INTERNATIONAL RESEARCH JOURNAL OF ENGINEERING AND TECHNOLOGY (IRJET) E-ISSN: 2395-0056
VOLUME: 07, SPECIAL ISSUE | JUNE 2020 WWW.IRJET.NET P-ISSN: 2395-0072
International Conference on Recent Trends in Science & Technology-2020 (ICRTST - 2020)
Organised by: ATME College of Engineering, Mysuru, INDIA

Identification of Groundwater In hard Gneiss Terrain using Remote Sensing and GIS

Sharanya Ram S. R[1], Sanath Kumar K. R[2], Akash Kumar A[3], Sumant Kumar Khan[4]

[1-4]Department of Civil Engineering, Nagarjuna College of Engineering and Technology,Mudugurki Village, Bangalore, Karnataka, India

---

Abstract— Groundwater is one of the major sources of water in the outskirts of Bengaluru as the city progresses due to the developmental activities the demand for water is also increasing. Groundwater is a portable form of water that can be used without treatment for domestic purposes. Identification of aquifer is a complicated task that can be executed by integrating various thematic maps such as drainage map, geomorphology map, slope map, aspect map, land-use/land cover map and validated with in-situ Borehole data by using RS and GIS. Devanahalli taluk is a severely drought-affected area in the recent past with hard Gneissose terrain which again does not hold good for the groundwater. Lineaments are another geological structure that can yield a good quantity of water.

Devanahalli taluk spread over 450 sq km area river Arkavathi and the Dakshina Pinakini are the two rivers that flow from north to south of the district, have the 4th order drainage and have Semi dendritic to dendritic drainage pattern. Surface water is stored in 134 tanks in Devanahalli Taluk which acts as recharge sources for GW and also serves for irrigation. 128 number of lineaments are present in the Devanahalli taluk which holds good Source of Groundwater. Overly analysis of nine layers are utilized to find the potential zones of Groundwater.

Keywords: Aquifer, Water, Drought Management, Gneiss terrain.

1. INTRODUCTION

Remote sensing and GIS are useful tools to map the potential groundwater zones as it is quick and reliable with economical and less manpower than conventional techniques (M. Sedhuraman et. al(2014)). To serve the demands of the domestic and industrial water requirements, surface water is insufficient to fulfill the demand. Hence, there is a need for groundwater exploration. The water stored underneath the earth's surface in aquifers is referred to as groundwater (Govindaiah.S et.al (2017)). Identification of the groundwater is not an easy task, and at the same time, it's very difficult as the Aquifers provide small hints for its presence. When the terrain belongs to hard rock and the aquifer is at greater depth, then it cannot be confirmed by Groundwater potential zone mapping with the surface layers only, for this reason, borehole depth plays a key role in the aquifer identification. Many times in the shallow aquifers are identified by the clusters of Vegetations. In addition, quantitative morphometry of the drainage basin also plays a major role in evaluating the hydrological characteristics of the basin, which in turn helps to understand the groundwater condition (Krishnamurthy and Srinivas1995). Along with Morphometric parameters lineaments the large-scale linear cracks which are surficial expressions of underlying geological structural features like faults or joints also act as a source of groundwater in hard gneiss rock terrain (Chandra.S et al. (2006), Mondal. N. C. et.al (2008)). The high surface run-off controls the groundwater resources potentially as it depends on the lithological characteristics of the terrain (Ghosh.P et al. (2015)). Terrain properties like weathering grade, fracture extent, permeability, slope, drainage pattern, landforms, land use/land cover and climate which has potential command over the Groundwater storage (M. Sedhuraman et al. (2014),(Chandra.S et al. (2006),Govindaiah.S et.al (2017)). Groundwater storage begins with rainfall that porculate into the ground. The quantity of water that percolates into the ground varies according to the type of land surface cover and porculate into the ground is also strongly influenced by the season of the year (Dilip Kumar and Premendra Dev (2014)). However, it is important to note that the degree of influence of factors on groundwater occurrence varies and this may depend on space and time (Mallick. J et al. (2014).

The old and traditional methods of exploration such as field-based hydrogeological and geophysical resistivity investigations do not always take into account the diverse factors that control the occurrence and movement of groundwater (Jaiswal R. et al. (2003)). Systematic integrated synoptic view approach is a necessary requirement in the field of Groundwater exploration. Delineation of groundwater potential zones by the overlaying of thematic maps by weighted overlay method from the satellite data that is useful to identify the depth of unconfined aquifers and confined aquifers to semi-confined aquifers. (A. S. Jasrotia et al. (2013), Ghosh.P et al. (2015)), (Kesana Sai Teja and Dinesh Singh (2019)). Meteorological parameters like precipitation also have a major role in Groundwater recharge, Water in the basin is feeded in the form of precipitation as part of the hydrologic cycle (Dilip Kumar and Premendra Dev (2014)). Groundwater potential zones in skewed rainfall distribution area are identified by climatological aspects and multi thematic layer approach by Weighted index overlay analysis method (Gumma M. K and Pavelic.P (2012)). Rough sets were coupled with Lineaments data and Modified DRASTIC models with an information-analytic technique are helpful in understanding the aquifer vulnerability characteristics in the GIS environment (Khan. A et, al.(2014)). Analytic Hierarchy Process and multi-criteria decision making (MCDM) techniques are also useful for Groundwater identification in semi arid and hard terrain(Machiwal.D et. al., (2011)).The geomorphology and hydrogeological effects of the basin and the Multi-Criteria techniques are used for the analysis of groundwater potential zones (Dilip Kumar and Pramendra Dev (2014), Ghosh.P et al. and Machiwal.D et al. (2011)).

GIS have the capability to handle the larger remote sensing data sets, provide the facilities for the analysis of larger data sets and ground truth check is helpful for the further validation of results (Govindaiah.S et.al (2017)). Generating various thematic maps through remotely sensed data and their Analysis through GIS have proved that many thematic layers have indirect or direct control over groundwater occurrence (Jaiswal R. et al. (2003)). Applications of RS and GIS for the exploration of groundwater potential zones are successfully utilized by the researchers around the globe but prospective groundwater zones are poorly defined in the hard rock terrain (Ghosh.P et. al. (2015)). The integrated approach of subsurface studies show magnet, SP and resistivity method reveals that lineaments are also major resources of groundwater in hard rock terrains (Chandra.S et.al (2006)) along with it valley fill, valley flat alluvial plain are the target area for groundwater Preeja K. R. et. al., (2011). The borehole data are used for cross-validation Gumma M et.al.,(2012).

Groundwater serves as the major source for domestic and household needs in the semi-arid regions of Rural India. (Chandra.S et al. (2006)). Development in various sectors such as agriculture, industry and urbanization in countries like India, which has led to an increase in the demand of water supply mostly by the exploration of groundwater resources (Dilip Kumar and Premendra Dev (2014)). Economic and social development of any country the proper management of both surface and groundwater resources through systematic inventory, conservation and proper planning is essential (Jaiswal R. et al. (2003)). Due to depletion and uneven distribution of rainfall, nonexistence of adequate surface water, lack of water management techniques and the speedy progressive activities of society growth finally lead to the over exploitation of groundwater resources (Govindaiah.S et.al (2017)). Micro-watershed based development strategy is best suitable practice in drought-prone areas as the basic principle of watershed management is to conserve and develop water resources for land resource development and Management (Ghosh.P et al. (2015)).

2. STUDY AREA

Aquifer zone identification and subsurface mapping are done in Devanahalli taluk, Bangalore Rural district, Karnataka. It is covering an area of 450 sq. km. Devanahalli taluk is located between north latitude 13.0 06’44.0” and 130 21’53.7” & East longitude 770 33’26.7” and 770 50’04.4”. Devanahalli taluk is bounded by Chikballapur district on the North, Bangalore Urban district on the south, Hoskote taluk on east and Doddaballapur taluk on the western side. Location map of Devanahalli taluk of Bangalore Rural district is presented in fig. 1.

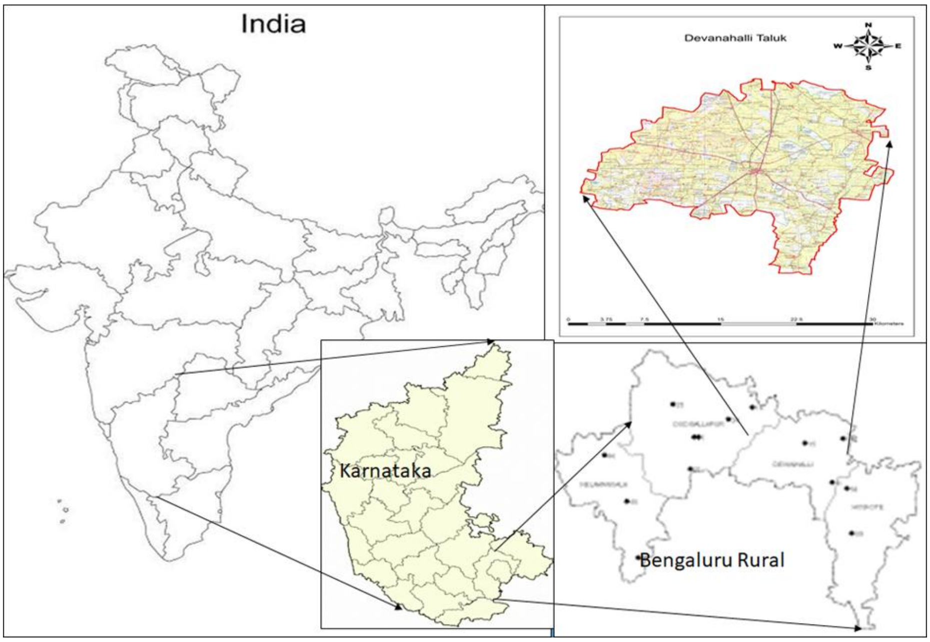

Figure 1. Showing Study Area, Devanahalli Taluk.

According to 2011 census, the population in Devanahalli taluk is 2,09,622. The study area has an overall devanahalli taluk has a population density of about 465 persons/km2.

The area falls under Karnataka state's eastern dry agro-climatic zone is categorized as drought-prone. The annual normal rainfall in Devanahalli taluk for the period 1981 to 2010 is 804 mm. Seasonal rainfall pattern indicates that a major amount of (447 mm) rainfall was recorded during South-West Monsoon seasons, which contributes about 56% of the normal annual rainfall, followed by North-East Monsoon season (216 mm) constituting 27% and remaining (140 mm) 17% in Pre-Monsoon season.(CGWB)

Geomorphologically, the taluk area is covered with uplands on Gneisses and Granites, which are ideal for agriculture. Physiography of the entire area is in the southern median region, characterized by an undulating landscape with broad valleys, where the surface elevation ranges from 700 m to 1338 m above mean sea level with a good degree of slope. The eastern part of the taluk is covered by prominent hill ranges which are the continuation of Nandidurga hill ranges running almost North-South direction and is the provenance for the sediment and drainage of Pennar. The remaining portion is having rolling topography undulating and gently sloping lands and valleys.

In Devanahalli taluk, there are no perennial rivers. There are a few streams that rise in the hills and feed the number of tanks. The drainage pattern of the area can be described as drainage pattern which is dendritic to sub-dendritic (S. Srinivasa Vittala et al. (2008)). The drainage patterns are described as sub-rectangular due to the marked influence of geologic structures and more or less similar lithological characteristics.

Devanahalli taluk is covered by four classes of soils that are clayey, clayey mixed, loamy skeletal and rocky land. The soil at the surface in this area are medium to coarse-grained texture, sub-surface soils are deep and heavily textured (S. Srinivasa Vittala et al. (2008))

Geologically, the area belongs to the Dharwar Supergroup of Archean Era. The main composition of rocks are granite and granitic gneisses which are exposed in the hills. Devanahalli is a Gneissose terrain that contains confined aquifers. The hydrogeological parameter is essential to investigate the availability of potable water from aquifer (Gail P et. al. (2011)).

3. MATERIALS AND METHOD

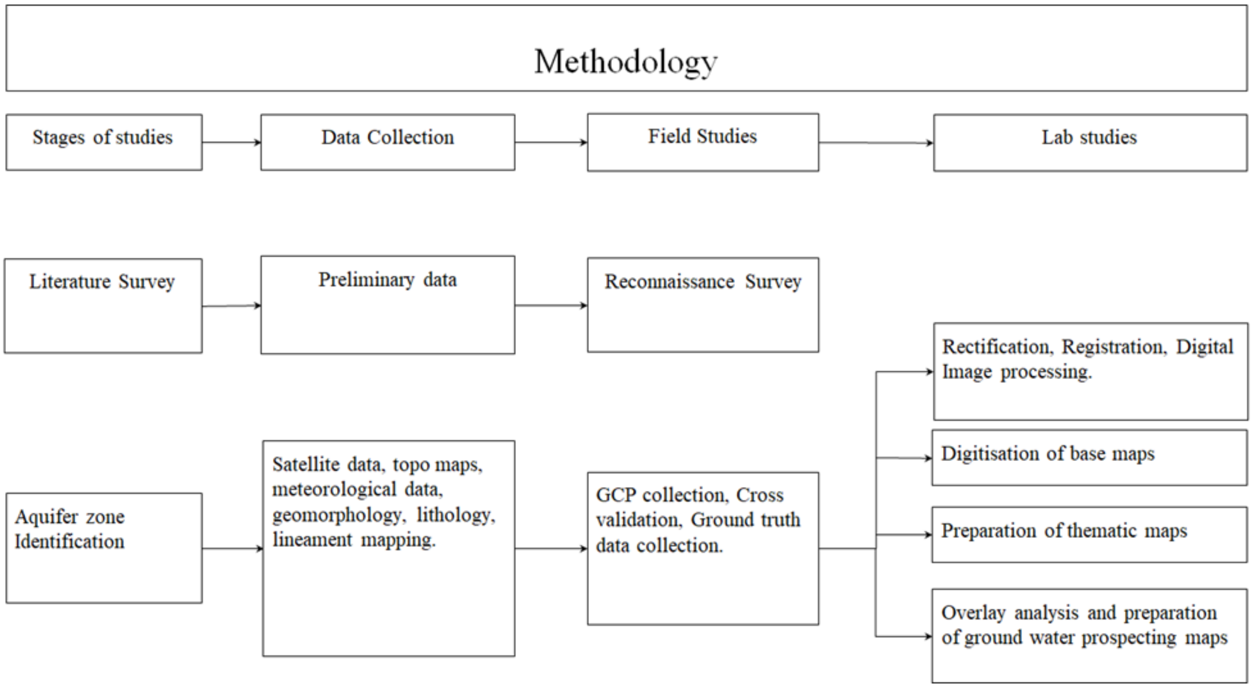

Figure 2. Flow Chart Showing the Methodology

[1] Satellite data from IRS Liss-III are collected from the Bhuvan portal.

[2] Topo Maps that are collected from the Survey of India are scanned and rectified using ArcGIS.

[3] Meteorological data collected from CHRS data portal for a few meteorological stations in the study area.

[4] The geomorphology map is prepared using the toposheets.

[5] Lineament mapping is prepared using the pre-existing map of the study area from NRSC website.

[6] Digital image processing is carried out for the satellite data from LISS-III to get LU/LC maps in ERDAS Imagine.

[7] Aspect map, Slope map and Contour map are prepared by using ASTER DEM.

[8] Digitization is carried out in order to get required thematic maps using base maps collected from various sources.

[9] Lu/Lc, Drainage, Lineament, Geomorphology, Slope, aspect, Contour, Rainfall data and Borehole depth data are used as raster data to carry out weighted overlay analysis to explore the potential zones of groundwater.

4. RESULT AND DISCUSSION

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads- the template will do that for you.

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

A. Drainage map

In this area 1st order to 7th order drainages are present and which have major influence on the infiltration and runoff. Total length of the drainages is 1206887.77 m and total number of different order of drainages are 3376.

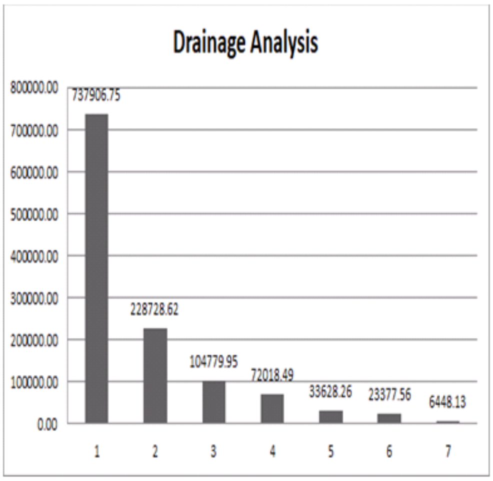

Figure 3. Flow Graph showing Length of the Drainage in Meters.

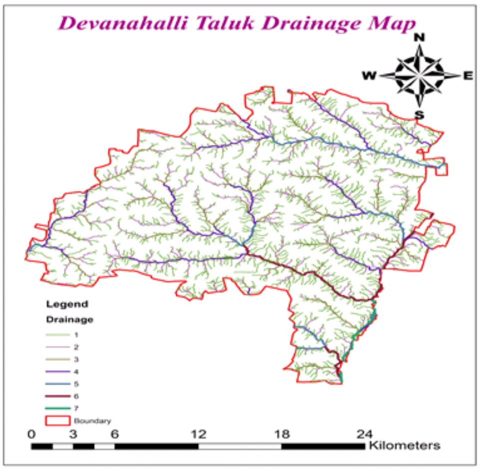

Figure 4. Drainage Map of Devanahalli Taluk

B. Lineament map

Devanahalli taluk has 126 lineaments and a total length of 9906 m distributed throughout the taluk. Most of them are minor lineaments in their shape and size and have good quantities of water bearing capacity.

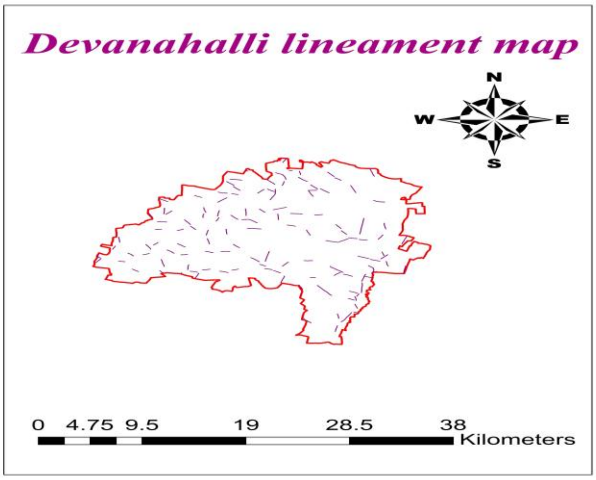

Figure 3. Lineament Map of Devanahalli Taluk.

C. Digital Elevation Model, Slope and Aspect map

Digital Elevation Model shows that areas have a minimum elevation of 764m, maximum of 1004m and elevation difference in the area is 240m. Northern side of the Devanahalli Taluk is covered with the hills, have maximum elevation and have gently sloping elevation in the east, west and southern part of Devanahalli Taluk. Slope map shows that areas have a maximum slope of 27.9% in few areas and remaining slope will be around 0-10%.

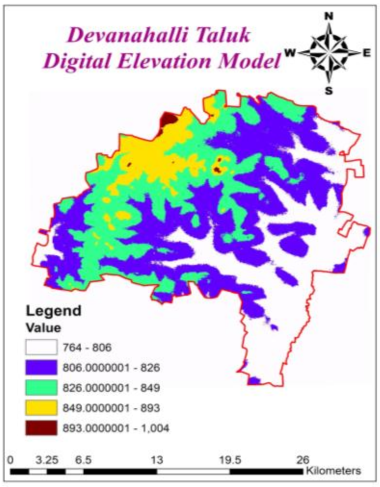

Figure 4. DEM Map of Devanahalli Taluk.

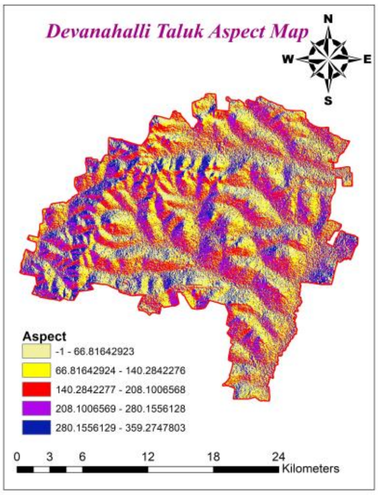

Figure 5. Aspect Map of Devanahalli Taluk.

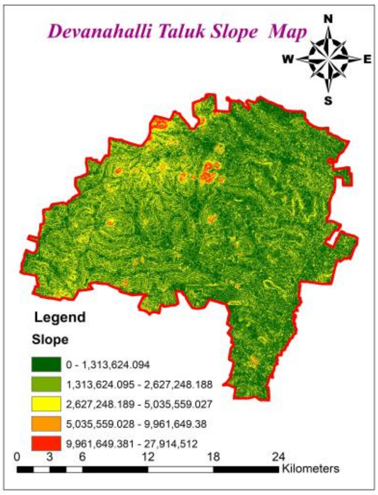

Figure 6. Slope Map of Devanahalli Taluk.

D. Land Use/Land Cover map

Lu/lc are classified into 10 classes most of the area is utilised for human settlement, Agriculture and to a certain extent is covered with surface tanks which holds most of the water in the taluk.

TABLE I. SHOWING LU/LC CLASSES AND AREAS IN METERS

Sl.No	Classes	Area
1	Road	34323455.77
2	Vegetation	58983670.42
3	Dry Vegetation	51197679.91
4	Patterned Vegetation	47954735.47
5	Thin Vegetation	18994190.45
6	Residential Area	66853867.84
7	Dry Land	53362844.97
8	Thick Vegetation	14115683.62
9	Uncultivated Land	75104928.37
10	Built Up Area	27431441.49

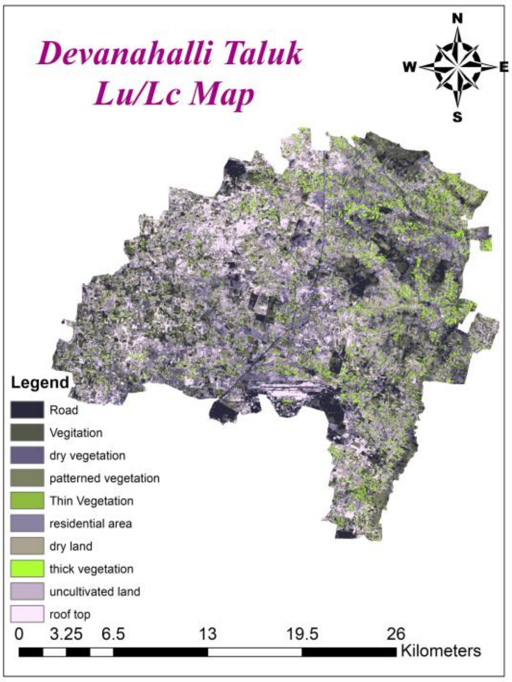

Figure 7. Lu/Lc Map of Devanahalli Taluk.

E. Geomorphology map

TABLE II. SHOWING GEOMORPHOLOGICAL UNITS AND AREAS IN METERS

Sl. No.	Geomorphological Units	Area
1	Antropic Terrain	2836244.94
2	Antropic Origin	644667.61
3	Denudation Hills	2839880.00
4	Denudation Pediplain	446542000.00
5	Water Body	22017083.71

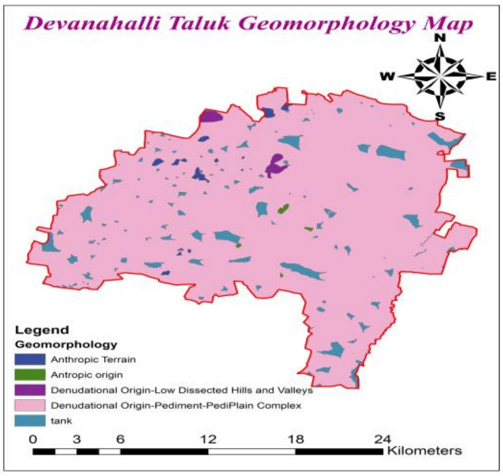

Figure 8. Geomorphology Map of Devanahalli Taluk.

F. Overlay Analysis

Overlay analysis is carried out with the weighted overlay method classified with 4 classes Excellent, Good, Moderate and Poor.

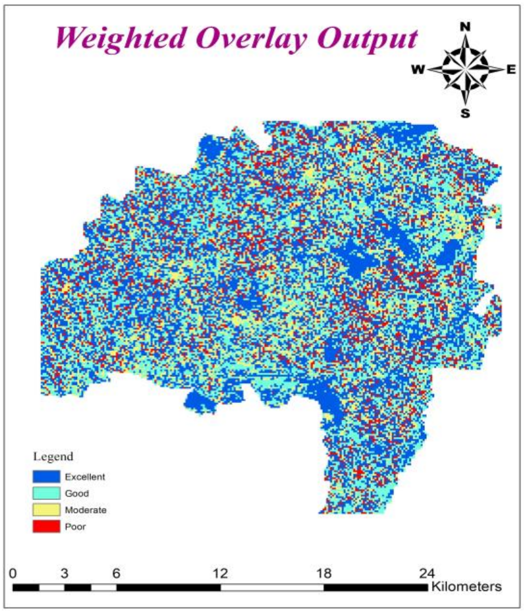

Figure 9. Overlay Analysis Output Map of Devanahalli Taluk

5. CONCLUSIONS

G. Overlay analysis draws the conclusion as follows:

Maximum areas which can hold a Moderate quantity of water and floodplain areas are the good potential zones of GW. Terrain belongs to the hard rock runoff is more and infiltration is very less hence tanks constructed across the stream to store the water. Northern part of the terrain has very little groundwater as it contains the high slope and hilly terrain. Southern part of Devanahalli Taluk is having good potential zones of groundwater as it has more tanks and 7th order drainages. Slope and aspect of the area reveals that the southern part of Devanahalli Taluk has a gentle slope compared with the northern part of the study area. The East and West part of Devanahalli Taluk have moderate groundwater potential zones, as they have moderate slopes. International airport is located at the southern part of the study area which needs more quantity of water. Rainwater harvesting is the only solution to recharge the aquifer, presently which is getting depleted due to the overexploitation of groundwater. Output is validated with the Borehole depth data which reveals that, borewell depth in few cases mainly depends on the Lineament and apart from this water is available at the Greater Depth around 1200ft. From the meteorological data it reveals that the source of Groundwater in Rainfall if failure in the seasonal rainfall hits directly the storage of GW intern results in the draught. Decrease in the water levels of the tanks are due to the highest evaporation rate in the study area in the peak summer.

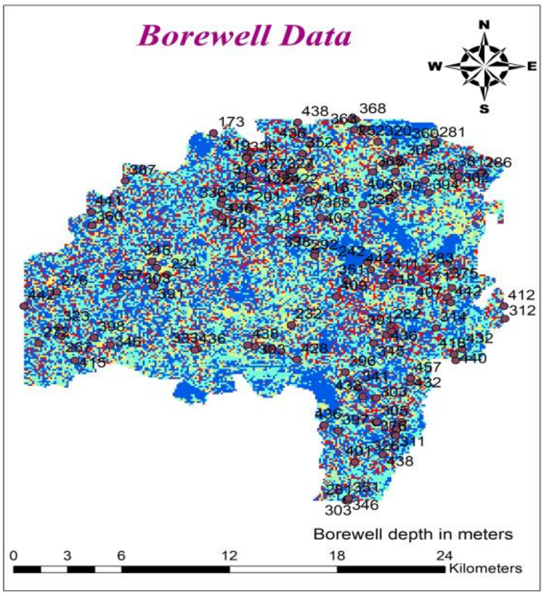

Figure 10. Overlay Analysis Output Map of Devanahalli Taluk

Acknowledgment

We would like to Acknowledge NRSC and Bhuvan ISRO for Providing LISS-III and DEM images to Carry Out this work. We would like to thank the Survey of India for Providing Toposheets required for the present study. We would also like to Thank USGS for Providing LANDSAT images. We would like to express our gratitude to NCET for giving the opportunity to pursue our Education and for continuous encouragement.

References

1. A.S.Jasrotia, A., Bhagat, B., Kumar, A. and Kumar, R. (2012). Remote Sensing and GIS Approach for Delineation of Groundwater Potential and Groundwater Quality Zones of Western Doon Valley, Uttarakhand, India. Journal of the Indian Society of Remote Sensing, 41(2), pp.365-377.

2. Chandra, S., Rao, V., Krishnamurthy, N., Dutta, S. and Ahmed, S. (2006). Integrated studies for characterization of lineaments used to locate groundwater potential zones in the hard rock region of Karnataka, India. Hydrogeology Journal, 14(6), pp.1042-1051.

3. Dilip Kumar and Premendra Dev (2014) "Groundwater Potential Zone Identification of Karwi Area, Mandakini River Basin, Uttar Pradesh Using Remote Sensing and GIS Techniques." International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org || Volume 3 Issue 11 || November 2014 || PP.10-19

4. Ghosh, P., Bandyopadhyay, S. and Jana, N. (2015). Mapping of groundwater potential zones in hard rock terrain using geoinformatics: a case of Kumari watershed in the western part of West Bengal. Modeling Earth Systems and Environment, 2(1).

5. Gumma, M. and Pavelic, P. (2012). Mapping of groundwater potential zones across Ghana using remote sensing, geographic information systems, and spatial modeling. Environmental Monitoring and Assessment, 185(4), pp.3561-3579.

6. Govindaiah.S et.al., "Delineation of groundwater potential zones of Tumkur-Gubbi watershed of Shimshal river basin, Karnataka, India, by using remote sensing and GIS techniques". Journal of international academic research for multidisciplinary. Impact factor 3.114, ISSN: 2320-5083, Volume 5, Issue 3, April 2017.

7. Jaiswal, R., Mukherjee, S., Krishnamurthy, J., and Saxena, R. (2003). Role of remote sensing and GIS techniques for generation of groundwater prospect zones towards rural development--an approach. International Journal of Remote Sensing, 24(5), pp.993-1008.

8. Khan, A., Khan, H., Umar, R. and Khan, M. (2014). An integrated approach for aquifer vulnerability mapping using GIS and rough sets: a study from an alluvial aquifer in North India. Hydrogeology Journal, 22(7), pp.1561-1572.

9. Karung Phaisonreng (2018) et. al., "Geospatial Technology-Based Groundwater Potential Zone Mapping In Parts of Noyyal Basin, Tamil Nadu, India." © 2018 IJSRST | Volume 4 | Issue 2 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X

10. Kesana Sai Teja, Dinesh Singh and Dinesh Singh (2019) "Identification of Groundwater Potential Zones using Remote Sensing and GIS, Case Study: Mangalagiri Mandal." International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-7, Issue-6 C2, April 2019.

11. M. Sedhuraman, S. S. Revathy, S.Suresh Babu (2014) "Integration of Geology and Geomorphology for Groundwater Assessment using Remote Sensing and GIS Techniques." International Journal of Innovative Research in Science, Engineering, and Technology (An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 3, March 2014.

12. Machiwal, D., Jha, M. and Mal, B. (2010). Assessment of Groundwater Potential in a Semi-Arid Region of India Using Remote Sensing, GIS, and MCDM Techniques. Water Resources Management, 25(5), pp.1359-1386.

13. Mondal, N., Das, S. and Singh, V. (2008). An integrated approach for identification of potential groundwater zones in Seethanagaram Mandal of Vizianagaram District, Andhra Pradesh, India. Journal of Earth System Science, 117(2), pp.133-144.

14. Mallick, J., Singh, C., Al-Wadi, H., Ahmed, M., Rahman, A., Shashtri, S. and Mukherjee, S. (2014). Geospatial and geostatistical approach for groundwater potential zone delineation. Hydrological Processes, 29(3), pp.395-418.

15. Preeja K. R., Joseph, S., Thomas, J. and Vijith H. (2011). Identification of Groundwater Potential Zones of a Tropical River Basin (Kerala, India) Using Remote Sensing and GIS Techniques. Journal of the Indian Society of Remote Sensing, 39(1), pp.83-94.

16. S. Srinivasa Vittala, S. Govindaiah and H. Honne Gowda (2008) "Prioritization of sub-watersheds for sustainable development and management of natural resources: An integrated approach using remote sensing, GIS and socioeconomic data". Current Science, vol.95, no. 3, 10 August 2008, pp.345-354.