomorphological map of the study area*

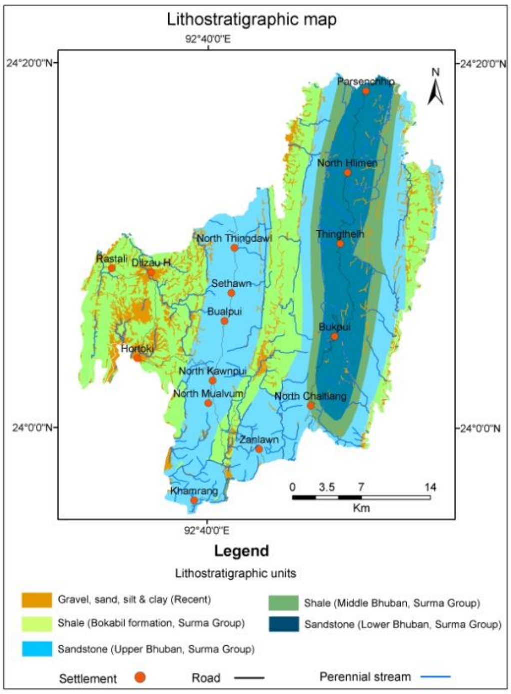


*Figure 3: Lithostratigraphic map of the study area*

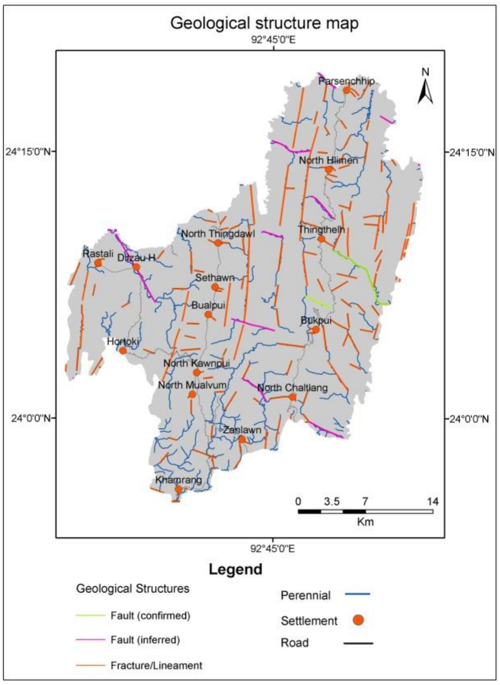


*Figure 4: Geological structure map of the study area*

## IV. METHOD FOR GROUND WATER PROSPECTING

In order to delineate the aquifers, the lithological, geomorphological and structural maps are subjected to overlay analysis by superimposing the layers one over the other in GIS environment. The information present in the layers as the attribute data is also subjected to analysis. During the process of integration, the geomorphic units and rock types are made co-terminus by adjusting the boundaries. As a result of the integration, the areas having unique lithology, landform and structure are delineated. There by the primary porosity and permeability of the rock formations and the secondary porosity and permeability developed due to structural deformation and geomorphic process / landform genesis are taken in to account. These integrated lithological-structural-geomorphic units are considered as aquifers. The different types of aquifers identified within the study area are unconsolidated sediments represented by alluvial and flood plains, Permeable Rocks which are the semi-consolidated sediments having primary porosity and permeability, and Fractured Rocks which generally acts as conduits for movement of ground water. (RGNDWM, 2008).

## V. GROUND WATER POTENTIAL MAP

Different types of aquifers were identified depending on the various combinations of the geological materials. The different types of aquifers were classified into 4 categories based on their geomorphic classes, lithological units and geological structures. This classification is done in accordance to their assumed or expected importance based on the *apriori* knowledge of the experts (Neelakantan and Yuvaraj, 2012; Krishna Murthy and Renuka Prasad, 2014). The final output is ground water potential map.

The different classes from ground water potential map can be described as follows-

*Very good:* This zone generally covers valley fill, flood plains and low-lying areas which are located within the proximity of water bodies, where there will be continual recharge. Besides, it includes the intersection of the structural units, such as lineaments and faults, with valley fill and flood plains. These geological structures offer channels for the sub-surface flow of water. Ground water can easily move through these fractures, and are found to be very suitable sites for ground water occurrence. Lithologically, this zone usually comprises areas where unconsolidated sediments, such as gravel, sand, silt and clayey sand are deposited. These have a high potentiality of retaining water since they allow maximum percolation due to their maximum pore spaces between the grains.

*Good:* All the remaining geologically structure controlled areas fall under the Good potential zone. The low-lying areas including gentle hillslope or Less dissected structural hills are included in this zone. Low and gentle relief areas have much better opportunities for infiltration and subsequent yield of ground water. Among the rock types exposed in the study area, sandstones are generally capable of storing and transmitting water through their interstices and pore spaces present in them, and are considered to be suitable aquifer. Hence, parts of areas where sandstones are exposed come under this zone.

*Moderate:* This zone mainly comprises areas where the recharge condition and the water-yielding capacity of the underlying materials are neither suitable nor poor. Topographically, it covers gently to medium sloping surface of the hill. Although the lithology may comprise good water-bearing rock formation such as sandstone, the potentiality is minimized by the sloping nature of the topography. In general, the moderate zone falls within the poor water-bearing rock formation such as silty shale that is, in turn, characterized by the presence of lineaments which formed secondary porosity in them.

*Poor:* This zone is mainly distributed in the elevated areas. In the area of high relief, a greater part of precipitation flows out as surface run-off, which is a poor condition for infiltration beneath the ground surface. Hence, the ground water yield is generally assumed to be low. Unless the elevated areas are traversed by geological structures, and possess high drainage density and suitable water-bearing rock formation, their ground water yield is generally low. The Poor zone is mainly distributed along the ridges is mainly considered as run-off zone.

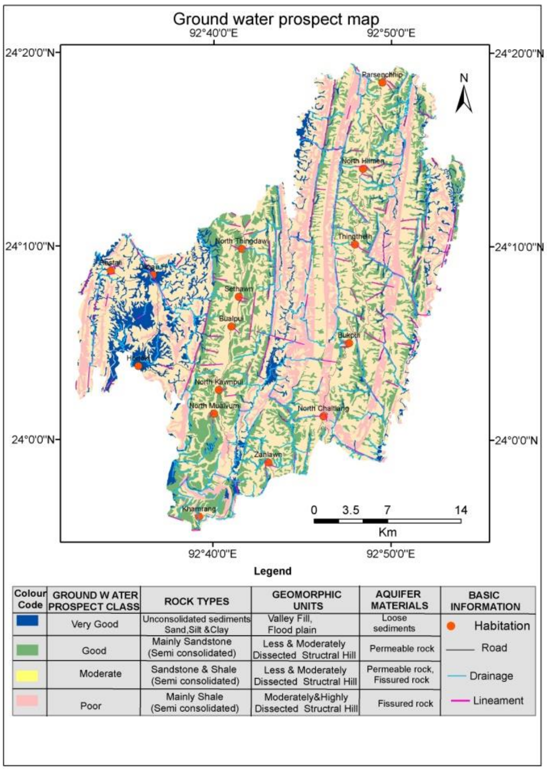


*Figure 4: Groundwater prospect map of the study area*

## VI. METHODO FOR GROUND WATER QUALITY ASSESSMENT

The base map was geo-referenced and digitized by using ArcGIS software for spatial analysis. The water samples were collected from 25 locations and were tested for their physico-chemical parameters. The characteristics of the water were subsequently evaluated using the Indian Drinking Water Standards as per BIS Guideline. The major parameters namely pH, Total Dissolved Solids, Alkalinity, Total hardness, Iron, Chloride, Nitrate and Fluoride of the samples were analyzed.

Spatial interpolation technique through Inverse Distance Weighted (IDW) approach has been used in the present study for generating spatial distribution of the ground water quality. This method is one of the most commonly used techniques for interpolation of scatter points and has been used extensively in ground water quality mapping( Ambica et al., 2017; , Mahalingam et al., 2014; Shyamala et al., 2017).

The spatial variation maps of major ground water quality parameters were prepared as thematic layers following BIS Guideline. This Guideline categorized each ground water parameters as Desirable limit, Permissible limit and Non-potable classes.

All the thematic layers were individually divided into appropriate classes and weightage value is assigned for each class based on their influence on the quality of ground water. This process is done in such a manner that less weightage represents better influence whereas and more weightage represent poorer influence towards the ground water quality. The assignment of weightage values for the different categories within a parameter is done in accordance to their assumed or expected importance in inducing different classes of the ground water quality (Ganesh Babu and Sashikkumar, 2013; Karthykeyan et al., 2013).

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## VII. GROUND WATER QUALITY MAP

Based on these spatial variation layers of major water quality parameters, an integrated ground water quality map of the study area was prepared using GIS technique. Results and discussion for the major parameters are as follows:

**7.1 pH:** pH is one of the important parameters of water quality which determines the acidic and alkaline nature of water. As per BIS guideline pH values of water were categorised into two classes viz., Desirable (6.5-8.5) and Non-potable (<6.5 and >8.5). Majority of the study area falls within desirable limit (6.5-8.5). However, considerable part of the study area falls in Non-potable classes (<6.5). The spatial variation map for pH was prepared and presented in Figure 5.

**7.2 Total Dissolved Solids (TDS):** The Total Dissolved Solids (TDS) of water is classified in to three ranges (0-500 mg/l, 500-2000 mg/l and >2000 mg/l) by BIS guideline. The present study area falls within the ranges of 0-500 mg/l and 500-1000mg/l, which are desirable class and permissible class respectively. The spatial variation map for TDS was prepared based on these ranges and presented in Figure 6.

**7.3 Total Hardness:** The Total hardness is classified in to three ranges (0-300 mg/l, 300-600 mg/l and >600 mg/l) by BIS guideline. The present study area was falls within desirable class. The spatial variation map for total hardness has been presented in Figure 7.

**7.4 Alkalinity:** According to BIS guideline, Alkalinity is categorized in to three ranges (0-200 mg/l, 200-600 mg/l and >600 mg/l). The present study area falls within desirable and permissible limits. Based on these ranges the spatial variation map for total hardness has been obtained and presented in Figure 8.

**7.5 Iron:** Concentration of iron was divided into three ranges as desirable, permissible and non-potable with values of <0.3 mg/l, 0.3-1.0 mg/l and >1.0 mg/l respectively according to BIS guideline. Desirable and permissible classes were found within the study area. The spatial variation map for iron is presented in Figure 9.

**7.6 Chlorides:** Chlorides was classified in to three ranges (0-250 mg/l, 250-1000 mg/l and >1000 mg/l) by BIS guideline. The entire study area falls within desirable and permissible classes in terms of chlorides concentration. The spatial variation map for chlorides has been presented in Figure 10.

## VIII. CONCLUSION

Geological factors like lithology, geomorphology and geological structures play important role for the occurrence of ground water. The ground water potential map shows detailed idea about ground water potentiality of the area. This, can therefore, forms an important database for developmental activities, and also for identifying critical areas for implementing ground development and management programme.

The Ground water quality map helps us to know the existing ground water condition of the study area. The calculation of ground water quality zones can be used for ground water exploration, development and management programme. Althought Iron concentration in more areas falls within permissible range, the major disturbing chemical characteristic of the water quality is pH value. It can be concluded that the quality of ground water need to be monitored on regular basis with the growing population and urbanization.

The study shows that remote sensing and GIS techniques can be used as vital tools in delineating ground water potential zones and for mapping ground water quality.

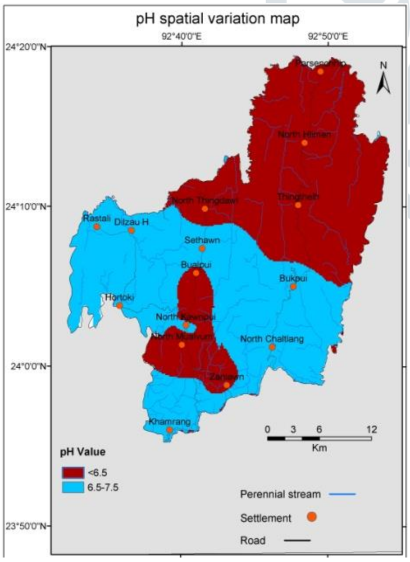


Figure 5: Spatial distribution of pH

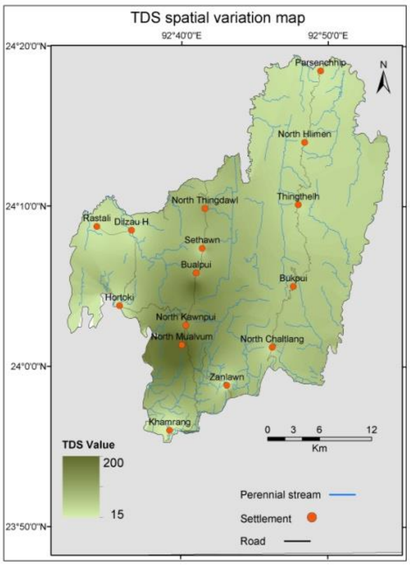


Figure 6: Spatial distribution of TDS

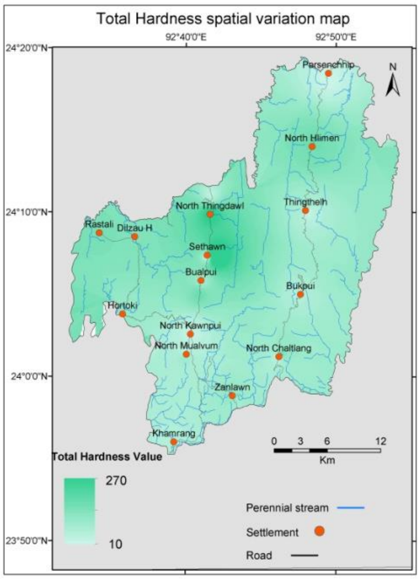


Figure 7: Spatial distribution Hardness

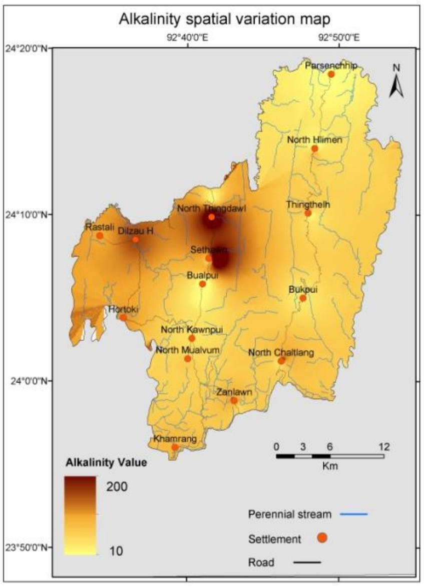


Figure 8: Spatial distribution of alkalinity

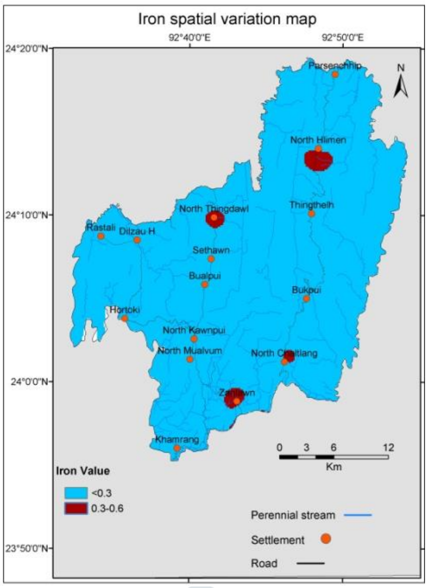


Figure 9: Spatial distribution of iron

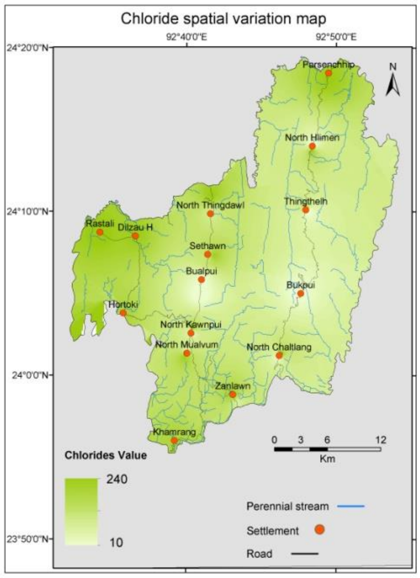


Figure 10: Spatial distribution of Chlorides

## IX. ACKNOWLEDGMENT

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