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GROUNDWATER STUDIES THROUGH DIGITAL ANALYSIS OF IRS LISS- II DATA IN JAMUNIYA RIVER BASIN, DISTRICT BALODA BAZAAR [CG]

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Abstract

Baloda Bazaar has been well known for occurrence of karstic limestone, geologically. It has been extensively extracted for supply of cement grade limestone to ongoing CG Cement Industries. The karstic limestone has other significance for being promising to potential local aquifer [groundwater bearing zone]. It has been utilized as supplement of irrigation to the traditional cultivation of rice, since the area is "Bowl of Rice in CG".

Jamuniya river basin of District-Baloda-Bazaar has been selected to conduct scientific study for its hydro-geological significance towards occurrence of groundwater in prevailing karstic limestone terrain. Karstic aquifer has been established in-fact globally, as leading source of groundwater supply to New-York city and it's surrounding [USA]. The evolved methodology is based upon two approaches namely: Conventional and Advance. The Conventional approach is based upon relevant literature review and field observation for the identification of few surface karstic features and basic terrain characteristics. The Advance approach is based upon developing digital interpretation tools through IRS LISS-II Satellite data for precise delineation of surface and sub-surface related karstic features with their field validation. Ten karstic features in the area of study have been documented with their identification.

The documentation of major karstic features has been perspective groundwater bearing zone for high yield of groundwater extraction. These are to be further proved through Resistivity Investigation [Geophysical tool] before actual drilling for their successfulness. The protection cum conservation of karstic aquifer in the area is demand of time to fulfill the requirement of potable - renewable groundwater in different sectors namely: Irrigation, Domestic water supply and allied developmental activities, at local to regional scale.

Introduction

Jamuniya river has its length about100 Km. The drainage basin of Jamuniya river, with elongated shape; belongs to left portion of Shivnath river sub-basin, in Mahanadi river catchment. It has been originated at village- Chikhali [elevation of 304 m] in Tehsil-Arang of District Raipur. It has started as Jamuniya nalla with flowing SE to NE direction and covering localities namely- Tilda, Neora, Baikunth, Sakri, Rawan and Sonadih [elevation 232 m]. It has confluence with Shivnath river. Jamuniya nalla has another tributary named Banjari nalla in eastern portion and meets at village-Gohri and afterwards it is called Jamuniya nadi/ river.

The eastern boundary of Jamuniya river drainage basin follows Rudri Barrage Left canal, which is also called Mahanadi canal [Modified in1992-93]. The Banjari nalla at village-Kumhari has Kumhari Earthen Dam, constructed by British Government in 1927 for irrigation purpose. These Hydraulic structures namely: Canal and Earthen Dam in Jamuniya river drainage basin are the part of surface water related irrigation projects and is lacking for any scientific groundwater related study/project of government sponsored. The area is famous for cultivation of rice over agricultural soil, produced by weathering of karstic limestone and alluvium along nalla cutting, traditional as well as proudly, “Bowl of Rice in CG”.

Area of Study

Jamuniya river drainage basin belongs Survey of India topographic-sheet No. 64K/1 & 64K/2, with geographic coordinates: Latitude N 21° 26’ to N 21°-47’ and Longitude E81°45’ to E 82° 15’. It is one of the smallest drainage basin of Sheonath sub-river basin and illustrated as Fig.1-Location map for area of study

Administratively, it belongs to District Raipur and Baloda Bazaar. It is well connected by Raipur-Belha road-as State Highway No. 130- B.

Fig. 1 Location Map for area of study

Evolved Methodology & Objectives

The evolved methodology has two approaches namely: Conventional and Advance. The conventional approach is based upon relevant literature review and field observation. The advance approach is based upon developing digital interpretation tools of corrected IRS LISS-II [MSS] –Satellite data along-with field validation.

The desired objectives are as follows:

- Identification of prominent karstic features at preliminary level in field for documentation and validation purpose in relation to favorable groundwater perspective zone.
- Pre-processing of IRS LISS-II [MSS]-Satellite data, with creation of Sub-scene in synchronization with relevant field observation.
- Developing digital interpretation tools for précised delineation of karstic features with field validation.

Result & Discussion

The mode of occurrence for groundwater in Jamuniya river drainage basin depends upon local Geomorphology, Geology, Hydrology and Hydrogeology.

Geo-morphologically, the area has following basic characteristics as per interpretation of Survey of India, topographic sheet No. 64K/1 & 64K/2:

- ✓ Surface relief as per orientation, variation and pattern of contour is in between highest elevation [304 m] to the lowest elevation [232 m],from origin of jamuniya nalla to the confluence of Jamuniya nadi with Sheonath river. It is illustrated as Fig.2 Surface Relief Map. The surface relief governs the flow direction and movement of groundwater at subsurface.
- ✓ Type of Landform, governs the distribution of groundwater at subsurface. Four types of landforms occur in the area, namely: Pediplain, Terra rossa, Alluvium & Agricultural plain. The pediplain and terra rossa are karstic feature of surface nature and have not any connection with groundwater. The alluvium is being recent deposit along nalla section and river vicinity and having sufficient groundwater properties, but their occurrence is very limited. The agricultural plain is extensively distributed and occurs on account of weathered product of karstic limestone in association with alluvium. It requires lot of water of surface and groundwater both categories for cultivation of rice.

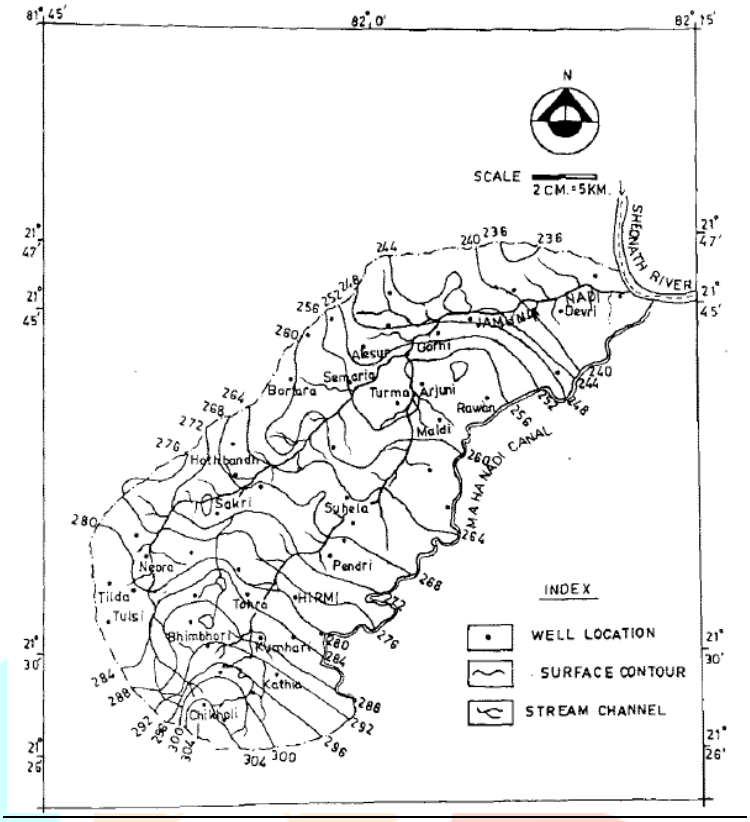

Fig.2 Surface Relief Map

- ✓ Human settlement is the prime area for groundwater consuming centers towards domestic supply. The area have prominent human settlement in the form of village/town and are: kothia, Kumhari, Bhimbhari**,** Tilda, Neora, Tohra, Hirmi, Suhela, Sakri, Hathbandh, Rawan, Semaridh, Gorhi and Sonadih from southern to northern direction.

Geologically, the area of study has been dominated with disposition of calcareous rock of sedimentary origin. It is composed of stromatolic limestone of purple color and dolomitic limestone of grey color with shale intercalation. The stromatolic limestone belongs to karstic aquifer, while shale of impermeable nature [1]. The stromatolic limestone has been associated with open joint in rectangular pattern and illustrated as Fig.3.

Hydrologically, the area has hydraulic structures as Dam, Canal and several surface water ponds of varying shape and sizes, including stream with their confluence, nalla, nadi as well as river. The surface drainage is mixed with dendritic to trellis. The average annual rainfall is of 1250 mm.

Fig.3 Stromatolic limestone, associated with open joint in rectangular pattern

Hydro-geologically, the area has two categories of aquifer namely: promising to potential and poor. The promising to potential aquifer belongs to Stromatolic limestone with extensively occurrence in the area. The poor aquifer belongs to dolomitic limestone and occurring in scattered manner with isolated patches. The Stromatolic limestone has two conventional types of aquifer namely Unconfined aquifer and Confined aquifer [2].The Unconfined [pheratic] aquifer is associated with weathered zone, fractured limestone with occurrence of shale at bed from ground surface to depth. It is suitable to most of dug wells and illustrated as Fig. 4, as per field observation at village: Tohra

Fig. 4 Un-confined aquifer with typical dug well at village: Tohra

The recharge characteristics for unconfined aquifer have been rainwater infiltration along surface karstic features like: Swallow Hole, Limestone Pavement-who facilitate it more smoothly and verified through field validation. The Swallow Hole has been observed along the path of Jamuniya nalla, explaining the gaining nature stream at village Khapri and illustrated as Fig.5. The Limestone Pavement has been observed along bedding plane of karstic limestone on smooth surface. The bedding plane is parallel to open joint and widened through solution activity and observed at village Khapri as well as illustrated as Fig. 6. The

alluvium occurrence along nalla cutting of Banjari nalla does also act as natural percolation of limited nature. The depth of unconfined aquifer varies in the range of 6-8 m from the local ground surface along-with hydraulic gradient in the range of 2.5 m to 4.5 m/Km, during the period Jan 1994 to Jan 1996.

Fig 5 Swallow Hole along Jamunia nalla

Fig.6 Limestone Pavement at village: Khapri

The Confined aquifer is influenced by karstic features predominantly with it's occurrence up-to depth of karstification process in depth the range of 10-15 m from the ground surface. It has been also underlained by shale bed. It is recharged through infiltration along hydraulic structures [canal & dam] and surface ponds. The groundwater fluctuation is minimal of 1.1 m at village: Saraidih and maximum of 12.5 m at village: Meera during pre-monsoon period and 2-5 m during post-monsoon period.

The well failures have been observed at villages namley: Kathia, Kuthhhirand and Pendari even after post-monsoon season, on account of their locations over dolomitic limestone. It has been also influenced by Lateritic capping present on the ground surface.

- **Identification of prominent karstic features at preliminary level in field for documentation and validation purpose in relation to favorable groundwater perspective zone.**

Karstic features have two types of origin namely: Fluvial and True karstic [4]. The Fluvial is related to surface river water regime, with example of Pediplain and belong to shallow depth. The True Karst is related to karstification process with belonging to sub-surface and surface, both. The surface related karstic features like- swallow Hole and Limestone Pavement have already identified with their validation towards recharge aspect of unconfined aquifer. Terra rossa is typical surface karstic feature, developed through physical weathering, has not any relevance with groundwater. The names of subsurface karstic features, as per field observation are: Solution Cavities, Sink-hole, Paleo-drainage, Paleo-karst and Lineament and have been associated with groundwater. Solution Cavities are narrow opening of irregular shape and size from surface to subsurface under the influence of solution activity. It is confined by shale under geochemical weathering and illustrated as Fig.7. Sink-hole has cylindrical to funnel shaped closed depression along fractured limestone with presence of groundwater. Paleo-drainage is sub-surface water carrying conduit / channel in karstic limestone terrain covered by recent sediments. Paleo-karst is subdued karstification activity of past. Lineament is regional tectonic, controlled by surface and subsurface drainage. Karstic limestone is surface outcrop with rectangular joint pattern All ten identified karstic features are summarized in Table 1.

Fig.7 Solution cavity

- **Pre-processing of IRS LISS-II [MSS]-Satellite data, with creation of Sub-scene in synchronization with relevant field observation**

IRS LISS II [MSS Bands # 4, 5, 6 & 7] has been used of date 23 January 1994 with path & row-23/53. The field observation for major karstic features had been carried out during the same period as reconnaissance survey during 20-30 January 1994. It had been executed for synchronization purpose in between Satellite data and actual field cum terrain characteristics during the same period. The detailed field work along-with other study had been carried out during the remaining period of study [3]

S N	Name of karstic feature	Mode of occurrence	Identification tools
1	Pediplain	Hydro-geomorphic activity	Field Observation & Digital Interpretation
2	Terra rossa	Physical weathering	Field Observation
3	Swalllow Hole	Structural Geology	Field Observation
4	Lime Pavement	Structural Geology	Field Observation
5	Solution cavities	Structural Geology	Field Observation
6	Sink-Hole	Geochemical activity	Field Observation & Digital Interpretation
7	Plaleo-Drainage	Hydrogeological activity	Digital Interpretation
8	Paleo-karst	Geological acivity	Digital Interpretation
9	Lineament	Regional tectonics	Digital Interpretation
10	Karstic limestone	Geological acivity	Field Observation & Digital Interpretation

Table 1: Major Karstic Features of Jamuniya River Drainage Basin

IRS LISS II Satellite data has vast geographical area at regional scale. So, the Sub-scene of 512X512 pixels has been created for the concerned area of study purpose. The Sub-scene had been rectified for radiometric and geographic correction- as pre-processing before the actual digital interpretation. The radiometric corrections have been applied through two Sub-scenes of same path, but different adjacent rows have been merged to each other for data of same date. Similarly the geometric corrections have been applied through selection of 25 Ground Control Points [GCP] from Survey of India topographic sheet 64K/1 & 64K/2 for geo-reference purpose. The sub-scene has been almost cloud free for digital interpretation purpose.

- **Developing digital interpretation tools for precise delineation of karstic features with field validation**

The preprocessed Sub-scene has been analyzed digitally through standard tools as well as their further developing tools by interchanging various band relationships in order to get more précised karstic features with their field validation. The utilized standard and developing tools for digital interpretation are summarized as follows:

[1] BAND RATIO:- The band ratio of 4/2 without designation any color code has delineated Paleo-drainage & Pediplain near the confluence of Jamuniya nadi with Sheonath river at both banks, along Sonadih. It is illustrated as Fig. 8 & Field validation as Fig. 9.

Fig.8 Paleo-drainage through Band ratio 4/2 along village; Sonadih

Fig.9 Pediplain along Jamuniya nadi

[2] EDGE ENHANCEMENT:- It is carried by linearly stretching DN values of Band # 2, 3 & 4 and their super-imposing to each other. It has precisely delineated Paleo-drainage over Paleo- karstic limestone in Jamuniya nalla section along with field validation. It is illustrated as Fig.10 & Fig.11,exhibiting edge enhancement and Field observation respectively.

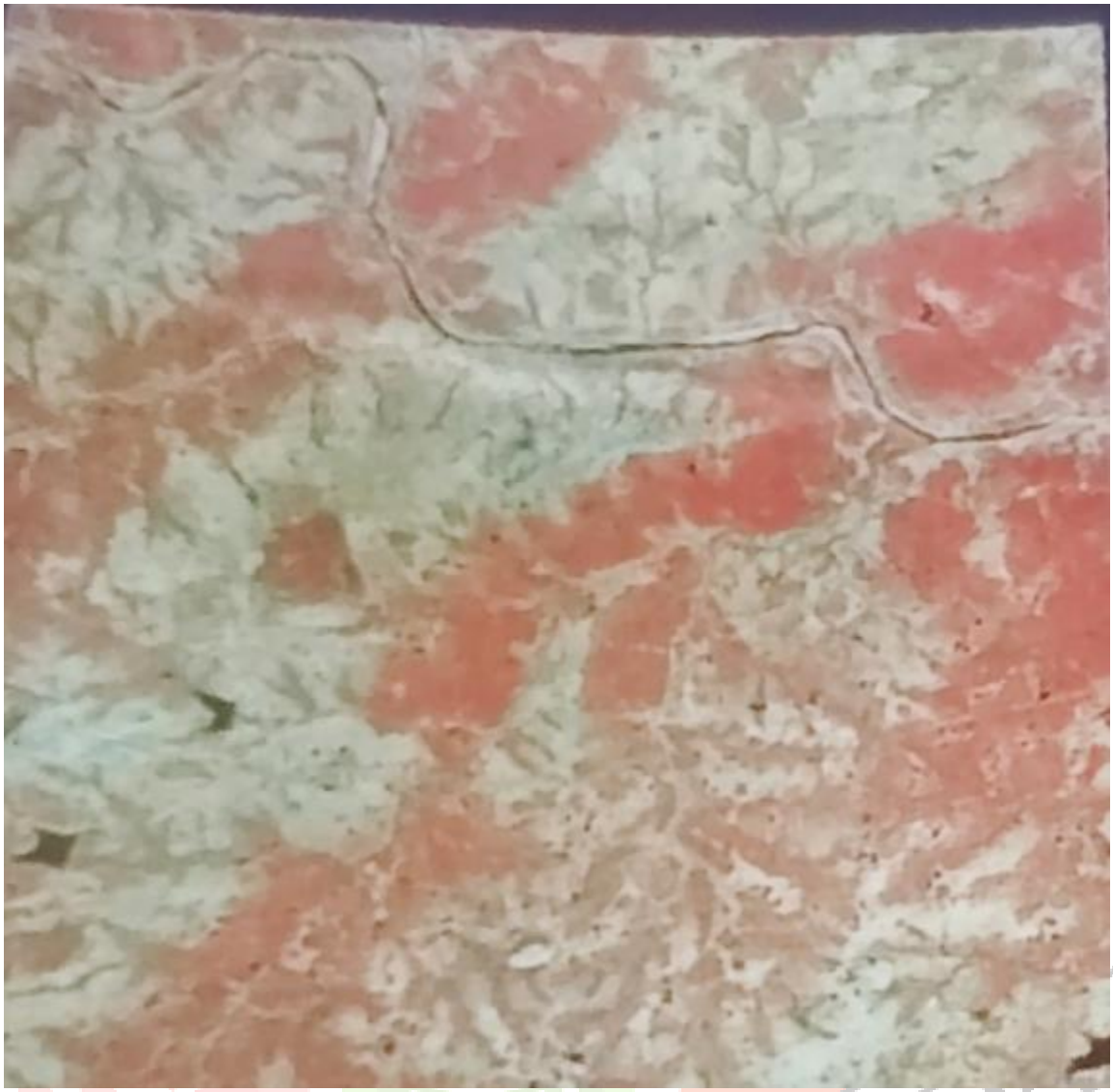

Fig.10 Edge Enhancement # 2,3 & 4 Showing Paleo-drainage over PaleoKarst terrain

Fig,11 Jamuniya Nalla showing Karstic Limestone

[3] PRINCIPAL COMPONENT TRANSFORMATION [PCT]:- It has been carried in two modes namely BAND # 2, 3 & 4 and BAND # 1, 2 & 3. The band combination # 2, 3 & 4 has delineated the following features promptly- Confluence of jamuniya nalla and Banjari nalla, Kumhari dam, Reserved forest and Lineaments. It is illustrated as Fig.12.

The band combination # 1, 2 & 3 has precisely delineated the characteristic for the confluence of Jamuniya nadi with Sheonath river along it's both bank namely: Pedi-plain and Vegetation at western

& eastern side respectively, illustrated as Fig 13. It has been cross verified through Field Observation also, illustrated as Fig.14.

[4] SUPERVISED CLASSIFICATION:- It has been obtained through correlation of training sets pertaining to prominent topographic features as GCP. It has precisely delineated surface pond inventory, main connecting road in between Baloda-Bazar & Kasdol and Sink-Hole along eastern margin of Sonadih limestone mining area. It is illustrated as Fig.15.

[5] STANDARD FALSE COLOR COMPOSITE [FCC]:- It has been obtained through band combination of # band 2, 3 & 4. It has precisely demarcated Terra rossa illustrated as Fig.16 along with field validation.

[6] SUPERIMPOSING OF PCT [# 2, 3 & 4] WITH SUPERVISED CLASSIFICATION:- It has demarcated identical Kumhari dam and linements. Kumhari dam is of earthen type constructed during British period [1927] for irrigation purpose [5]. It is illustrated as Fig.17.

Fig.12. PCT# 2, 3 & 4 Showing Lineament and confluence of Banjari & Jamuniya Nalla

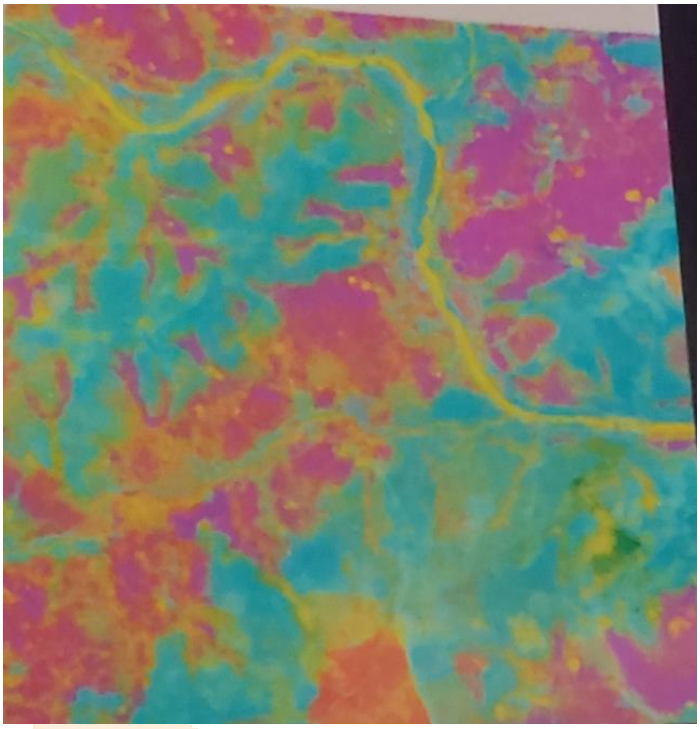

Fig.13 PCT # 1, 2 & 3 Showing Pediplain and Vegetation at different banks of jamuniya nadi, before meeting with Sheonath river

Fig.14 Showing Pediplain and Vegetation at different banks of jamuniya nadi, before meeting with Sheonath river

Fig. 15 Sink-Hole along eastern margin of Sonadih limestone mining area

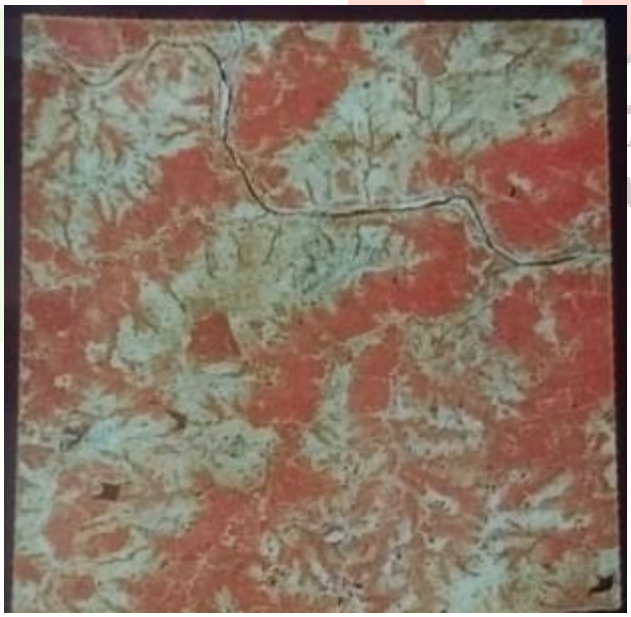

Fig.16: Standard FCC showing Terra rossa

Fig.17 Lineaments and Kumhari Dam

Summary & Conclusion

Groundwater is renewable cum potable resource for any kind of utilization to human welfare and related developmental activities. The occurrence of groundwater in karst aquifer is globally well known [7]. The reliable methodology, based upon Conventional & Advance approaches has been evolved for identification, precisely delineation and documentation for groundwater perspective zone in karstic limestone of Baloda-Bazaar. The groundwater perspective zones are required to be verified through Resistivity Investigation [Geophysical tool], before conducting actual drilling in order to achieve optimize groundwater extraction [6].

Jamuniya river drainage basin is traditional area for rice cultivation, as being the portion of "Bowl Rice of CG" and emerging industrial sector for Cement manufacturing. Both activities require optimized groundwater utilization, conservation and management in sustainable manner through suitable methodology.

The evolved methodology has scope at local to regional level for groundwater study with use of latest temporal satellite data having better spatial resolution for aquifer mapping in conjunction with pumping data and drawdown characteristics. It may be helpful for comprehensive assessment of groundwater.

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