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Abstract

Integrated analysis of hydro-geomorphology is a vital aspect of locating groundwater perspective zones. It also provides a systematic approach to groundwater evaluation and promotes the sustainable development of resources. This study employed geospatial techniques to obtain the hydro-geomorphology of Medchal Mandal, located in the North-East direction of Hyderabad. The following analysis has been summarized from the study; (1) pediplain (5184.59 ha), which is moderately weathered, found the groundwater prospects in this zone ranging from poor to moderate (2) Pediplain shallow weathered (6066.10 ha), and noticed the groundwater condition varying from moderate to poor noticed (3) pediment (1554.75 ha) to hold moderate groundwater (4) pediment inselberg complex (5614.06 ha), was located in the study implied poor groundwater conditions (5) denudation hills (161.82 ha) has a groundwater potential ranging from poor to negligible and noticed that the cause for poor groundwater conditions was significant runoff produced and mild infiltration. Lineaments were identified in the following villages, Gaudavalli, Gosaiguda, Ghanpur, Sreerangavaram, and Nuthankal, indicating major orientations along with N-S and NE, SW, and SE directions. In the study area, the observed groundwater resource was found acceptably satisfactory. Furthermore, the thematic maps of hydro geomorphology and geomorphology showed possible artificial recharge areas that can be employed alternatively to manage groundwater resources in the study area about complex rock terrain localities. Using the multi-influence factor (MIF) and weighted overlay techniques in Arc GIS, the eight layers were created and given set scores and weights based on their propensity to hold water. The results can be paragraphed as three zones visible on spatial exposure (a) 28% good groundwater potential zone, (b) moderate (33%), and (c) poor (39%) were evaluated. Thus, the groundwater potential model is a predominant tool for assessing sustainable groundwater resources.

Keywords (separated by '-')

Geology - Geomorphology - Groundwater potential zones - Multi-influence factor - Medchal Mandal

Chapter 17
Systematic Approach of Groundwater Resources Assessment Using Remote Sensing and Multi-influence Factor (MIF) Techniques in Medchal Mandal, Telangana State, India

D. Naresh Kumar, Thumati Venkateshwarulu, Vamsi Kalyan Veerla, Balaji Etikala, Y. Mohana Prasada Rao, and Anvesh Jukitala

Abstract Integrated analysis of hydro-geomorphology is a vital aspect of locating groundwater perspective zones. It also provides a systematic approach to groundwater evaluation and promotes the sustainable development of resources. This study employed geospatial techniques to obtain the hydro-geomorphology of Medchal Mandal, located in the North-East direction of Hyderabad. The following analysis has been summarized from the study; (1) pediplain (5184.59 ha), which is moderately weathered, found the groundwater prospects in this zone ranging from poor to moderate (2) Pediplain shallow weathered (6066.10 ha), and noticed the groundwater condition varying from moderate to poor noticed (3) pediment (1554.75 ha) to hold moderate groundwater (4) pediment inselberg complex (5614.06 ha), was located in the study implied poor groundwater conditions (5) denudation hills (161.82 ha) has a groundwater potential ranging from poor to negligible and noticed that the cause for poor groundwater conditions was significant runoff produced and mild infiltration. Lineaments were identified in the following villages, Gaudavalli, Gosaiguda, Ghanpur, Sreerangavaram, and Nuthankal, indicating major orientations along with N-S and NE, SW, and SE directions. In the study area, the observed groundwater resource was found acceptably satisfactory. Furthermore, the thematic maps of hydro geomorphology and geomorphology showed possible artificial recharge areas that

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can be employed alternatively to manage groundwater resources in the study area about complex rock terrain localities. Using the multi-influence factor (MIF) and weighted overlay techniques in Arc GIS, the eight layers were created and given set scores and weights based on their propensity to hold water. The results can be paragraphed as three zones visible on spatial exposure (a) 28% good groundwater potential zone, (b) moderate (33%), and (c) poor (39%) were evaluated. Thus, the groundwater potential model is a predominant tool for assessing sustainable groundwater resources.

Keywords Geology · Geomorphology · Groundwater potential zones · Multi-influence factor · Medchal Mandal

17.1 Introduction

One of the priceless natural resources that safeguard trade, socioeconomic growth, and human health is groundwater [4, 7, 9, 19, 56, 59], (Balaji et al. 2020). It is a significant source of water supply for an Indian agricultural, residential, and industrial zone. Numerous hydro geomorphologic processes have influenced the occurrence, mobility, availability, storage, and transmission of groundwater in the aquifer zone [3, 34, 36]. It is necessary to field authenticate hydro-geomorphology, geomorphology, geology, and geological structures to identify potential groundwater zones [6, 12, 13, 17, 33, 62].

Due to geological formation and seasonal variations, the supply of groundwater differs from one place to another [32, 45]. Identification of groundwater prospects is aided by an integrated investigation of the hydro-geomorphology, lineaments, and geomorphology of the research area utilizing geospatial tools [1, 57, 63]. Lineaments give primary baseline data that regulate the occurrence and movement of groundwater [46, 55]. Initiation of remote sensing, appropriate arrangement of high-speed computers, and GIS bid for assessment of hydro-geomorphic themes that will aid in the identification of groundwater potential zone in the Medchal area [38, 40]. Many research scholars, professors, and scientists have used spatial techniques to determine potential groundwater zones with good results [16].

The combination of remote sensing (RS) and geographic information systems (GIS) has shown to be an effective method for identifying groundwater potential zones because it requires less time and labor. Considering several important parameters, including lithology, lineament/drainage density, slope, geomorphology, rainfall, land use patterns, and soils, provides reliability and lowers the possibility of human error. Combining primary and secondary data sets is an advantage of RS and GIS. In the past, researchers have utilized various methods, such as multi-influence factor analysis (MIF), to identify potential groundwater zones [5, 29, 54].

Sub hub of Hyderabad of Medchal Mandal population has risen from the decade, the water supply and increased demands of groundwater resources. To solve this problem, there is a need for the required method. The project aims to define possible groundwater zones utilizing spatial methodologies and statistical analysis in Medchal Mandal, Telangana state, India.

17.2 Study Area

Medchal Mandal is located northeast of the Medchal-Malkajgiri District of Telangana State, India. The Mandal is situated within of 78°22′–78°45′ East longitudes and 17°42′–17°50′ North latitudes (Fig. 17.1). There are 29 villages and 18 village panchayats in Medchal Mandal. It is 602 metres above sea level on average. There are 93,102 people living in the 196.3 km^2 area as per the 2011 Census. The amount of rain annually is 835.7 mm. Between June and September, the region receives rain from the southwest monsoon zone. It begins in the northern part of Kerala State, travels through Rayalaseema, and then ends up in the Hyderabad region. As a result of the scorching summer, the study area experienced dry climate conditions. Geomorphological features have been covered in Medchal Mandal such as the denudation hill, pediment-pediplain complex and anthropogenic bodies [2, 20, 49, 51]. The denudational origin of the Pediment-Pediplain complex has been covered in Medchal Mandal, with a minor portion covered by anthropogenic bodies. Humans sculpt and transform the landscape through the physical change of shape and behavior of surface material and subsurface substances. Contamination by harmful elements dumped at a place that simultaneously pollutes soil, water, and the air is an anthropogenic area. Girmapur, Gosaiguda, Ghanpur, Ravalkole, and Kandlakoya villages have anthropogenic bodies.

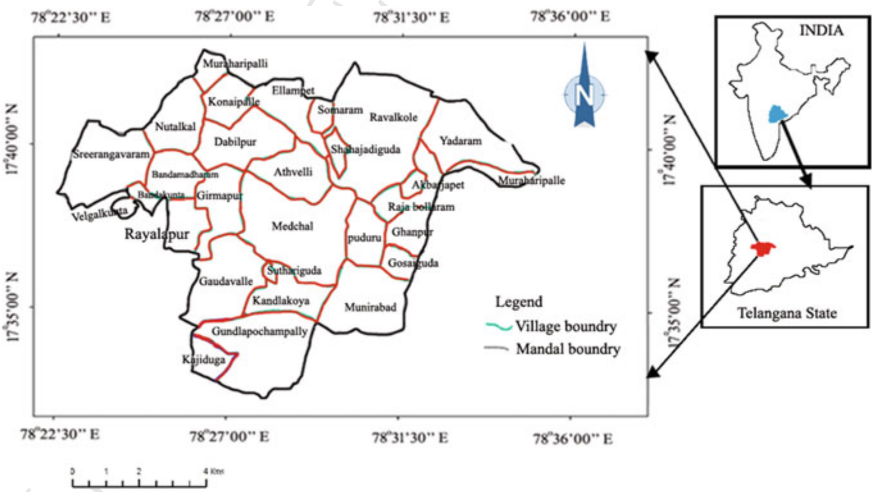

Fig. 17.1 Medchal Mandal location map, Medchal-Malkajgiri District, Telangana State

The Medchal Mandal slope can be categorized as very gently sloping, flat to nearly level, gently sloping, moderately sloping, and relatively steeply sloping [43]. Medchal Mandal contains predominantly Peninsular Gneiss Complex (PGC), granite, and Alkali feldspar granite rocky terrains and some parts covered by amphibolite, hornblende, and biotite schist rocks [27, 48]. few minerals like epidote and Pyroxene is also subsequently observed. Granite aquifers' transmissivity varies from 30 to 200 m^2/day [10]. Medchal Mandal has variable water resources but their distribution over the surface is difficult because of undulation, slope gravity, and varied rainfall.

17.2.1 Physiography and Hydrogeology

Most of Medchal Mandal is flat and descends gradually in a northwesterly direction. The region is 420 and 640 m above mean sea level (MSL). Different lake tributaries drain rainwater from Medchal Lake and Shameerpet Lake. Undulation and lowland areas, fractures have controlled drainage, and joints in igneous rocks parallel to the sub-parallel pattern in the east, northeast, and south-eastern.

17.2.2 Geotechnical Characteristics

Medchal Mandal, Medchal-Malkajgiri District's terrains have been demarcated into engineering geological provinces. Granites and gneiss have low permeability, high (1000–2000 kg/cm^2) bearing capacity/ compressive strength, and 'excellent' foundation characteristics. The entire area of Medchal-Malkajgiri and Hyderabad Districts falls under seismic zone-III.

17.3 Methodology

The flow chart illustrates the process for evaluating and mapping the hydrogeomorphology in the Medchal Mandal. Survey of India toposheets (56K/6 and 56K/10 on 1:50,000 scale) and linear imaging self-scanning sensor of IRS P6 LISS III (Path 24 and Row 61). Utilised to visually comprehend many topics such as shape, size, texture, pattern, tone, and related features. Georeferencing of satellite photos was done using the WGS1984 zone 44N datum. RS data, SOI topographic maps, geological maps obtained from the GSI (Geological Society of India), and data from multiple sources were used to create several thematic maps. A base map was made using the SOI (Survey of India) toposheets. All thematic maps are created using the Medchal Mandal hydrogeomorphological map, which was created using the ARC GIS 10.2.2 program. This map is used to identify probable groundwater zones.

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17.3.1 Multi-influencing Factor (MIF)

The multi-influencing factor (MIF) technique was combined with a geographic information system to map potential groundwater recharge zones. Hydrogeological components such as drainage, lineament, geology, slope, land use/land cover, rainfall, and soil influence groundwater recharge. These parameters were categorized and integrated based on weights obtained using the MIF technique.

17.3.1.1 Weightage and Assignment

Each class was weighed based on published literature. The results covered the good-to-poor ratio and were associated with potential zones.

17.3.1.2 Weighted Overlay Analysis

Analysis of weighted overlays uses GIS to overlay thematic maps of weighted data to discover the best groundwater potential zones.

17.3.1.3 Lineament Map

Lineaments are naturally occurring linear surface components immediately understood from satellite data. Lineament can be displayed as a single continuous line or a series of broken lines. The alignment of ponds and straight stream segments has revealed lines. Scale weights are assigned to each feature class and are projected in Table 17.1. These facts significantly impacted the research area's groundwater recharge. The layer's weight parameters are analyzed by GIS software, which then reveals the potential groundwater zone. The Weightage and Assignment stage connected the Liner Density stage for weightage overlay and all layers' weight conversion findings of potential groundwater zones were then displayed [14, 23]. A weight of 1 was given to the significant influencing factor, while a weight of 0 was given to the minor influencing factor (Table 17.2).

17.3.1.4 Slope Map

The slope map was created using a digital elevation model (DEM) from the National Remote Sensing Centre's Cartosat-I DEM (NRSC). The geology map, geomorphology map, slope map, lineaments map, drainage density map, and contour map coincide with this hydro-geomorphologic map [11, 39]. The state of recharge and the types of rocks, landforms, and exploration spots are well explained by hydrogeomorphic maps and drainage networks. The final output map of the recharge potential

Table 17.1 Calculation of scale weights that affect groundwater recharge weights

S. no	Parameter	Feature class	Scale weight
1	Geomorphology	River, Tank	24
		Pediment	20
		Pediplain	15
		Pediment inselberg complex	10
		Denudational hill	4
2	Geology	Predominantly granite and alkali feldspar granite	20
3	Slope	Level to nearly level	10
		Very gently sloping	8
		Gently sloping	6
		Moderately sloping	4
		Moderately steeply sloping	12
4	Hydro-geomorphology	Pediplain moderately weathered	24
		Pediplain shallow weathered	18
		Pediment	15
		Pediment Inselberg complex	10
		Denudation hill	4
5	Lineament density (km^2)	<0.6	4
		0.6–0.8	8
		0.8–1.0	10
		1.0–1.2	15
		>1.2	20

Table 17.2 Shows influences, relative impacts, and weights given to each potential component

Factors	Major effect (A)	Minor effect (B)	Relative weight (A + B)	Assigned weight for each influential factor
Geomor phology	4	0	4	24
Geology	3	0.5	3	20
Slope	1	0.5	2.5	12
Hydro geomor phology	2	0	2	24
Lineaments Density	2	0.5	2.5	20
Total			Sum: 14	100

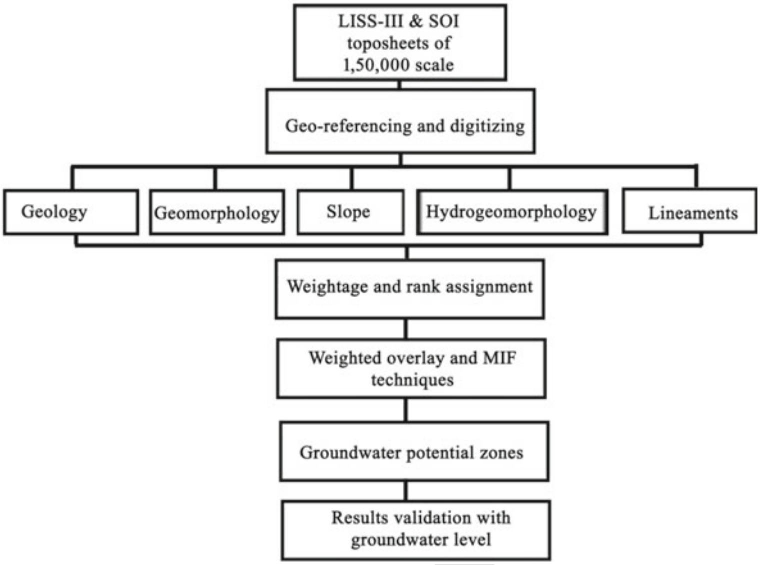

Fig. 17.2 Flowchart representing the processing method of groundwater potential map

zone was created using thematic layers with a 30 m resolution and a standard coordinate system of UTM WGS-84. The results were then verified using historical drill yield information. Figure 17.2 illustrates the study's methodology.

17.4 Results and Discussion

17.4.1 Geomorphology

The Medchal Mandal's geomorphic unit comprises the Pediment-Inselberg Complex, Pediplain, Pediment, and River Tanks. Because there are so many little inselbergs in the Pediment-Inselberg Complex, it might be challenging to tell them apart from regular pediments. The Pediment-Inselberg Complex region's low aquifer content needs better groundwater potentials. As a result, it was given little weight. Pediplain has an extensive, multi-concave, rock-cut erosion surface, in this region groundwater flow is moderate; hence we assigned 20% weightage. Pediments represent a mature stage of the erosion cycle and have good aquifer content, so we allocated 27% of weightage. Denudation hill have negligible water content so it assigned very low value of weightage [21, 50]. River and tank regions have good water resources as a weightage distribution we given 10 weightage (Fig. 17.3a).

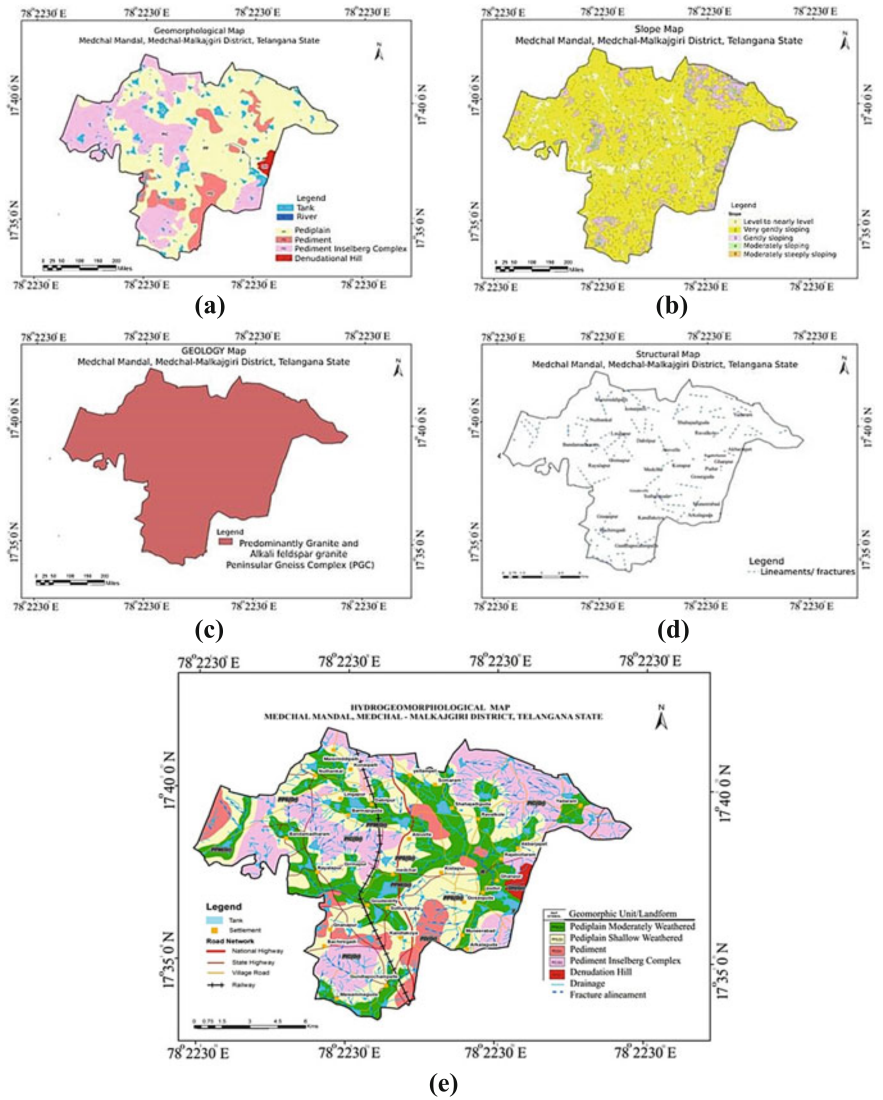

Fig. 17.3 **a** Geomorphological map, **b** slope map, **c** geological map, **d** lineament map, **e** hydrogeomorphological map with groundwater prospects of Medchal Mandal, Medchal-Malkajgiri District, Telangana State

17.4.2 Slope

Slope and undulations are essential aspects of groundwater recharge. Low land areas, lakes, and tributaries are complementary geomorphologic structures for collecting groundwater. Very gently sloping covered Mandal 42% (Table 17.3) of the area,

Table 17.3 Medchal Mandal slope classification as per percentage

S. no	Classification of slope	Min to max limit of the slope (%)
1	Level to nearly level	18
2	Very gently sloping	42
3	Gently sloping	20
4	Moderately sloping	12
5	Moderately steeply sloping	08

runoff is high in this region low groundwater prospect is low. Levels to nearly level and gently sloping both are covered 20% of the part, gently sloping not suitable for underground water. Moderately sloping and moderately steeply sloping are occupied 12 and 8% of the Medchal Mandal, both land features are moderate to good for groundwater filling (Fig. 17.3b). When assessing the possibility for groundwater, the dominance of the very gently sloping slope class is unfavorable, hence they were given little weight. It was given high weight because of the good groundwater potential of gently sloping and level to the almost level slope.

17.4.3 Geology

Grey and pink granite are transitory and gradational in both lateral and vertical directions. The origin is the exact equivalent in the two rock types [8, 37, 44, 58, 61]. Medchal Mandal is covered by pink granite in a large portion and grey granite moderate in a field survey observed that weathered granite rocks present in Ghanpur, Goudavalle, and Pudoor villages (Fig. 17.3c). Therefore, appropriate weights are given to various rock units in the research region based on the availability of groundwater. Because of their resistance to weathering, faulting, and jointing in the area, predominantly granite [18] and alkali feldspar granite were given low values.

17.4.4 Lineaments

Lineament is either a single continuous line or is shown as discontinuous line segments [42]. Lineaments have been exposed in the alignment of ponds, straight stream segments, and vegetation structure [15, 28, 31]. Dykes create linear ridges on the surface. This region has good groundwater prospects [24, 41, 53]. The research area's lineament density map's thematic layers showed five distinct lineament density classes: very low (0.1–0.6 km/km^2), low (0.6–0.8 km/km^2), moderate (0.8–1.0 km/km^2), and high (1.0–1.2 km/km^2) (Very high). Lineaments in Medchal Mandal are well exposed near the villages such as Medchal, Gaudavalli, Gosaiguda, Ghanpur, Sreerangavaram, and Nuthankal (Fig. 17.3d).

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Table 17.4 Hydrogeomorphology features in Medchal Mandal, Malkajgiri-Medchal District, Telangana State

S. no	Symbology	Geomorphic unit	Lithology	Groundwater prospects	Area in km^2
1	PPM	Pediplain moderately weathered	Peninsular Gneiss Complex Granite (PGC)	Good to moderate	51.8459
2	PS	Pediplain Shallow weathered	PGC	Moderate to poor	60.6610
3	PIC	Pediment inselberg complex	PGC	Poor	56.1406
4	PD	Pediment	PGC	Poor	15.5475
5	DH	Denudation hill	PGC	Negligible	1.6184

17.4.5 Hydro-Geomorphology

The hydro-geomorphology of Medchal Mandal is divided into five major categories: pediplainmoderately weathered, pediplain shallowly weathered, pediment Inselberg Complex, pediment, and denudation hills (Fig. 17.3e). Pediplain Moderately Weathered shows good water conditions, faults, lineaments, fractures, and weathered rock materials, which increase the scope for recharge of groundwater. Table 17.4 Shows the hydrogeomorphological features, corresponding groundwater prospects and their summary statistics of Medchal Mandal, Malkajgiri-Medchal District, Telangana State. This geomorphic unit is noticed at the villages around Gundlapochampalle, Kajiguda, Kondlakoyya, Suthariguda, Gosaiguda, Ghanpur, Pudoor, Rajabollaram, Akbarjapet, Rovalkol, Yadawaram, Yellampet, Somaram, Konayepalli, Atvelli, Maisereddipalle, Nuthankal, Bandamadharam, Girmapur, Goudavelly.

Pediment inselberg complex division is not possible to restore groundwater. These geomorphological units present in villages are Gosaiguda, Raja bollaram, Gundlapochampalle, Bandamadharam, Girmapur, Ravalkole, and Murharipalle. Ghanpur and Maisammaguda regions have denudation hills, and they have a high rate of water flow due to slope and gravitational force [22]. Continuous water flow increases weathered soil and spreads on the surface in vast regions [60].

17.5 Discussion

The Medchal Mandal has distinct hydro-geomorphological conditions, with topography and geology controlling the groundwater regime. Medchal Mandal has 124 lakes, 20 lakes are inside the outer ring road (ORR), and 104 lakes are outside the

ORR [26]. Moderate to shallow weathered Pediplains allowing rainwater percolation into the ground. These hydro-geomorphological features are suitable for increased groundwater levels [47, 52]. Probably a good density in geological structures like faults, fractures, lineaments, etc., is ideal for the storage of water structures due to inherent transmissivity, agricultural lands may be avoided so that the impounding water does not inundate fertile lands, as the artificial recharge in the immediate vicinity will further aggravate the problem [25, 30].

The study areas groundwater potential map (Fig. 17.4) depicts three distinct classifications (zones) that correspond to the area's "excellent," "moderate," and "poor" groundwater potential. The lakes and drainage network are primarily included in the good groundwater potential zone, which includes areas where low-elevation areas are ideal for storing groundwater and indicate the presence of groundwater.

A good groundwater potential zone covers approximately 52 km^2, accounting for 28% of the total area. The study area's central and northern portions are in the moderate groundwater potential zone; it covers 61 km^2, or about 33% of the total area. This section's hydro-geomorphic feature is deep to moderately buried under pediplain shallow weathered, implying a moderate groundwater storage capacity. However, the Pediment inselberg complex, Pediment, and Denudation Hill areas, which cover approximately 73 km^2, are located in poor groundwater potential zones. Due to the increased slope and unfavorable local geology and geomorphology, the groundwater potential in this area is lower. These prospective groundwater zones aid in the identification of artificial recharge sites in the study area.

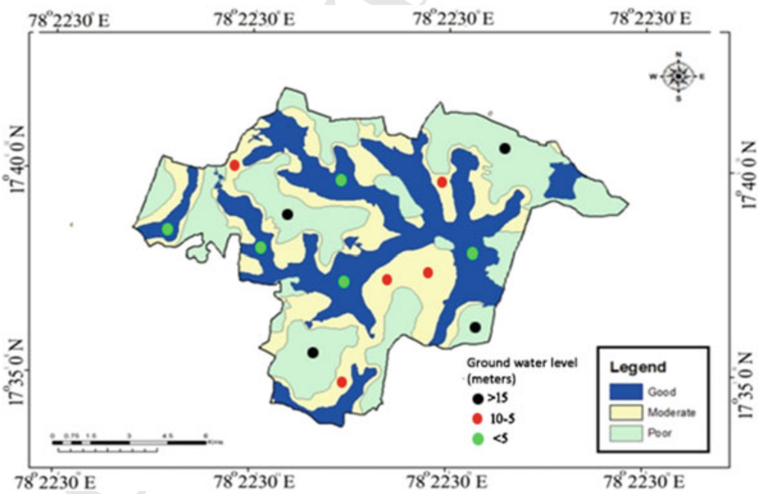

Fig. 17.4 Groundwater potential zone map of Medchal Mandal, Medchal-Malkajgiri district, Telangana

17.6 Verification Using Data from Bore Wells

To determine the accuracy of the results of prospective groundwater zones in the Medchal Mandal, borehole data was collected from the groundwater department of Telangana state and verified by remote sensing techniques. 5.5–15 m bgl is the range of the depth of weathering. Between 1.5 and 75 m^3/day are produced via extension bores drilled to bore well depths between 20 and 45 m. The specific capacity ranges from 0.005 to 0.16 m^3/m per unit cross-section in weathered granite (mainly dry) and alluvium, while the transmissivity values in these materials range from 100 to 150 m^2/day.

Medchal Mandal's average annual borehole depth in May is 18.24 m. bgl (below ground level), seasonal November month depth is 9.12 m. bgl. The average depth of the borehole is 13.44 m. bgl. On the groundwater potential zone map, existing borehole data overlapped, revealing a positive correlation for identifying groundwater points (Fig. 17.4).

17.7 Conclusion

This study uses remote sensing and GIS techniques to demonstrate groundwater resource potential zones in Medchal Mandal, Medchal-Malkajgiri district, Telangana state, India. The software module of ARC GIS offers a practical methodology in expenses and time. Thematic maps focused on hydro-geomorphology, geology, geomorphology, and lineaments to be integrated into GIS software to employ the weighted overlay method. Thematic layers consist of weight scores as per groundwater availability, high weightage indicates good groundwater resources, and low weightage represents poor groundwater content. Thus, this result implies grading the study area as a 'poor to good' zone for groundwater occurrence. Further, with obtained results, the study area was marked good, moderate and poor location for the presence of groundwater. Being a peneplain site with fairly weathered lakes and drainage networks, the research region had 28% of the outstanding groundwater potential zone. The low land regions in the area were identified through this research, and this characteristic guarantees water availability below the groundwater table. The study also discovered that it included 61 km^2 of medium groundwater potential or 33% of the zone's total. 39% of the study region has poor groundwater, compared to 73 km^2 of the area that exhibits a poor groundwater potential zone. The groundwater potential map and the nearby drill data were thus positively correlated. The borehole yields above >75 m^3/day in areas with good and excellent groundwater potentials, whereas it yields less than 55 m^3/day in areas with moderate and poor groundwater potentials. This research opens up possibilities for additional groundwater exploration studies and could help policymakers better manage and develop groundwater resources in several promising groundwater zones in the Medchal Mandal region.

The outcomes of integrated applications, techniques, and groundwater investigation are appropriate for creating and managing groundwater resources in these settlements and for sustainable management of water resources in hard-rock terrains.

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