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Influence of Geology and Terrain Characteristics on Ground Water Status of Rupnarayan-Dwarakeshwar Basin

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Abstract: ***The interaction of subsurface water with the surface water depends mainly on the geological and geomorphological setting of the landscape. Various geological and physiographic characteristics play a major role at different levels in the occurrence and movement of groundwater in any terrain. Water resources in the Rupnarayan-Dwarakeshwar basin are unevenly distributed in spatio-temporal domain. Here terrain parameters steer the discharge and recharge mechanism of ground water and it is observable in the water table fluctuation in the spatial domain. In this research, the application of satellite images proved to be very useful in identifying the landform characteristics of the study area. The study reveals the fact of low groundwater depth at the hard rock terrain and high depth of the same at the river mouth. The average depth of ground water of the basin is reported to be 4-8 metres below ground level. The findings obtained may be useful to study the interrelationship between specific terrain condition and the groundwater flow characteristics for future studies and also could be helpful for administrative planning purposes.***

Keywords: Laterite formation, Alluvial plain, LISS III, ASTER GDEM

1. Introduction

Water is considered as the most essential thing to sustain life for plants, animals and human beings. Even distribution of fresh water can satisfy all the needs of the human population. Our country is endowed with adequate water resources (4% of the total worldwide distribution) in form of perennial rivers and extensive groundwater [1] distribution is skewed in nature.
Our country is dependent on groundwater as the only source of drinking water supply because of its clarity and pollution free nature in comparison with the surface water [2]. However it gets contaminated due to natural and anthropogenic causes [3-8]. Apart from these, groundwater supplements rivers, lakes, and wetlands specifically in non-rainy seasons as base-flow [9]. Again, in rainy season groundwater gets recharged. Groundwater recharge may be broadly defined as the entry of water from the unsaturated zone into the saturated zone below the water table surface, together with the associated flow away from the water table within the saturated zone [10]. It occurs when water flows past the groundwater level and infiltrates into the saturated zone of groundwater [11]. In the context of groundwater recharge, the depth of groundwater becomes important. Depth of water in aquifers depicts a dynamic balance between groundwater recharge, storage and discharge. When recharge exceeds discharge, the water volume in storage will increase and water table will rise subsequently. Similarly, if discharge exceeds recharge, the volume of water will decrease and water table will drop down. Groundwater depth measurements also provide insight into the physical properties that control aquifer recharge, storage and discharge as these control the timing and intensity of responses to hydrologic stresses [12].
It is well established fact that the geological and terrain characteristics have a direct effect on the occurrence and movement of groundwater in any terrain. To assess groundwater potential it is necessary to understand different types of landforms and their characteristics, rock types and geological structures, the evolution of these landforms with respect to each other also need to be considered in this regard as they have definitive control over the movement and localization of groundwater. In addition to this, quantitative morphometric parameters of the drainage basin are crucial in evaluating the hydrologic parameters which in turn help in understanding the groundwater status in relation with the geological and terrain characteristics in a synergetic manner.

2. Study Area

Rupnarayan-Dwarakeshwar basin lies in the south-western part of West Bengal. It is bounded by 22°07´ N to 23°30´ N latitudes and 86°35´ E to 88°04´ E longitudes, having an area of 11349.64 sq. Km. (figure 1). The basin covers partially Puruliya, Bankura, Purba and Paschhim Medinipur, Hugli, Haora and Barddhaman districts of West Bengal. The climate of the basin is characterized by ‘monsoon’ conditions, representing seasonal rhythm. The alluvial basin is well drained by a number of perennial and non-perennial rivers.

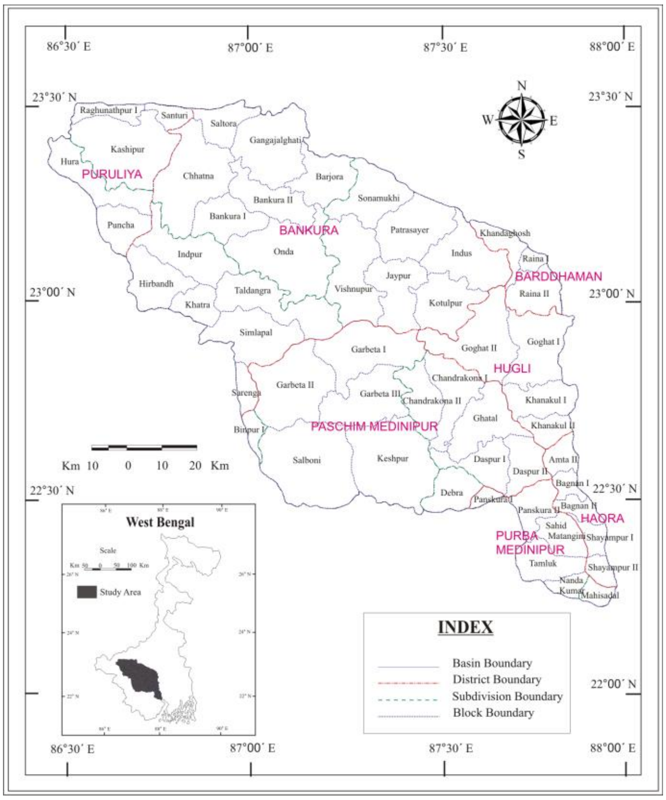

Figure 1: Study area

3. Materials and Methods

To assess the geological and terrain characteristics of the basin, the geological map of the southern part of West Bengal was collected from Geological Survey of India(GSI). The map was subset and digitised accordingly. The landform types and terrain characteristics were determined from Survey of India (SOI) toposheets of 1:50,000 scale and ASTER GDEM of 30 m spatial resolution. The draineage map has been created from IRS P6 LISS-III images and Survey of India toposheets. The groundwater information has been collected CD block wise from the Central Ground Water Board (CGWB), Govt. of India and State Water Investigation Directorate (SWID), Govt. of West Bengal. All the maps and satellite images were co-registered and clipped according to the shape of the basin.

4. Results and Discussion

4.1 Geological Formation

The basin is formed of rocks of various formations – from Achaean Proterozoic Metamorphic to the sedimentaries of recent age (figure 2) (table 1). The north-west part of the basin is mainly represented by Proterozoic with patches of Achaean Proterozoic metamorphic mainly composed of granite-gneiss, biotite, schist and quartz veins.

The middle part is composed of Cainozoic Laterite formation and Lower Pleistocene formation in between. Laterites occur in hard massive beds and blocks. Towards east of the basin, rocks are mainly of Lower Pleistocene and Holocene age. Layers of sandstones are frequently found with embedded pebbly conglomerates. The southern portion of the basin is marked by Middle to Upper Quaternary formation and Cainozoic Laterite formation. The laterites rocks are mainly gravelly, pisolitic and nodular in nature. Laterites occur here as duricrusts with varying thickness (6-15 m) [13]. The south-eastern part of the basin is composed of alluvium of Holocene age and presents no features of special geological interest.

Table 1: Stratigraphic succession and sequence of geological formation

Era	*Period*	*Epoch*	*Formations (Rocks)*
Cambrian	Quaternary	Holocene	Daintikri Formation (Q_2P)
		Pleistocene	Lower – Sijua Formation (Q_1S)
	Cainozoic		Upper to Middle – Lalgarh Formation (Q_1l) (Residual Soil)
			Laterite (C_zl)
---------------------------------Unconformity---------------------------			
Pre-Cambrian		Anorthosite (P_ta) Proterozoic	Chotanagpur Granite Gneiss
			Complex (Ptc) i) Composite Gneiss ii) Quartz – Biotite Gneiss
		Achaean Proterozoic	Unclassified Metamorphic (Apt_1m)

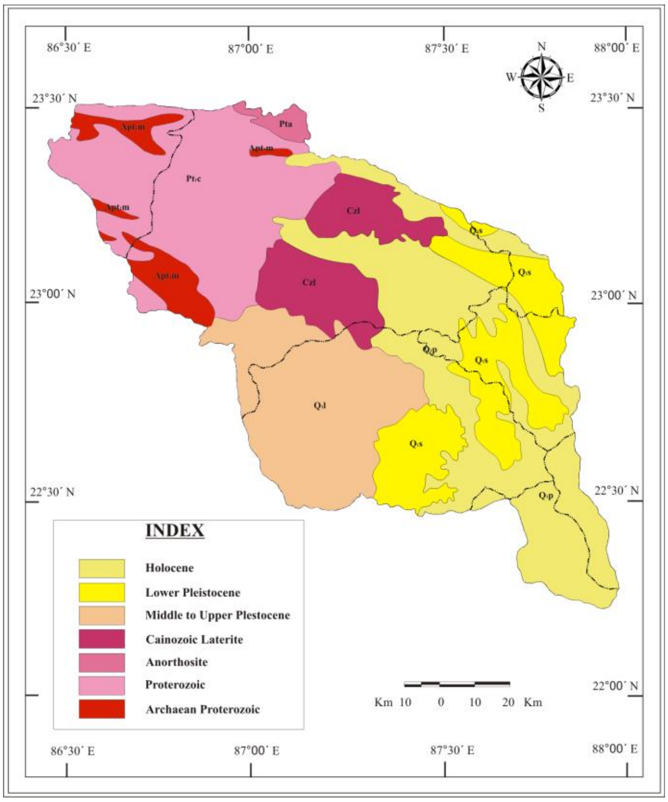

Figure 2: Geological formation

4.2 Terrain Characteristics

Relief is the surface expression of underlying geological configuration. The topography of the basin is highly variable, though the general slope of the land is from NW to SE. Based on the contour pattern and the drainage system, the entire basin can be divided into two broad groups, namely low dissected plateau and alluvial plain (figure 3) [13].

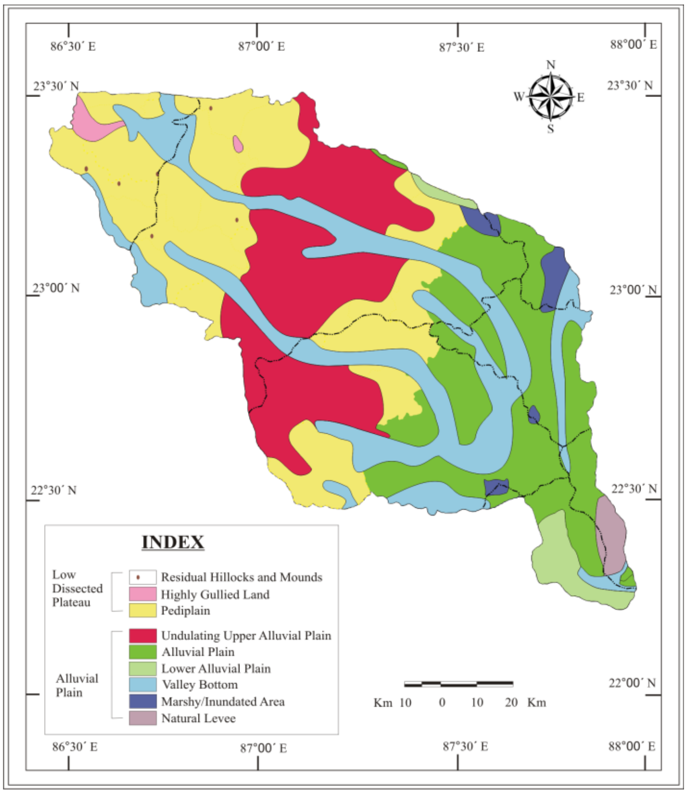

Figure 3: Landform types

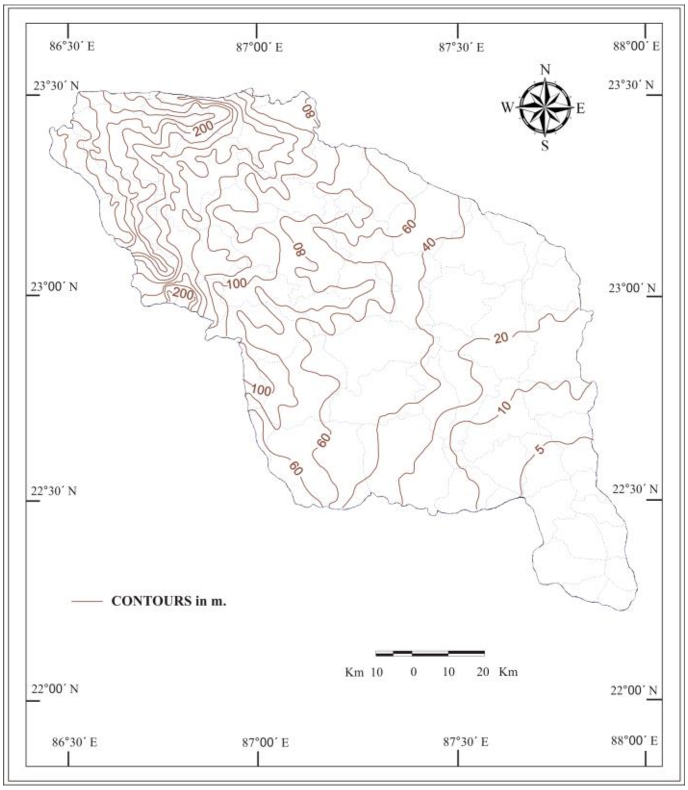

Figure 4: Absolute relief

The north-western part of the basin is covered with highly gullied land and pediplain. The average elevation of this part is 150 m. The 100 m contour marks the eastern boundary of the low dissected plateau (figure 4). The area covers approximately 30% of the whole basin. This region is distinguished easily from the adjoining alluvial plain because of its higher elevation and undulating character. Excessive soil erosion aggravated by flash floods is the characteristic feature of this region. Intensive vertical valley deepening gives rise to steep valley profiles. In the southern and south-western parts of the low dissected plateau some residual hillocks and mounds of low altitude are found.

The alluvial plain covers nearly 70% of the entire basin area with an average elevation of 30 m. The alluvial plain based on the height of the terrain can be subdivided into three parts, namely undulating upper alluvial plain, middle alluvial plain and lower alluvial plain. The upper alluvial plain lies in the middle portion of the basin. This undulating older alluvial plain is detached by the 80 m contour from the low dissected plateaus of the western part of the basin. The middle alluvial plain covers approximately 50% of the entire basin area. It is composed of the younger alluvial deposits of Dwarakeshwar and Silai rivers. It is differentiated by the 50 m contour from the upper alluvial plain. The slope is gentler here and decreases to the SE. The region is marked by patches of marshy and inundated area in the NE and SE. The natural levee can be found at the SE corner of the region where the average height is 3 m. The lower alluvial plain is also composed of younger alluvial deposits. The average height of this part of the basin is 3 m. The lower and middle alluvial plains are liable to recurrent floods in rainy season. The digital elevation model (DEM) shows the 3D effect of the landform. The DEM was prepared from the ASTER GDEM and above which IRS P6 – LISS III mosaiced image was draped for visualisation (figure 5).

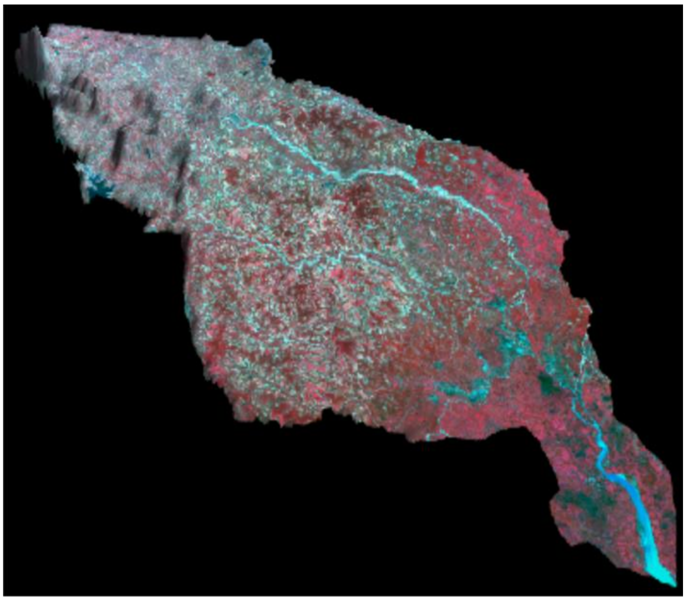

Figure 5: Digital elevation model

4.3 Drainage System

The Rupnarayan – Dwarakeshwar basin is well drained by a number of perennial and non-perennial rivers (figure 6). The perennial condition increases from NW to E and SE direction. The drainage system of the region consists of mainly three rivers with their tributaries, namely Rupnarayan, Dwarakeshwar and Silai [13]. Along with these three rivers, Gandheshwari, a small river with rocky beds flowing SW of Susunia hill and north of Bankura district is also important. It joins the Dwarakeshwar River near Bhutsahar at Bankura town. The Gandheshwari River is prone to flash floods in the rainy season.

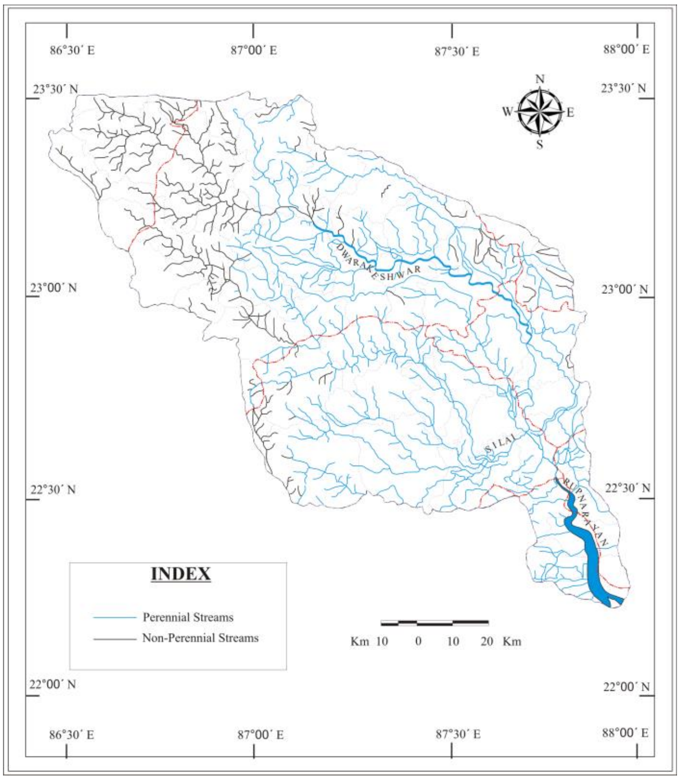

Figure 6: Drainage network

The upper portion of the course of the Rupnarayan, a tidal river throughout its course is called the Dwarakeshwar River. The Rupnarayan River enters the basin in the north-east of Ghatal block and follows a south-easterly course upto Tamluk, after which it bends to the east and exits the basin. The Dwarakeshwar or Dhalikisor River is the main river flowing through this region from NW corner with all its tributaries. The Dwarakeshwar river originates near the Tilabani hills in Puruliya district and flows towards SE direction and enters Bankura district near Dumda in Chhatna. The river follows a tortuous course to the SE with some bifurcations through Bankura, Onda and Vishnupur blocks and leaves Bankura district near Huzra in Kotulpur block and enters Hugli district at Goghat. The Dwarakeshwar river, in its lower course, after the confluence with the Silai River, near the border of the Purba Medinipur district becomes the Rupnarayan River. In rainy season, this river is subject to heavy flood.

The Silai or Silabati River also rises from Puruliya district near Salanpur in Khatra block. It follows a tortuous course at the lower part of the basin towards east. Afterwards it turns to the SE and south through Ghatal block and joins the Dwarakeshwar River to form the Rupnarayan River. It is navigable throughout the year in its lower portion. Silai River is also highly susceptible to floods in rainy season.

4.4 Groundwater Condition

In the context of adequate drinking water supply and increasing crop yields, development of groundwater resources is essential. In the upper layers of the surface, groundwater is found in the vicinity of porous, fractured and jointed crystalline and weathered rock beds and within the sediments along the major river valleys. Large reserves of sub-surface water resulted in course of geological time, despite the fact that only a small portion of the precipitation from any single storm may reach the saturated zone. Occasionally highly mineralised water is trapped in sedimentary strata. The spatial variation of the depth of groundwater is essential for the appraisal of the groundwater resources of an area. This helps to classify the whole basin into very low, low, medium, high and very high depth zones (figure 7).

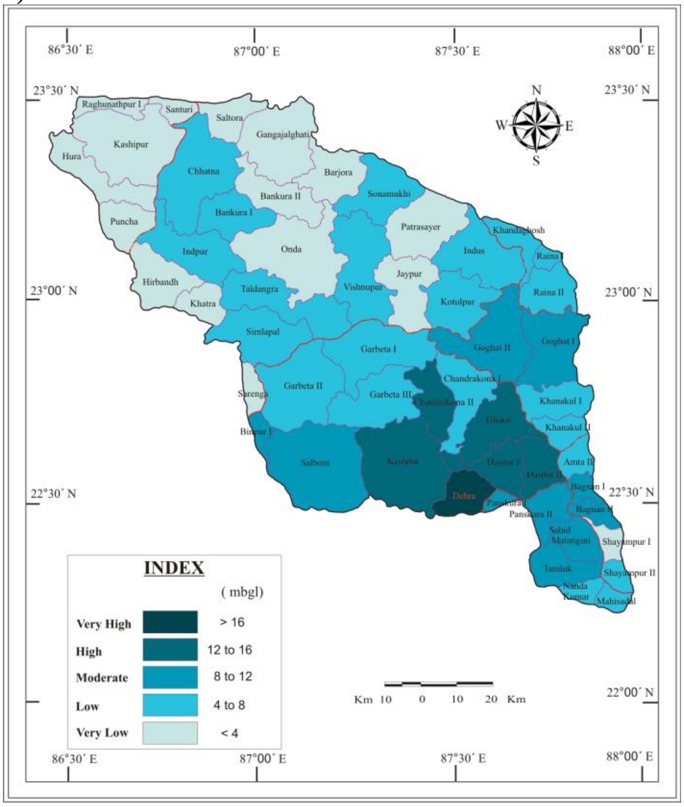

Figure 7: Average depth of groundwater

Very low depth zone covers the NW part including five blocks of Puruliya district of the basin where the depth of groundwater is 4 metres below ground level (mbgl). The zone also forms a narrow strip covering Hirbandh, Khatra and Sarenga blocks of Bankura district. This zone is identified as very high groundwater potential zone. Low depth zone covers north, central and extreme SE parts of the basin where the depth ranges between 4 to 8 mbgl. This is the most continuous and extensive region where the conditions are favourable to large scale exploitation of groundwater and may be considered as high groundwater potential zone. Medium depth zone covers the SE parts of the basin, mainly with patchy occurrence in Binpur-I and Salboni blocks of the basin. The depth ranges between 8 to 12 mbgl. This zone has medium groundwater potential. In the high depth zone, the groundwater ranges between 12 to 16 mbgl. This zone is less continuous covering the blocks of Ghatal, Daspur-I & II and Keshpur of Paschhim Medinipur district. This zone is identified as the low potential zone. Only Debra block of Paschhim Medinipur district comes under the very high depth zone where the depth is more than 16 mbgl. The groundwater level exists in the deep, underlying fractured zones. This block is demarcated as very low groundwater potential zone.

4.5 Relation between Terrain Condition and Groundwater Status:

The interaction of surface and subsurface water in river basin is affected by the interchange of local and regional groundwater flow systems with the rivers and by flooding and evapo-transpiration. Small streams get inflow of groundwater primarily from local flow systems, which usually have limited extent and are highly variable seasonally. In case of larger rivers that flow in alluvial plain, the interaction of groundwater and surface water is generally more diverse than it is for smaller streams. If we have terraces present in the alluvial plain, local groundwater flow systems may be associated with each terrace. As a result of this, lakes and wetlands may be formed. In the areas of river valley walls, local and regional groundwater flow systems may discharge in close proximity [14].

The water table does not usually lie far below the land surface in alluvial plain. Therefore, plant root systems can transpire water directly from subsurface water. In areas of groundwater discharge, vegetation effect lowers depth of water. Similarly, urbanization and extraction of water can also cause loss of groundwater. This is actually happening in the SE part of the basin. In comparison to this, the hard-rock terrain in the NW part is able to retain water at the subsurface level. Therefore, in this region, the depth of groundwater is very low. Due to high amount of infiltration in that region, the surface water becomes scanty, but increases the scope of groundwater storage.

5. Conclusion

The present paper describes two major aspects of the study of the groundwater level: the influence of geological background and the impact of terrain condition. The description of geological formation and landform characteristics has been proved to be useful in understanding the spatial pattern of groundwater depth. The application of remote sensing proved to be effective in understanding the landform and drainage characteristics in this regard. The study supports the fact of the availability of groundwater near the surface in hard rock terrain. However, the study found that near the mouth of the Dwarakeshwar - Rupnarayan river, the depth of water table is more. Dense population, agriculture and resultant consumption of groundwater are suspected as the probable causes of groundwater depletion in that area. However, the study may be considered as one of the important steps of research on groundwater condition in the area and useful for administrative policy makers.

6. Acknowledgement

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